Structural Design Related Geotechnical Updates

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Topics:

- Construction Control: Driven Piles
- Static Load Test LRFD Calibration- “MnPile”
- Dragload/Downdrag
- Large Diameter Piles
- Shallow and Geosynthetic Reinforced Soil (GRS) Foundations
- Reports/Recommendations
- Performance Monitoring/Instrumentation

Construction Control: Driven Piles

- Different methods with different LRFD resistance factors
- AASHTO values and/or local calibration

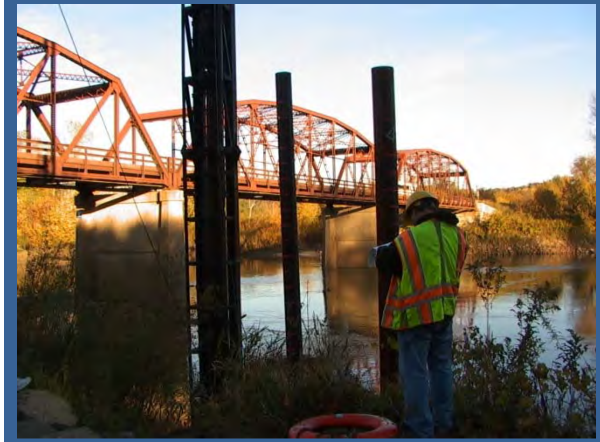
Table 10.5.5.2.3-1—Resistance Factors for Driven Piles

Condition/Resistance Determination Method		Resistance Factor
Nominal Bearing Resistance of Single Pile—Dynamic Analysis and Static Load Test Methods, φ_{dyn}	Driving criteria established by successful static load test of at least one pile per site condition and dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.80
	Driving criteria established by successful static load test of at least one pile per site condition without dynamic testing	0.75
	Driving criteria established by dynamic testing* conducted on 100% of production piles	0.75
	Driving criteria established by dynamic testing,* quality control by dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.65
	Wave equation analysis, without pile dynamic measurements or load test but with field confirmation of hammer performance	0.50
	FHWA-modified Gates dynamic pile formula (End of Drive condition only)	0.40
	Engineering News (as defined in Article 10.7.3.8.5) dynamic pile formula (End of Drive condition only)	0.10

* Dynamic testing requires signal matching, and best estimates of nominal resistance are made from a restrike. Dynamic tests are calibrated to the static load test, when available.

MnDOT Construction Control Methods

- Factored Resistance ≥ Factored Load
  - MnDOT dynamic formula (φ = 0.4)
  - PDA/CAPWAP (φ = 0.65)
  - Static Load Test (φ = 0.8)



- Nominal Bearing Resistance
  - Geotechnical Failure; Pile Deflection; Static Equilibrium

Construction Control (φ = 0.4)

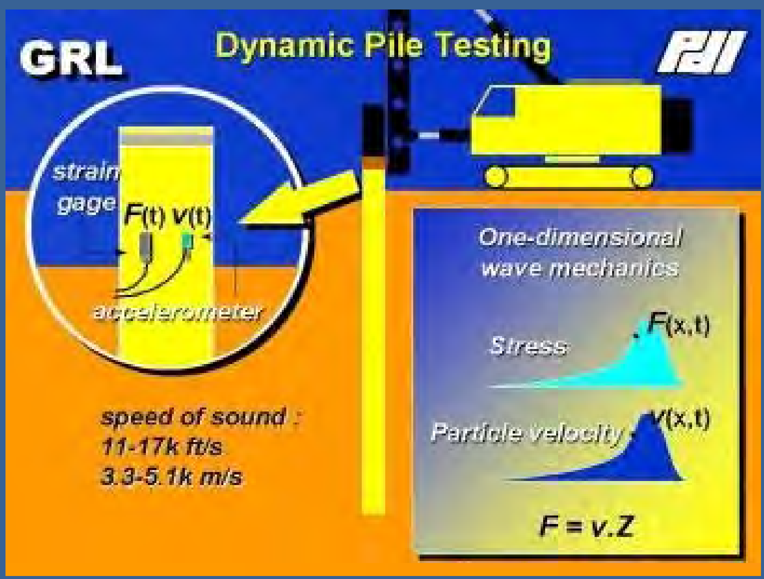
- "MnDOT formula"
  - Most common control method for state bridge projects in MN
  - Predicts pile capacity

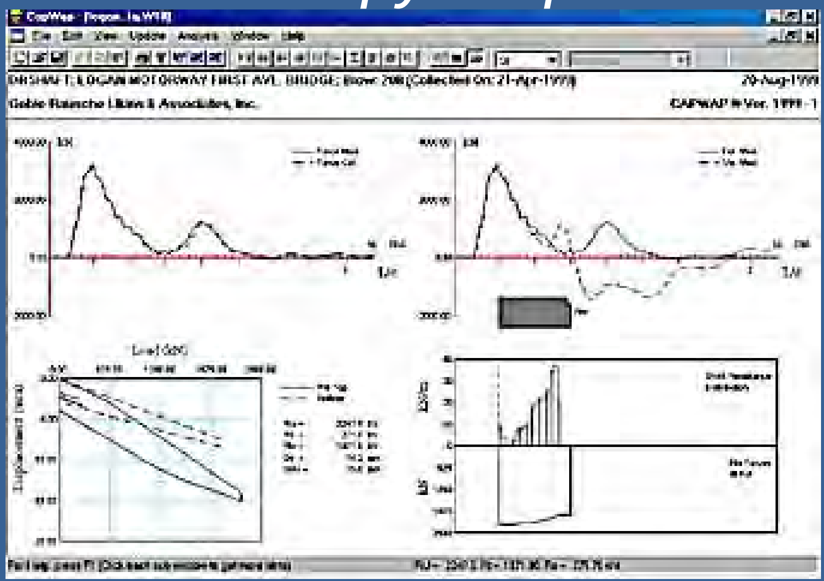
$$R_n = \frac{10.5\,E}{S + 0.2} \times \frac{W + 0.1\,M}{W + M}$$

W = Weight of striking part of hammer (pounds)
H = Height of fall (feet)
E = W*H (ft*lb of energy per blow/full stroke)
M = Weight of pile plus driving cap (pounds)
S = Avg. penetration (inches) per blow for the last 10 or 20 blows

Construction Control (φ = 0.65)

- PDA/CAPWAP
  - Pile Driving Analyzer
  - High Strain Dynamic Monitoring and Wave Equation Analysis: Case Pile Wave Analysis Program
  - Predicts pile capacity based on force and velocity
  - *Note: Send ALL electronic/hard-copy output to MnDOT*





Construction Control ($\varphi = 0.8$)

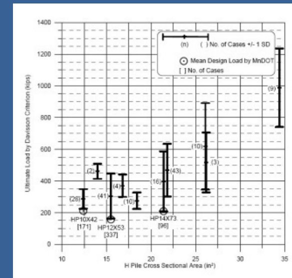
- Static Load Test (SLT)
  - Run to geotechnical failure
  - Provide high level of confidence for capacity
  - Measure capacity
  - Davisson Offset Failure Criterion

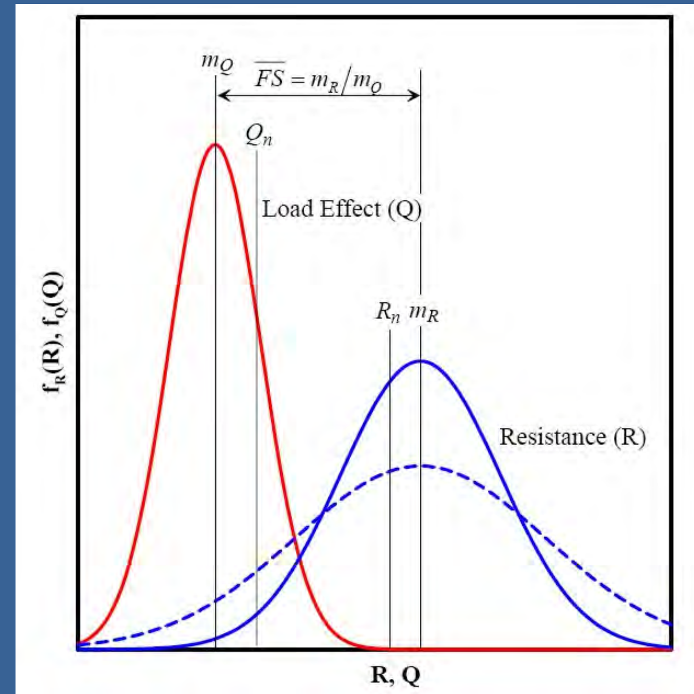
Mn/DOT Research Project:
Developing a Resistance Factor for Mn/DOT's Pile Driving Formula
Final Report

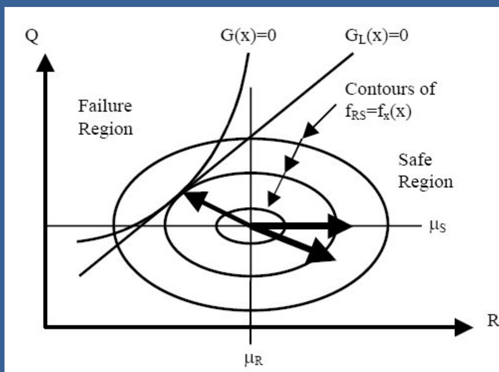
Due to the Mn/DOT dynamic equation **over-prediction** and **large scatter**, the obtained resistance factors were consistently low, and a resistance factor of **φ = 0.25** is recommended to be used with this equation, for both H and pipe piles.

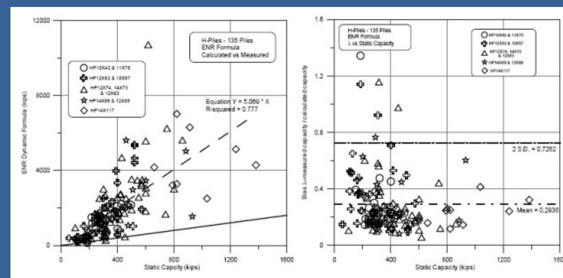
The reduction in the resistance factor from **φ = 0.40** currently in use, to φ = 0.25, reflects a significant economical loss for a gain in a consistent level of reliability. Alternatively, one can explore the use of other pile field capacity evaluation methods that perform better than the currently used Mn/DOT dynamic equation, hence allowing for higher efficiency and cost reduction.

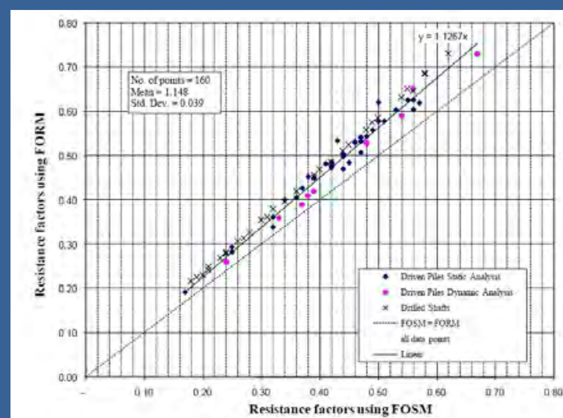
$$\phi = \frac{\lambda_R\left(\gamma_D \frac{Q_D}{Q_L} + \gamma_L\right)\sqrt{\frac{1+COV_{QD}^2+COV_{QL}^2}{1+COV_R^2}}}{\left(\lambda_{QD}\frac{Q_D}{Q_L}+\lambda_{QL}\right)\exp\left\{\beta_T\sqrt{\ln[(1+COV_R^2)(1+COV_{QD}^2+COV_{QL}^2)]}\right\}}$$

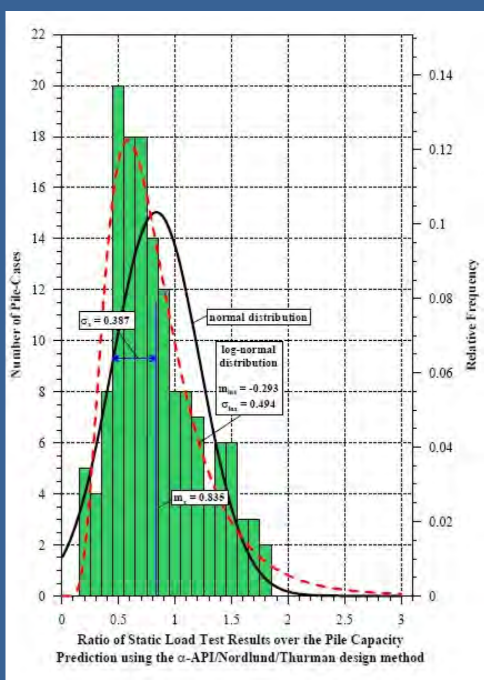


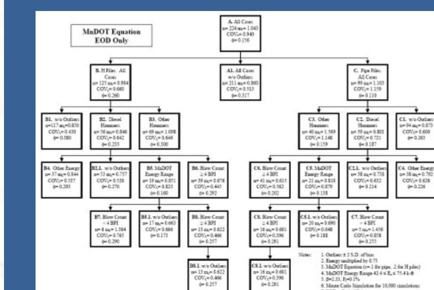


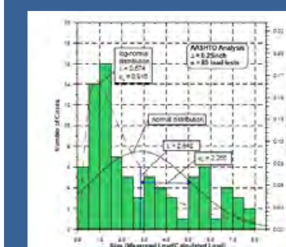



(a) Static Capacity vs. ENR Dynamic Formula
(b) Static Capacity vs. Bias









$$\beta = \frac{m_{RN} - m_{QN}}{\sqrt{\sigma_{QN}^2 + \sigma_{RN}^2}} = \frac{\ln\left[(m_R/m_Q)\sqrt{(1+COV_Q^2)/(1+COV_R^2)}\right]}{\sqrt{\ln\left[(1+COV_R^2)(1+COV_Q^2)\right]}}$$

New MnDOT Formula

- Two studies to refine and improve formula
  - Based on SLT database
  - Collection of MnDOT case studies
  - Based on MnDOT pile driving practice/local projects
  - Existing formula could be improved
- Adopt new formula
  - Conduct static load tests to locally calibrate
  - Adjust resistance factors as more data is available

Eq #	Equation	Description	Reference
4.1	$R_u = \frac{12(W_r * h)}{S+0.1}$	Drop Hammer	Engineering News-Record (1892)
4.2	$R_u = 27.11\sqrt{E_n * e_h}(1-\log s)$		Gates (1957)
4.3	$R_u = 1.75\sqrt{E_n} * \log(10 * N) - 100$	Modified Gates Equation	FHWA (1982)
4.4	$R_u = 6.6 * F_{eff} * E * Ln(10N)$		Washington State DOT (Allen, 2005)
4.5	$R_u = \frac{10.5E}{S+0.2} x \frac{W+0.1M}{W+M}$	Uniform Format for all piles	Minnesota DOT (2006)
4.6	$R_u = 35\sqrt{E_h} \times \log(10N)$	See Chapter 6 for details	First Stage Proposed New Mn/DOT Equation

Notes:

R_u= ultimate carrying capacity of pile, in kips
W= mass of the striking part of the hammer in pounds
M= total mass of pile plus mass of the driving cap in pounds
E= developed energy, equal to W times H, in foot-kips (1.4)
E= energy per blow for each full stroke in foot-pounds (1.5)
e_h= efficiency
E_n= rated energy of hammer per blow, in kips-foot
Ln= the natural logarithm, in base "e"
W_r= weight of falling mass, in kips
s= final set of pile, in inches
N= blows per inch (BPI)
h= height of free fall of ram, in feet
F_{eff}= hammer efficiency factor

New MnDOT Formula

- New MnDOT formula (in final development)
  - Planned for 2013 projects; training this winter
  - Decreases variability (reduced variance/scatter)
  - Improved LRFD resistance factor
- Anticipated for use on most projects:
  - dense soil layers and end bearing piles

$$R_n = [\, 35\sqrt{E_h} * \log(10 * \mathrm{N})]$$

E_h = measured hammer energy
N = blows per inch at the end of initial driving

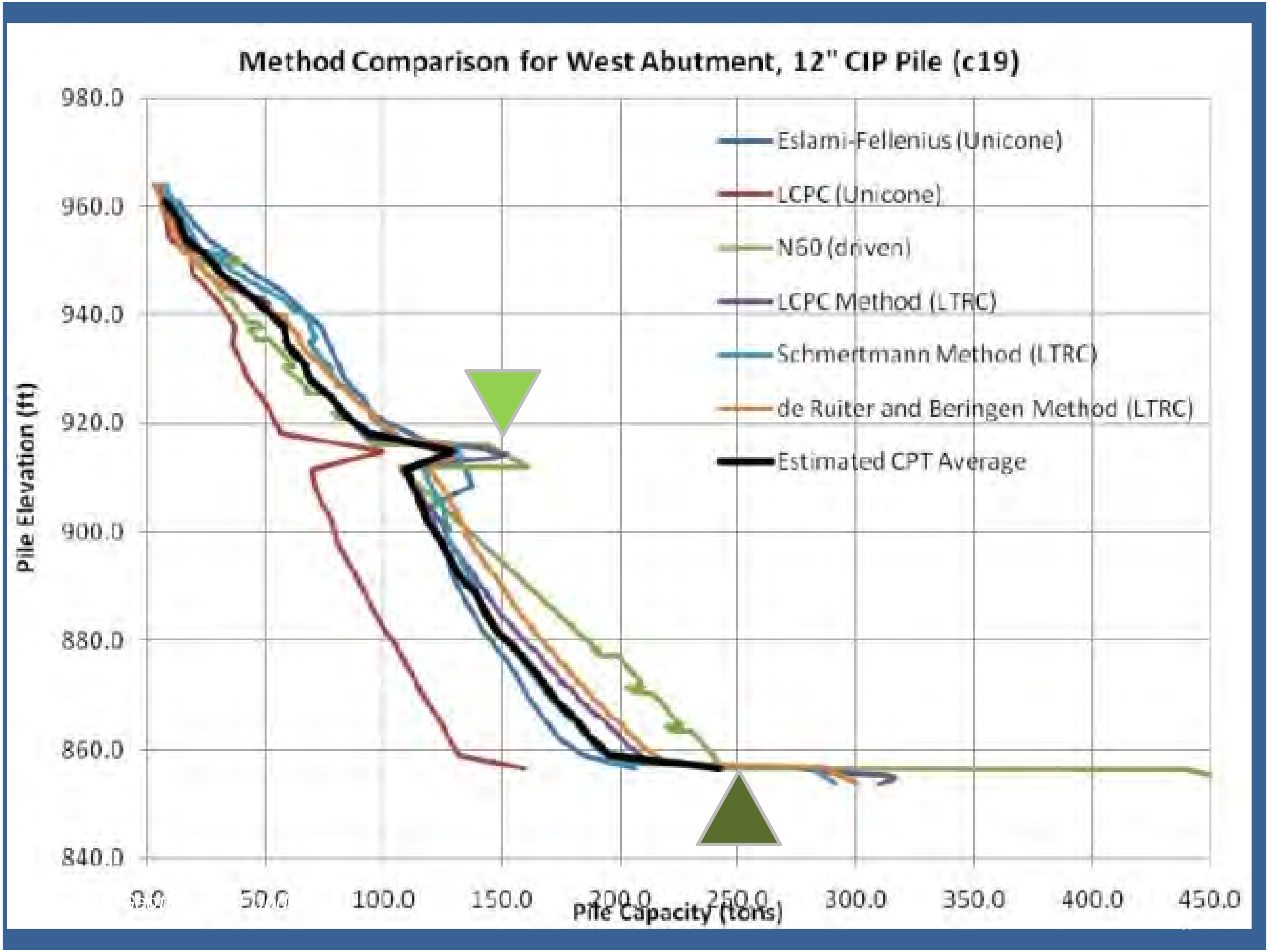
Time, Cost, and Project Value

- Dynamic Formula
  - Shallow bearing layers (common)
  - Small # of Piles
  - Dynamic formula is sufficient in most cases
- PDA/CAPWAP
  - Friction piles
  - Soil set-up
  - Pile damage possible
  - High capacity piles/large # of piles
- Static Load Test (SLT)
  - High value projects; expensive foundations
  - LRFD calibration

Impact of Construction Control

- Resistance Factors
  - Dynamic formula, PDA/CAPWAP, Static Load Test
- 100 tons factored load (for design purposes)
- Field Verification:
  - 100 tons/(φ = 0.4) = 250 tons = R_n
  - 100 tons/(φ = 0.65) = 153 tons = R_n
  - 100 tons/(φ = 0.8) = 125 tons = R_n

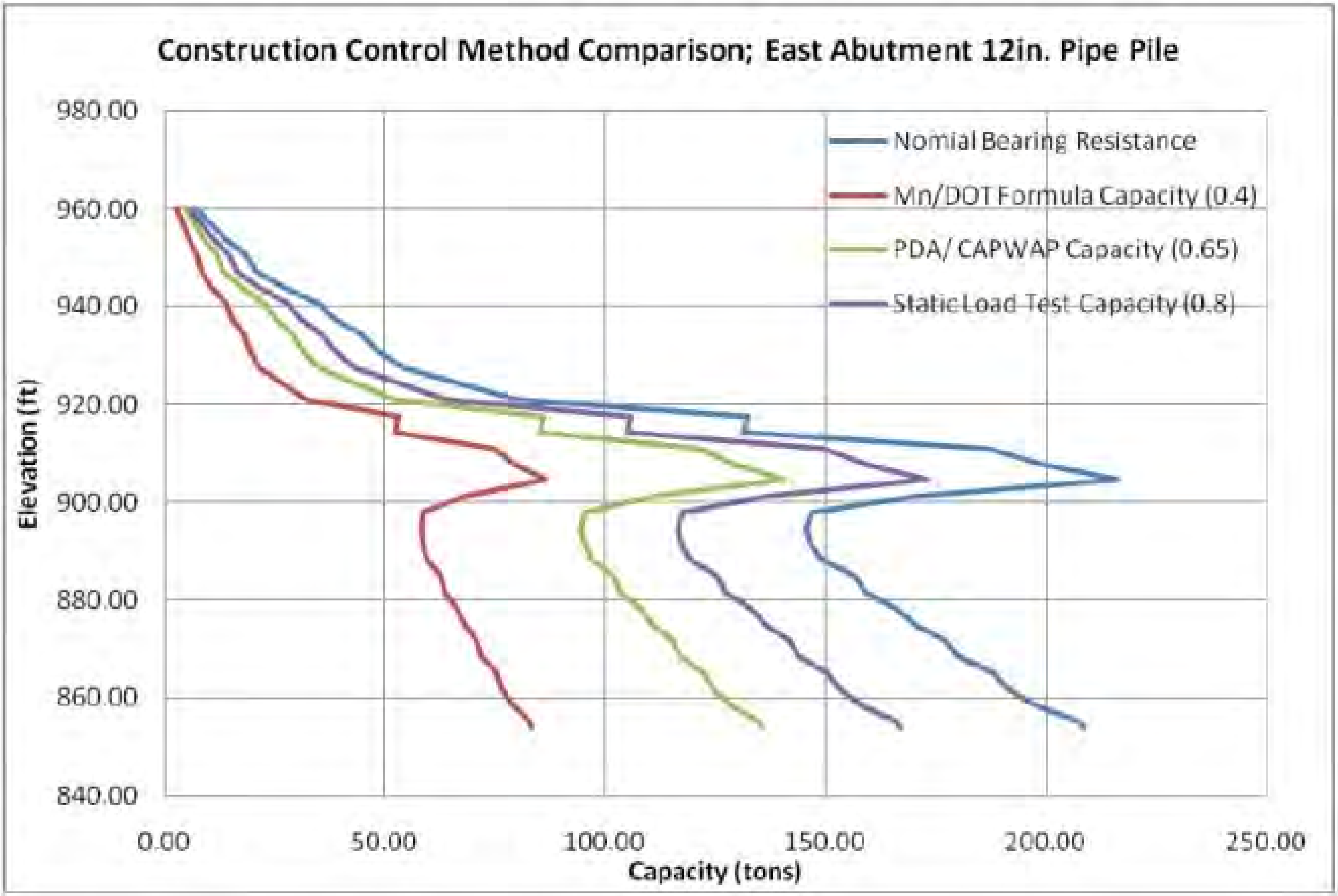
Rn = Required 'Nominal Bearing Resistance,' at the Strength Limit State, measured in the field for the SPECIFIED type of construction control method



Method Comparison for West Abutment, 12" CIP Pile (c19)
Pile Elevation (ft)
980.0
960.0
940.0
920.0
900.0
880.0
860.0
840.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
Pile Capacity (tons)
Eslami-Fellenius (Unicone)
LCPC (Unicone)
N60 (driven)
LCPC Method (LTRC)
Schmertmann Method (LTRC)
de Ruiter and Beringen Method (LTRC)
Estimated CPT Average

Impact of Construction Control

- Dynamic Formula vs. SLT
- 100 tons factored load/(φ = 0.4) = 250 tons = R_n
  - 855 elevation
- 100 tons factored load/(φ = 0.8) = 125 tons = R_n
  - 915 elevation; 60 ft. shorter
  - (60' * $30/ft.) = $1,800
  - $1,800 * 30 piles = $54K
  - SLT cost estimate = $24K
  - Project Savings ($54K - $24K) = $ 30K
    - Plus MnPile program benefit
- Consider construction control method "value"



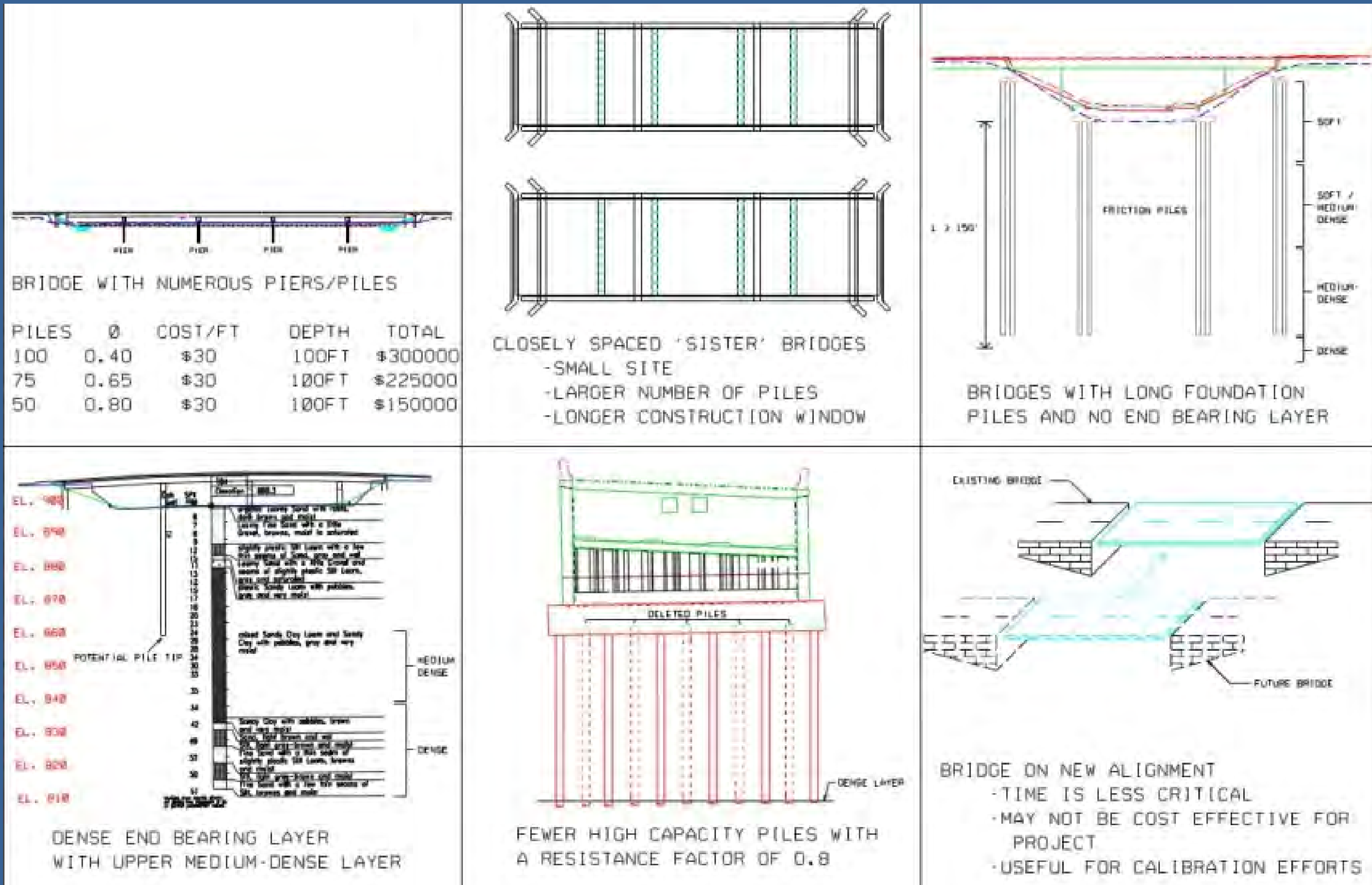
Nominal Bearing Resistance = Geotechnical Capacity = Static Equilibrium

“MnPile” SLT Program

Determine actual ‘load/deflection’ performance

Compare performance results with static predictions, MnDOT formula, and PDA/CAPWAP, based on criteria

- 500 ton and 1000 ton Frames
  - –Victoria: BR 10003 (June 2012)
  - –Shoreview: BR 62717 (July 2012)
  - –Dresbach; Butterfield (2013)



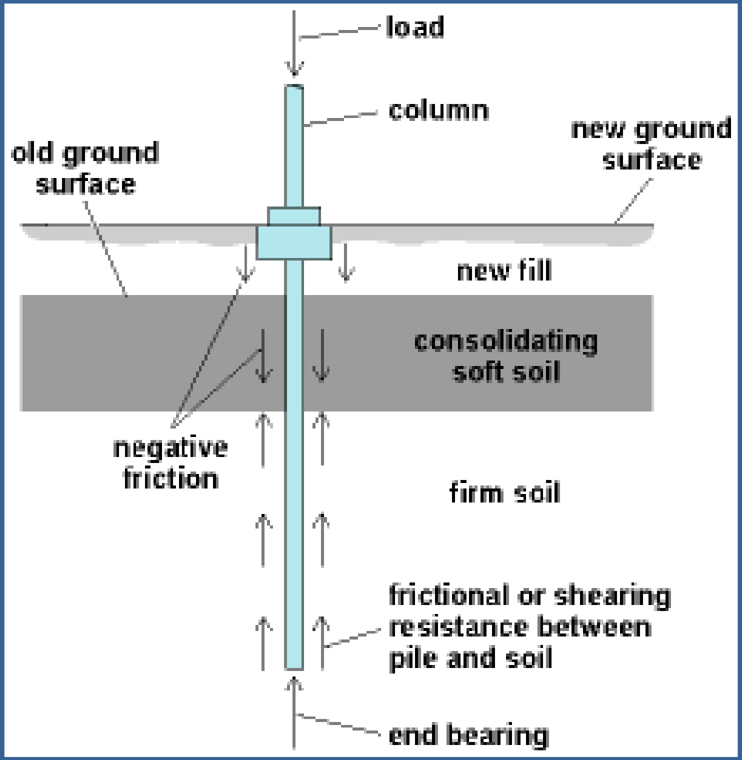
Sample project types for SLT consideration

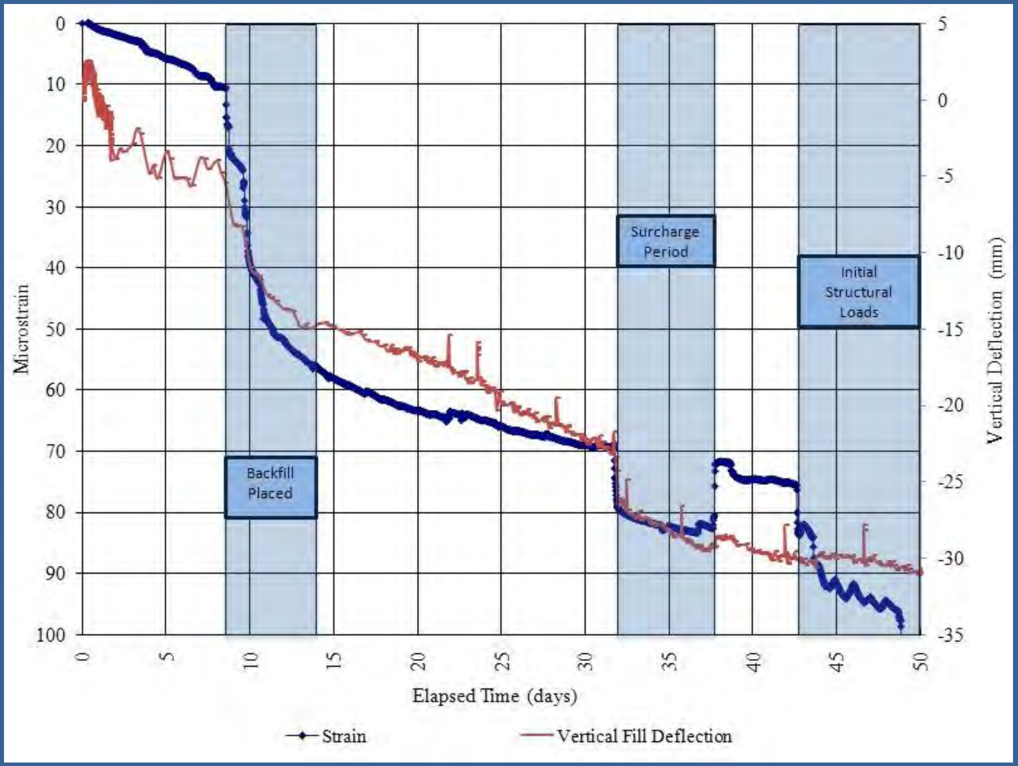
SLT and MnPile

- Additional Investment:
  - Plan details (pile arrangement + piles)
  - Special provisions, sequencing, time
  - Coordination and planning w/Districts
- Benefits:
  - Provides project and program cost savings (φ factor)
    - Sites are pre-selected for project/program benefit
    - Fewer piles or higher capacity
    - Improved quality control
  - Useful for proving high capacity pile strengths
  - Critical component of formula calibration
  - MnDOT provided frames improve efficiency

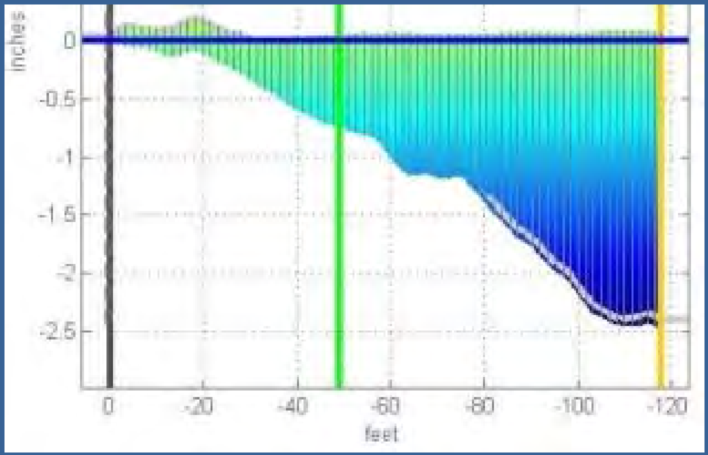
Pile Dragload/Downdrag

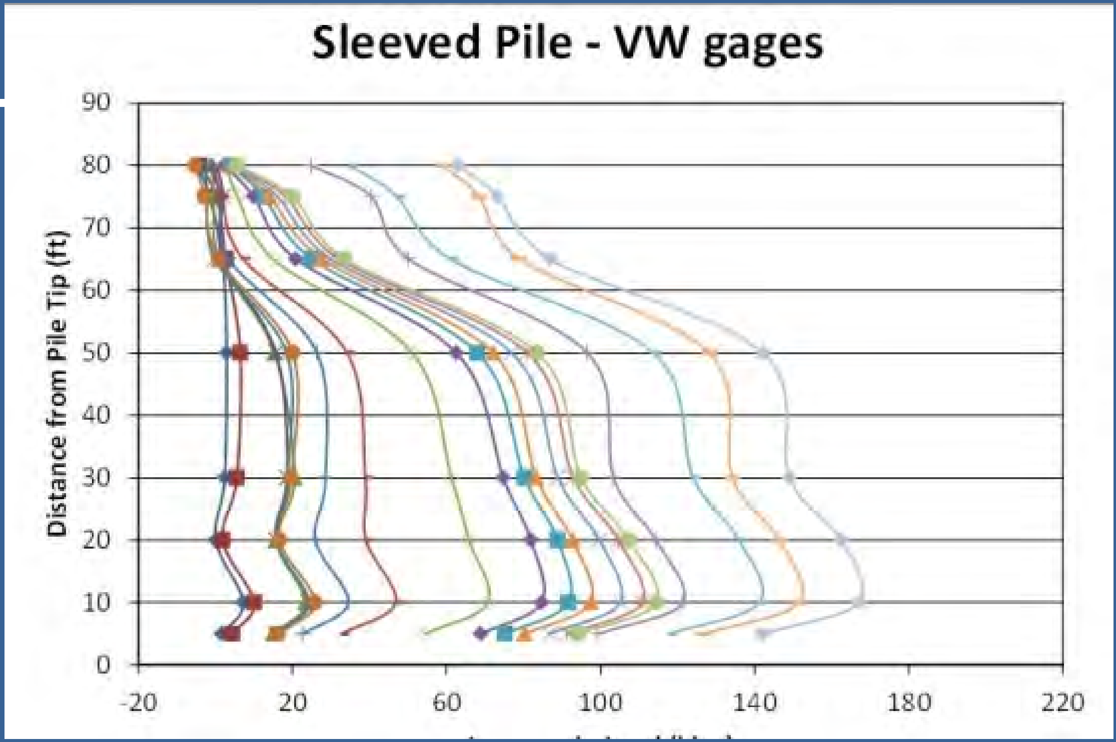
- Large (measured) strains/loads
- Mitigation strategies produce variable results

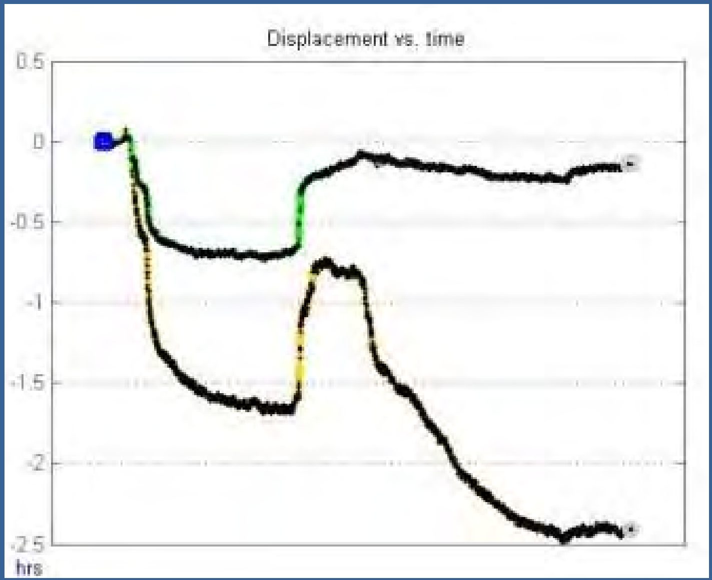




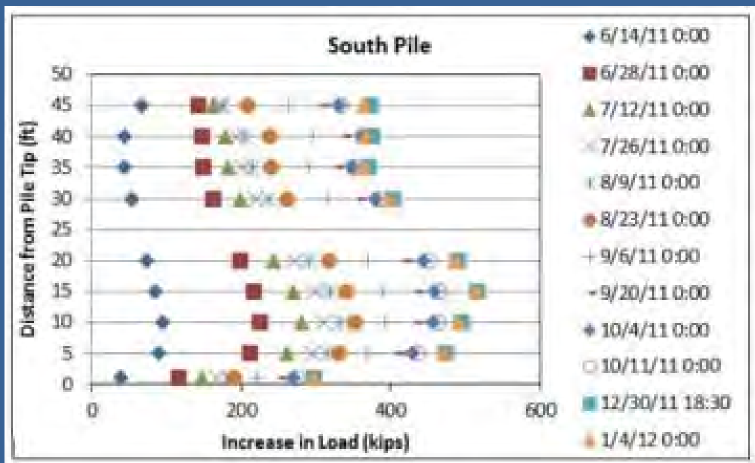
Dragload

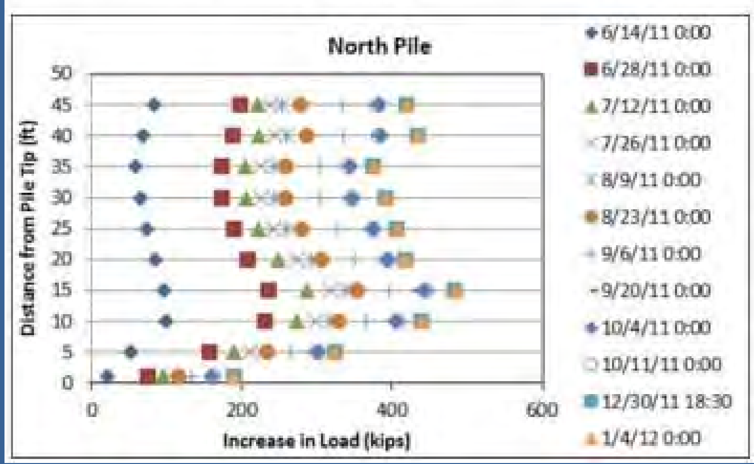

inches
0
-0.5
-1
-1.5
-2
-2.5
0
-20
-40
-60
-80
-100
-120
feet

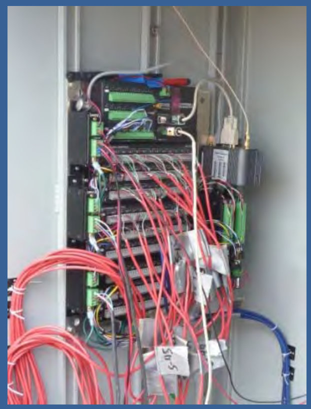

Sleeved Pile - VW gages
Distance from Pile Tip (ft)
90
80
70
60
50
40
30
20
10
0
-20
20
60
100
140
180
220

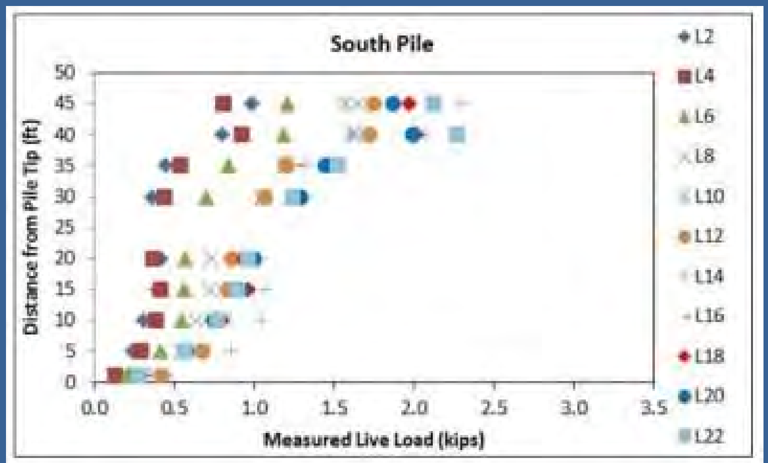

Displacement vs. time
0.5
0
-0.5
-1
-1.5
-2
-2.5
hrs

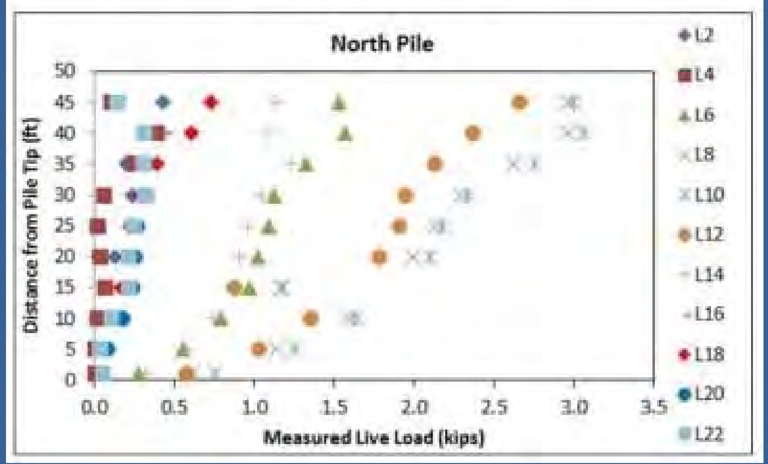
Dragload, Dead Load, Live Load







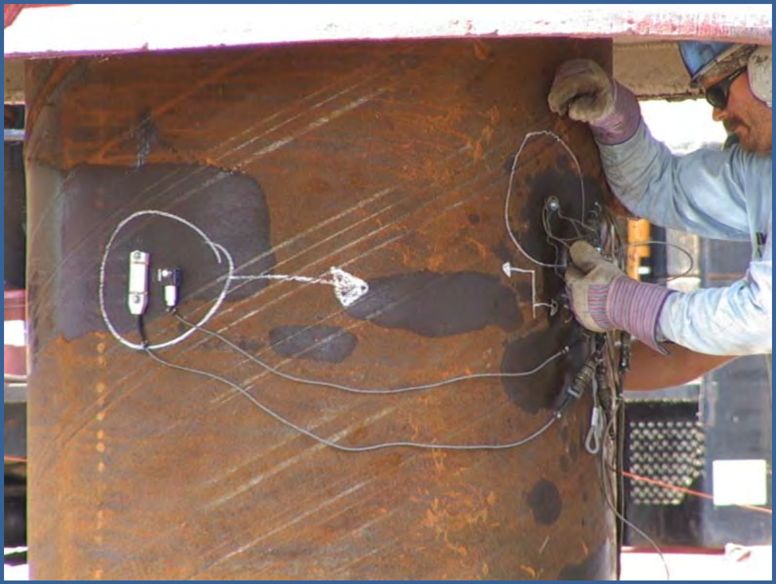




Pile Dragload/Downdrag

- New policy in development (2013)
  - Incorporates MnDOT performance monitoring
  - Strength limit
    - Pile structural capacity
  - Service limit
    - Pile head deflection
    - All cases except piles to rock
  - Performance Monitoring
- Mitigation strategies
  - Embankment preload/surcharge
  - Pile sleeves; coatings
  - Eliminate new load or design for additional load
  - Spread footings

Large Diameter Piles



Large Diameter Driven Piles

- Used for long span bridges
  - Wakota, Lafayette, Hastings
  - Dresbach, St. Croix
- Load tests (Statnamic)
- Driven open-ended
  - Filled with concrete
  - To bottom of seal or minimum 10’ below scour elevation
- If additional structural strength is required
  - Thicker wall
  - Additional reinforcing steel inside
    - Consider constructability

Spread Footings

- Now more common
  - Better prediction methods
    - SCPTu, DMT, PMT
  - Improved performance monitoring data
  - Cost effective
  - Similar deformations to adjacent embankments

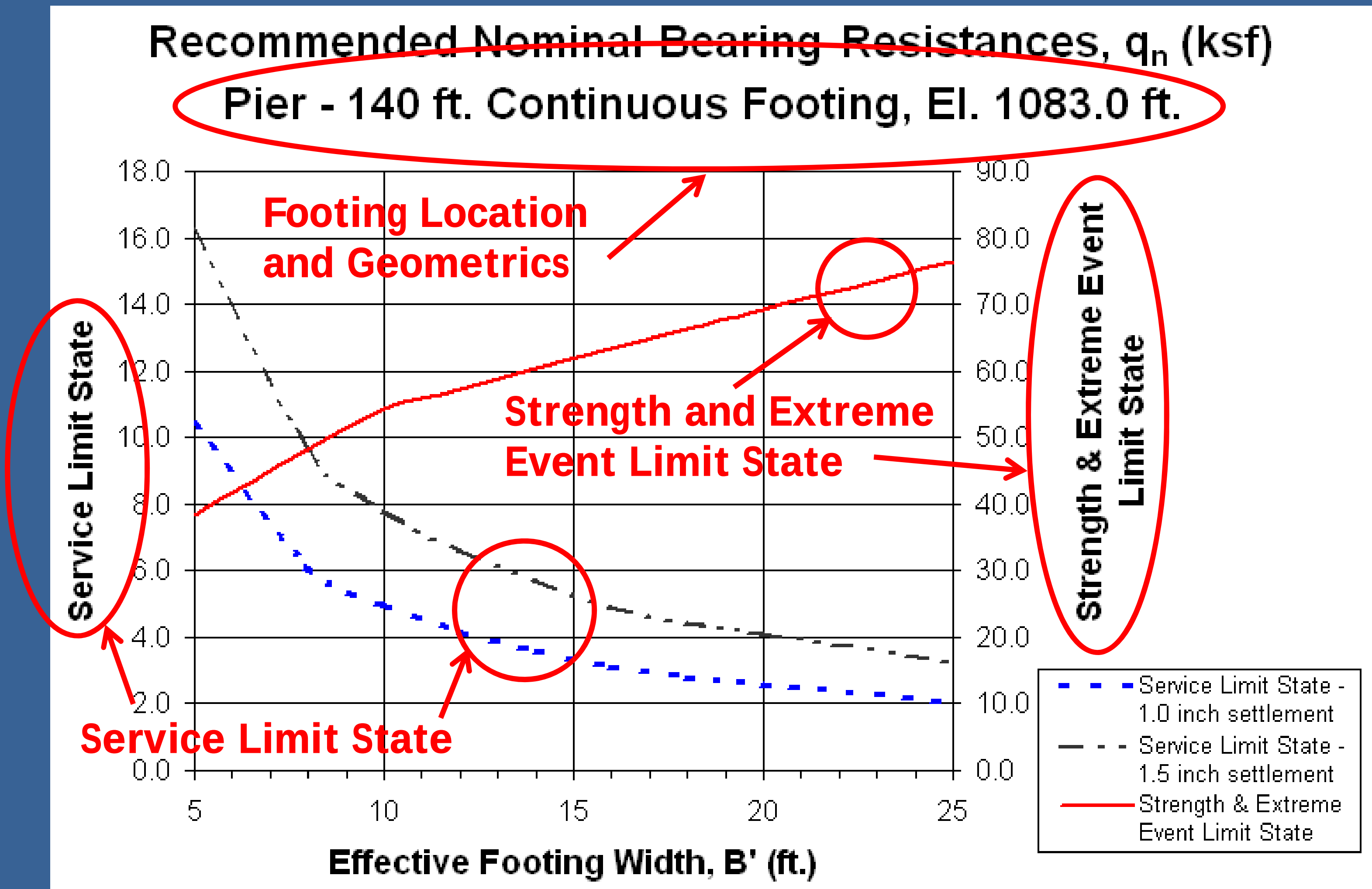
Spread Footing Monitoring

BRIDGE	Predicted Settlement			Actual Settlement*			Over - Prediction Of Settlement (Yes or No)
	N. Abut (inches)	Pier (inches)	S. Abut (inches)	N. ABUT (inches)	PIER (inches)	S. ABUT (inches)	
Pedestrian	2	1.5	2	< 0.25	< 0.25	< 0.25	YES
Hemlock Lane	1.5	1	1.5	< 0.25	< 0.25	< 0.25	YES
Zacahary Lane**	1.5	1.5	1.75	< 0.25	< 0.25	< 0.25	YES
Revere Lane	2	1.5	2	< 1	< 1	< 1	YES
Jefferson**	1.5	1.5	1.75	< 0.25	< 0.25	< 0.25	YES

**Settlement experienced by the beams and decks will be smaller than the indicated values; studies in the past have shown about 50% of settlement occurs before the beam and deck are set.*

***Construction of these brides is not complete and final settlement might be a little bit higher*

Nominal Bearing Resistance Graph



Foundation Recommendations Form

FOUNDATION AND OTHER RECOMMENDATIONS
Bridge Construction Unit

Report No. ______________ (1) Bridge No. ______________

Location ______________________________

Substructure Unit	Approx. Station	Estimated Bottom Elevation of Footing or Bent Cap	*Factored Spread Footing Bearing Resistance Φq_n (tsf)	Factored Pile Bearing Resistance, ΦR_n (tons)	Pile Type and Size			Estimated Pile Lengths		
					Other	Steel H	C.I.P. Concrete	Test Piles		Foundation Pile Length
								No.	Length	
(2)	(3)	(4)	(5)							

*Based on Foundation Engineer's Recommendations dated ______________ Scour Recommendations ______________

- ☐ Use special pay items for piling
- ☐ Use thick wall pipe pile option
- ☐ Use the following pile tip protection (6)
  - ☐ Pile points ____
  - ☐ Pile tip protection ______
- ☐ Use lump sum excavation item (except where rock excavation indicated)
- ☐ Excavation to be incidental (to 1A43 Concrete or other)
- ☐ Concrete seal required
- ☐ *Time delay recommended for approach embankment settlement:
  - ☐ ______ months
  - ☐ 72 Hrs.
  - ☐ None

Other Recommendations:

- ☐ Use special concrete placement procedures on deck pours (for skewed bridges, etc.)
- ☐ Paint color of exposed pile shells ______________

☐ Remarks (Basis for above determinations):

- 1. Basic project info
- 2. Substructure unit
- 3. Approximate station
- 4. Estimated Bottom footing elevation
- 5. Factored bearing resistance, ϕq_n
- 6. Additional info and remarks

Date preliminary received by reviewer __________ Reviewed by ______________ Concurred by ____________ Date ______

cc: Foundations Engineer, Preliminary Plans Engineer (3 copies), & Program Clerk

11/1/06
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MINNESOTA DEPARTMENT OF TRANSPORTATION

Nominal Bearing Resistance, q_n

- Foundation report will provide the nominal bearing resistance, q_n
  - On rock, q_n for all footing widths
  - On soil, q_n is plotted graphically q_n vs. $B_{(effective)}$
- Foundation report provides q_n based on
  - Bearing failure – strength limit state
  - Tolerable settlement criteria – service limit state
    - 1" max currently used in most cases by Mn/DOT for soil
    - Higher deflections may be permitted with monitoring
    - Footings on rock assumed to satisfy service limit state

GRS-IBS Abutments

- Geosynthetic Reinforced Soil Integrated Bridge System
- MnDOT/FHWA: Rock County project

GRS Approach

This GRS-IBS bridge took ten days to build, start to finish. Shown is phase 1 of construction.

Not approved for use at this time- specification, erosion potential, and approved material considerations (among others) are unresolved.

Reports and Recommendations

- State Projects
  - Foundation Investigation Report
  - Bridge Construction Foundation Recommendation

Minnesota Department of Transportation
MEMO
Office of Materials & Road Research
Geotechnical Engineering Section
Mailstop 645
1400 Gervais Avenue
Maplewood, MN 55109

Date: April 12, 2011

To: Nancy Daubenberger, State Bridge Engineer
Office of Bridges & Structures

From: Karl Johnson, Graduate Engineer
Geotechnical Engineering Section

Concur: Derrick Dasenbrock, Foundations Geomechanics Engineer
Geotechnical Engineering Section

Concur: Gary Person, Foundations Engineer
Geotechnical Engineering Section

Subject: S.P. 1002-89 Bridge 10003 (Replacing 6654)
T.H. 5 (Arboretum Blvd.) over Lake Minnetonka LRT Regional Trail
Located 4.0 miles west of junction T.H. 41 in Victoria
Foundation Investigation and Recommendations and
Recommendation for Static Load Testing at this Site

Project Description

This report provides the Foundation Investigation and Recommendations for constructing Bridge 10003, replacing in-place Bridge 6654 spanning over Lake Minnetonka LRT Regional Trail. The new structure will be approximately 139 feet long with a width of 47 feet 4 inches and will be comprised of MN45 prestressed concrete beams supported by parapet type abutments at a 42 degree skew. Please refer to the attached boring plan for more details on the proposed bridge layout. There may be some additional embankment fill placed to accommodate a raise in grade along the roadway approaches. If additional details related to slope design are necessary, these will be described in a separate report.

Field Investigation and Foundation Conditions

Five Cone Penetration Test (CPT) soundings were taken in the area of the bridge to characterize the soil. The CPT soundings were taken in August 2010 and March of 2011 by the Mn/DOT foundations unit. Four additional CPT soundings were taken below the bridge on the Lake Minnetonka LRT Regional Trail in February 2011. Lastly, Standard Penetration Test (SPT) boring was advanced below the bridge in March 2011. Copies of these soundings and boring are included with this report.

FOUNDATION AND OTHER RECOMMENDATIONS
Bridge Construction Unit

Report No. 1680 Bridge No. 73037

Location TH 23 SB over N. Fork Crow River, 0.3 mi. S. of Jct. TH 23 & TH 55

Substructure Unit	Approx. Station	Estimated Bottom Elevation of Footing or Bent Cap	*Factored Spread Footing Bearing Resistance Φq_n (tsf)	Factored Pile Bearing Resistance, ΦR_n (tons)	Pile Type and Size: Other	Pile Type and Size: Steel H	Pile Type and Size: C.I.P. Concrete	Estimated Pile Lengths: Test Piles No.	Estimated Pile Lengths: Test Piles Length	Estimated Pile Lengths: Foundation Pile Length
South Abut.	180+70	1154.0		100 t			12"	2	40'	30'
Pier 1	181+91	1162.0		135 t			16"	2	50'	40'
Pier 2	183+14	1163.0		135 t			16"	2	50'	40'
North Abut.	184+34	1154.0		100 t			12"	2	35'	25'

*Based on Foundation Engineer's Recommendations dated 7-14-08 Scour Recommendations 6-13-07

___ Use special pay items for piling
___ Use thick wall pipe pile option
___ Use the following pile tip protection
___ Pile points ________
___ Pile tip protection ____________
X Use lump sum excavation item (except where rock excavation indicated)
___ Excavation to be incidental (to 1A43 Concrete or other)
___ Concrete seal required
X *Time delay recommended for approach embankment settlement:
___ ________ months
X 72 Hrs.- North Abutment
X None - South Abutment

Other Recommendations:
X Use special concrete placement procedures on deck pours (for skewed bridges, etc.)
X Paint color of exposed pile shells Aluminum

X Remarks (Basis for above determinations):

Specify that the pier piling be driven to a minimum penetration of tip elevation 1130. (Preliminary estimated scour elevation is 1145.4. If a final analysis for scour is significantly deeper, the minimum pile tip elevation may be revised).

Do not required PDA (Pile Analysis) in the special provisions.

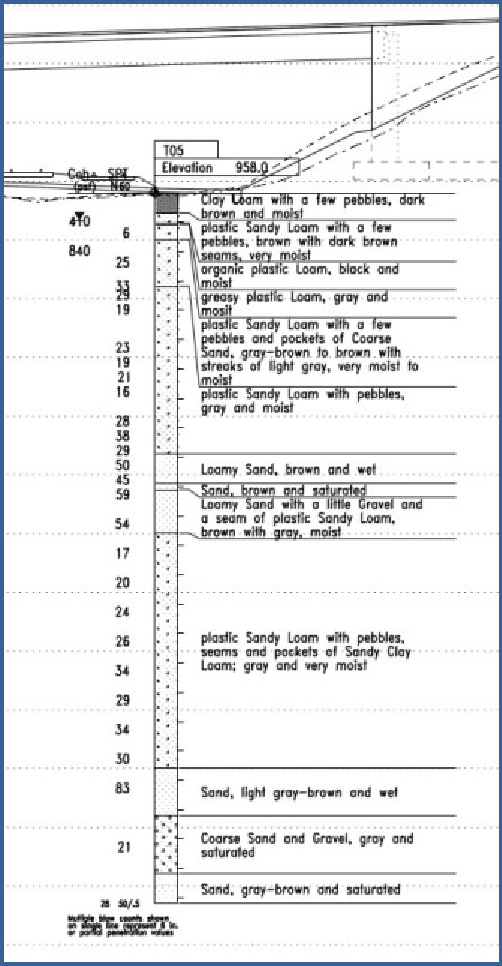
72 hour time delay for settlement of embankment is only at North Abutment.

Date preliminary received by reviewer 1-29-09 Reviewed by B.A. Iwen Concurred by [signature] Date 2/5/09

cc: Foundations Engineer, Preliminary Plans Engineer (3 copies), & Program Clerk

Reports and Recommendations

- CSAH Projects
  – Geotechnical Consultant Report
  – Bridge Design Consultant
- Report should address:
  – Foundation type (Strength)
    - shallow, piles, shafts, etc.
  – Construction control choice
    - Dynamic formula, PDA/CAPWAP, SLT
    - Project value (strata, damage, cost)
  – Settlement (Service)
    - Waiting periods/settlement plates/instrumentation
  – Scour, downdrag/dragload
  – Stability (where appropriate)
  – Other considerations- utility conflicts, erosion



Performance Monitoring

- Instrumentation: (during construction/service)
  - Piezometers
  - Inclinometers/ShapeAccelArrays (SAA)
    - (horizontal/vertical/angle)
  - Settlement plates, settlement cells
  - Strain gages/earth pressure cells/tiltmeters
  - Survey targets/prisms

Questions?

- Construction Control
  - Driven Piles
- SLT LRFD Calibration- MnPile
- Dragload/Downdrag
- Large Diameter Piles
- Shallow and GRS Foundations
- Reports/Recommendations
- Performance Monitoring
  - Instrumentation

Thanks for your participation.

Wall Selection, Design and Details

Paul Pilarski
Senior Engineer

Outline

- Foundation Analysis and Design Recommendation (FADR)
- Wall Types
- Wall Design Process, Plan and Spec Requirements
- Contacts and References

FADR

- Foundation Analysis and Design Recommendation (FADR)
- Design parameters
- Address global stability
- Document ground water level
- Required for:
  - Proper wall selection
  - Excavation requirements
  - Drainage design
  - Long term performance

FADR

- Service bearing and settlement estimates
- Strength bearing
- Foundation preparation requirements
- Pile type, estimated pile tip elevation and length, pile setup
- Embedment of cantilevered walls
- Verify soils are consistent with assumptions in Standards

Wall Types

- CIP Cantilever (and Counterfort)
- MSE
  - Thin panel
  - Blocks
- Gravity Blocks
- Specialty Walls
  - Sheetpile
  - Anchored
- Noise walls

Common Retaining Wall Types

- Cast In Place Concrete (CIP)
- MSE Walls
  - MSE walls with thin precast panels (5” to 6” structural thickness panels)
  - Prefabricated Modular Block Walls, wet cast “Big Blocks” with soil reinforcement (PMBW)
  - Modular Block Walls, dry cast “small blocks” (MBW) with soil reinforcement
- Gravity Walls
  - Prefabricated Modular Block Walls wet cast “Big Blocks” without soil reinforcement (PMBGW)
  - Modular Block Walls, dry cast “small blocks” (MBW) without soil reinforcement

Proprietary & Prequalified

Cantilevered CIP walls

5 - 30ft

Benefits:

- **Aesthetics**
- **Durability**
- **Less Backfill**

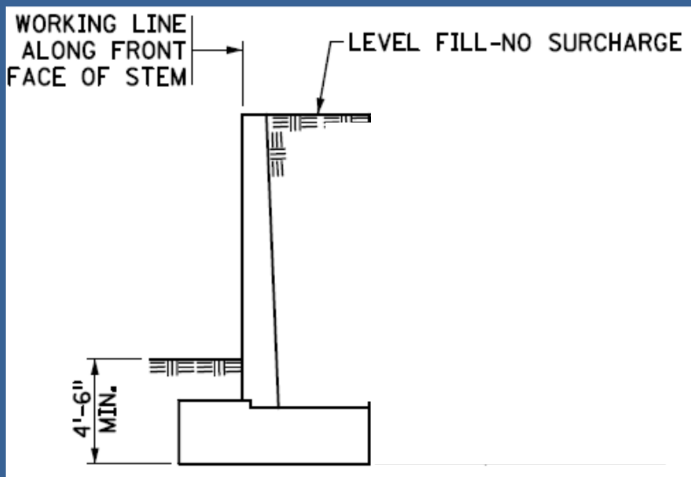
Limitations:

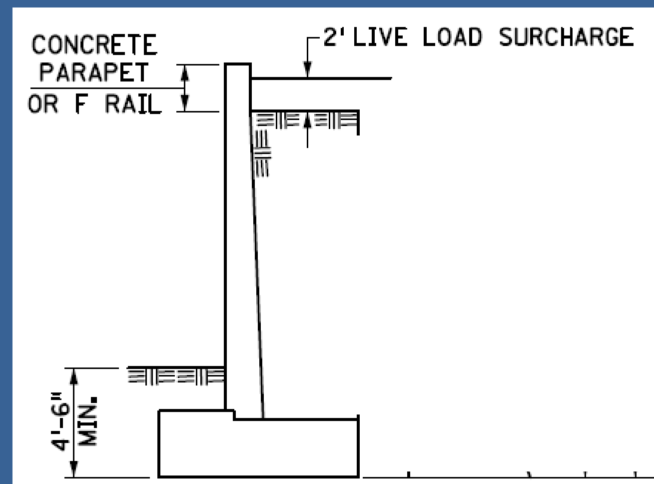
- **Piles or large subcut may be required**
- **Relatively long construction time**

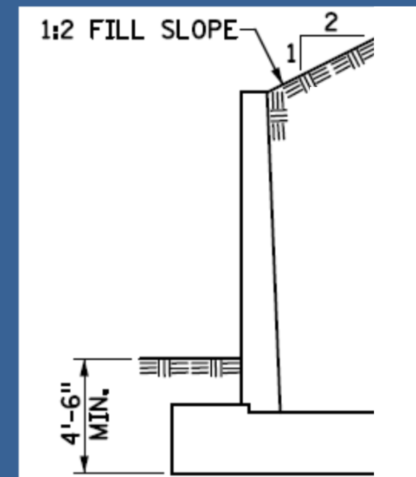
Economical in:

- **Moderate cuts**
- **Fills**

Cantilevered Wall CIP Standards







Not applicable when:

- **High water or non-drained backfills**
- **Other wall types more cost effective**

Cantilever Retaining Wall Standards

- Updated, LRFD standards are being developed
- Eliminating standards for walls supported on timber piles
- Using only 100 ton (CIP and H-Pile) piles
- New standards:
  - Use fewer shear keys for sliding resistance
  - TL-4 barriers
  - Address construction tolerances
  - Refined stem reinforcement

Cantilever Retaining Wall Standards

- Level fill tolerance to 1V:6H backfill slope
- Pile layout guidance
- Spread footings - Service and Strength bearing pressure and effective width given:

UNIFORM PRESSURE DISTRIBUTION						TRAPEZOIDAL PRESSURE DISTRIBUTION		STEM HEIGHT
SERVICE		STRENGTH 1a		STRENGTH 1b		* STRENGTH		
EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	TOE PRESSURE KSF	HEEL PRESSURE KSF	h
7'-10 7/8"	1.103	8'-7/8"	0.910	7'-9 5/8"	1.532	1.062	1.751	**5**
3'-1/2"	1.452	2'-5/8"	2.125	2'-7 7/8"	2.166	2.888	0.000	**6**
3'-4 7/8"	1.505	2'-3 1/8"	2.256	2'-11 1/2"	2.260	3.014	0.000	**7**
3'-8 3/4"	1.683	2'-6 1/4"	2.487	3'-3 1/4"	2.509	3.346	0.000	**8**
3'-11 3/4"	1.953	2'-9 1/4"	2.829	3'-6 5/8"	2.886	3.848	0.000	**9**
4'-4 5/8"	2.083	3'-1 1/4"	2.979	3'-11 1/4"	3.064	4.086	0.000	**10**

Counterfort Retaining Walls

40 - 60ft Fills

Benefits:

- Aesthetics
- Durability
- Less Backfill

Limitations:

- Costly
- More forming and pours
- Piles or large subcut
- may be required
- Relatively long construction time

MSE Thin Panel Walls

10 - 50 ft

(Fill situations)

Benefits:

- Rapid construction
- Relatively low skill labor
- Facing flexibility
- Can accommodate some settlement

Source: Crosstown Project

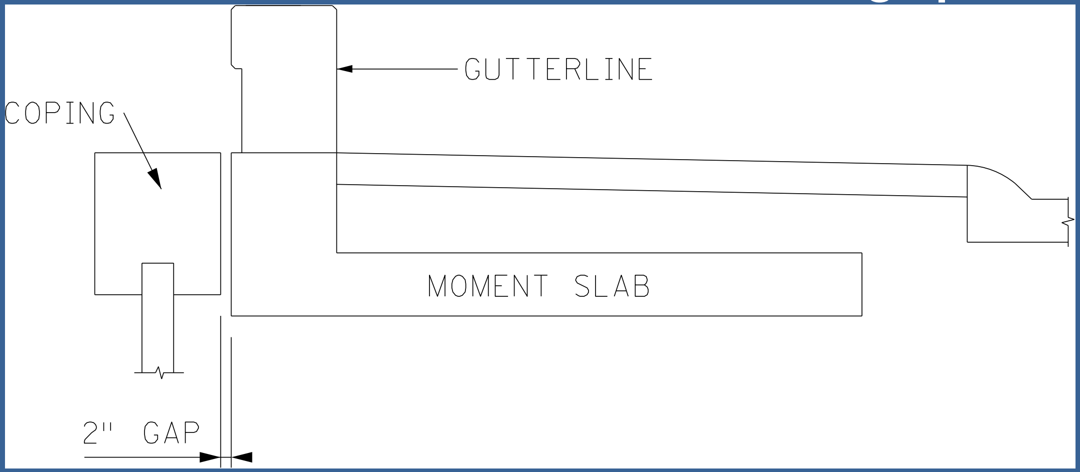
MSE Thin Panel Wall Limitations

- Water table
- Utility restrictions
- Settlement control
- Large amount select backfill
- Construction season limited
- Corrosion in aggressive environments

Source: TH 169

Additional MSE Considerations

- Barrier cannot contact panel
- Provide 2" min. movement gap



- Details of traffic barriers, moment slabs, coping, fencing and drainage
- Leveling pad at proper depth
- No planting above wall
- No excavation near/into wall

Reinforced Soil Walls

Acute Corner Angles >70 deg.

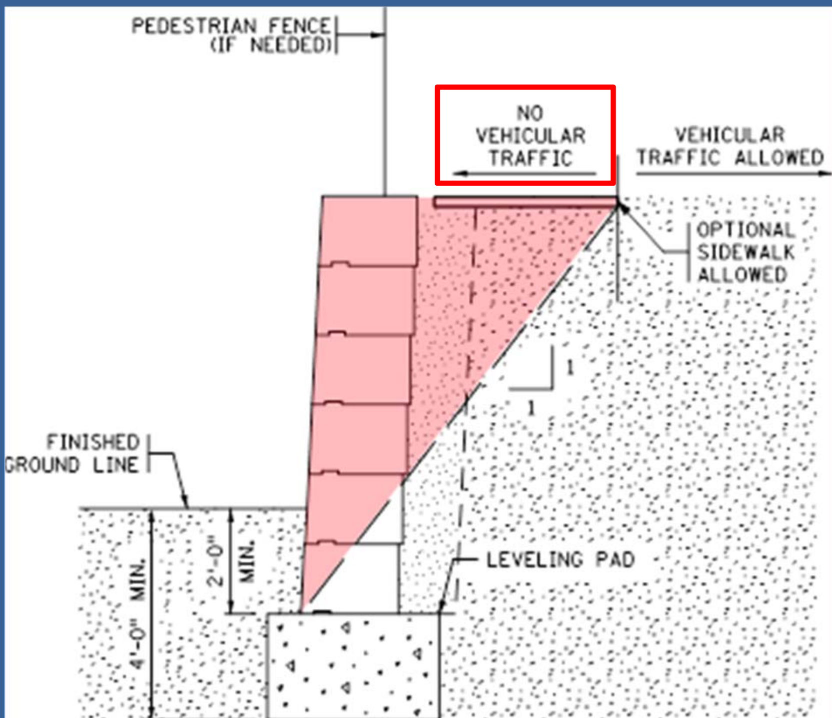
Source: Monticello I-94 Project 07-2010

PMBW and PMBGW

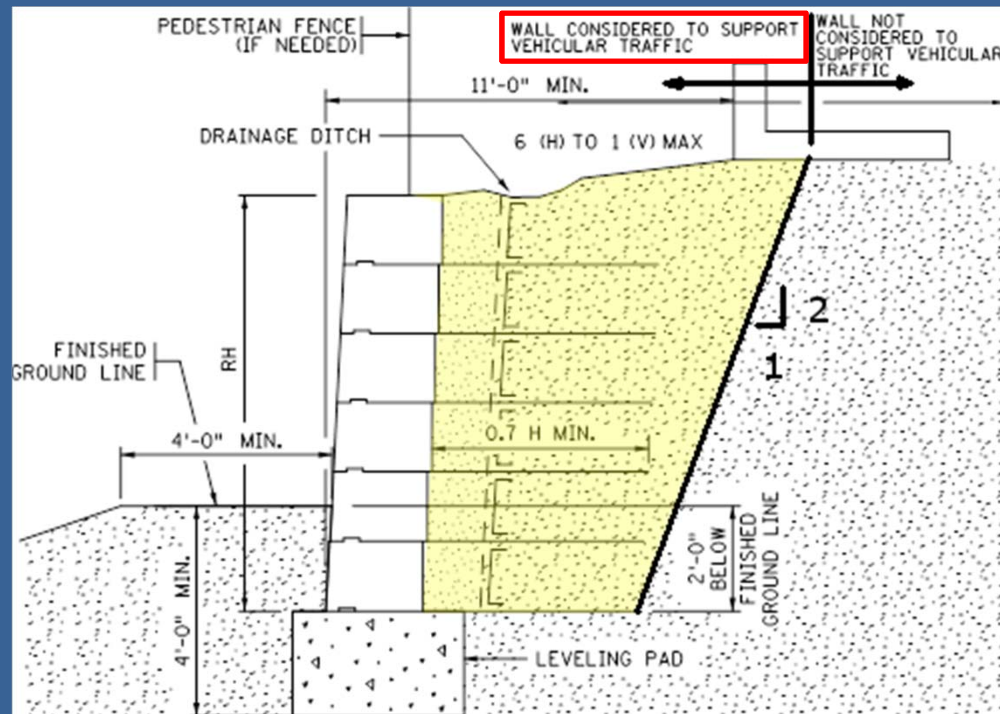
Up to 16" high,
48" wide,
60" deep

Approved Suppliers:
http://www.dot.state.mn.us/products/walls/PMBW.pdf

PMBW and PMBGW



PMBGW



PMBW
(Also applies to MSE with
Thin Panel Face)

Prefabricated Modular Block Walls PMBW and PMBGW

Up to 18 ft general range – limitations for roadway

- Adaptable to site conditions
- Can resist high horizontal pressures

Limitations:

- Soil reinforcement requires permanent easement or ROW
- Settlement ≤ 1/200

Modular Block Walls (MBW)

- Modular Block Gravity Wall aka "small block" aka "Segmental Concrete Masonry Units"
  - Reinforced $\leq$ 12-ft tall, 10-ft exposed
  - Unreinforced (Gravity only) not permitted to support roadway
  - Termed "MBW" when soil reinforcement added

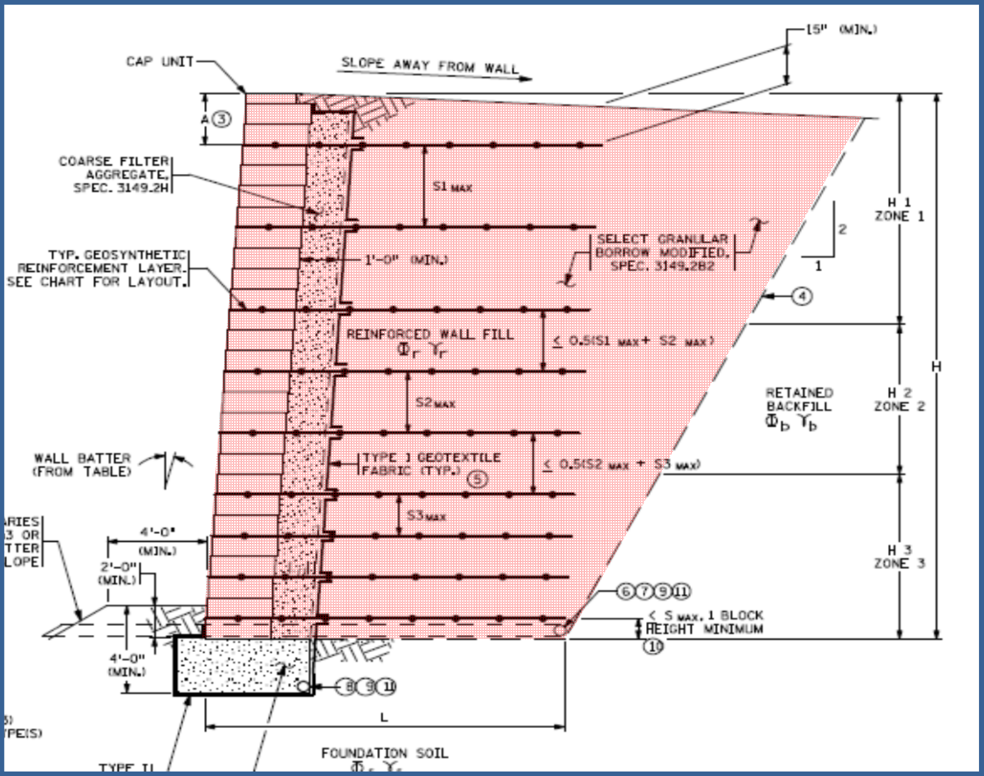
Dry Cast Modular Block Walls (MBW) with Earth Reinforcement

Keystone Retaining Wall Block

Width 18”
Depth 18”
Height 8”

Dry Cast Modular Block Walls (MBW) with Earth Reinforcement

- Standard plans 5-297.640, 641, 643, 644, 645
- MnDOT has experienced freeze-thaw durability issues with these block- See tech memo 08-06-MRR-01
- Gutter ≥ 0.5 H: 1 V from the back of the reinforcement (Tech memo 08-11-MRR-02)



Block Walls

Block type	Suppliers	Soil Reinf.?	Max Wall Height	Support Rdwy
MBW = small block (often dry cast)	Keystone, Anchor Block, Versa-Lok	No	Limited by design	No
		Yes	12' from top of leveling pad	No
PMBW = large block (wet cast)	Oldcastle Recon Redi-Rock Maccaferri London Boulder	No	Up to 8'	No
		Yes	See Pre-qualified notes for height limitations – up to 18-ft	Requires approved barrier details

Cantilevered Sheet Pile Walls

- Usually for temporary situations
- Low aesthetics
- Potential movement

Anchored Walls

15 - 65ft Cuts

Benefits:

- Adaptable to site conditions
- Can resist high horizontal pressures

Limitations:

- Skilled labor required
- Anchors require permanent easement or ROW

Noise Walls

- Timber noise wall standards
- Approved treatments
- New AASHTO Sound Barrier Specifications
  - Wind
  - Crash Requirements
- Design for Strength III
- Supporting Structures consider Strength III and Strength V

Wall Selection

Wall Design Process

- Road profile
- Prelim wall selection
  - Cut or fill
  - Retained height
  - Economy
  - Settlement
  - Utility & ROW
  - Aesthetics
- Contact Foundation Office or hire geotech

Wall Design Process

- Preliminary wall type selected
- Geotech performs site investigation (FADR)
- Wall designer reviews FADR or Geotechnical Report
- Confirm wall choice
- Design wall and/or Prepare Bid Documentation
- Structural review
- Review foundation preparation notes and spec

Wall Plan and Spec Information

- Wall height and plan geometry
- Top of wall profile
- Plan and cross section views showing:
  - ROW
  - Easement limits
  - Utilities
- Slopes
- Aesthetics
- Construction staging requirements
- Soil conditions with ground water
- Design criteria and loading conditions

Nonstandard or Proprietary Walls

- List of acceptable wall types and systems for each wall
- Consult with Bridge Architect i.e. Dave Hall for architectural considerations
- Any special structures on wall i.e. large signs, noise wall, lighting- these can affect resistance in the design
- Planning for fencing on wall – document completely in the design, or install sleeves during construction

Resource Links

- MnDOT LRFD Manual
- MnDOT Road Design Manual:
  - http://roaddesign.dot.state.mn.us/roaddesign.aspx
- Roadway Design Scene:
  - http://www.dot.state.mn.us/pre-letting/scene/index.html
- Standard Retaining Wall Presentation:
  - http://www.dot.state.mn.us/metro/finaldesign/sampleplan.html
- Standard Plans
  - http://standardplans.dot.state.mn.us/
- Materials and Road Research Tech Memos
  - Tech memo 08-06-MRR-01 "Use of Mechanically Stabilized Earth (MSE) Walls with a Segmental Precast Concrete Panel Facing"
  - Tech memo 08-11-MRR-02 "Use of Dry-Cast Segmental Masonry Retaining Wall Units"
- Approved Products:
  - http://www.dot.state.mn.us/products/walls/

Contact Information

- Khalid Obeidat, P.E. – Structural Wall Engineer
  651-366-4485 khalid.obeidat@state.mn.us
- Joe Nietfeld, P.E. – Bridge Standards
  651-366-4477 joe.nietfeld@state.mn.us
- Paul Rowekamp, P.E. - Bridge Standards Engineer
  651-366-4484 paul.rowekamp@state.mn.us

Abutments

Karl Johnson
Bridge Designer

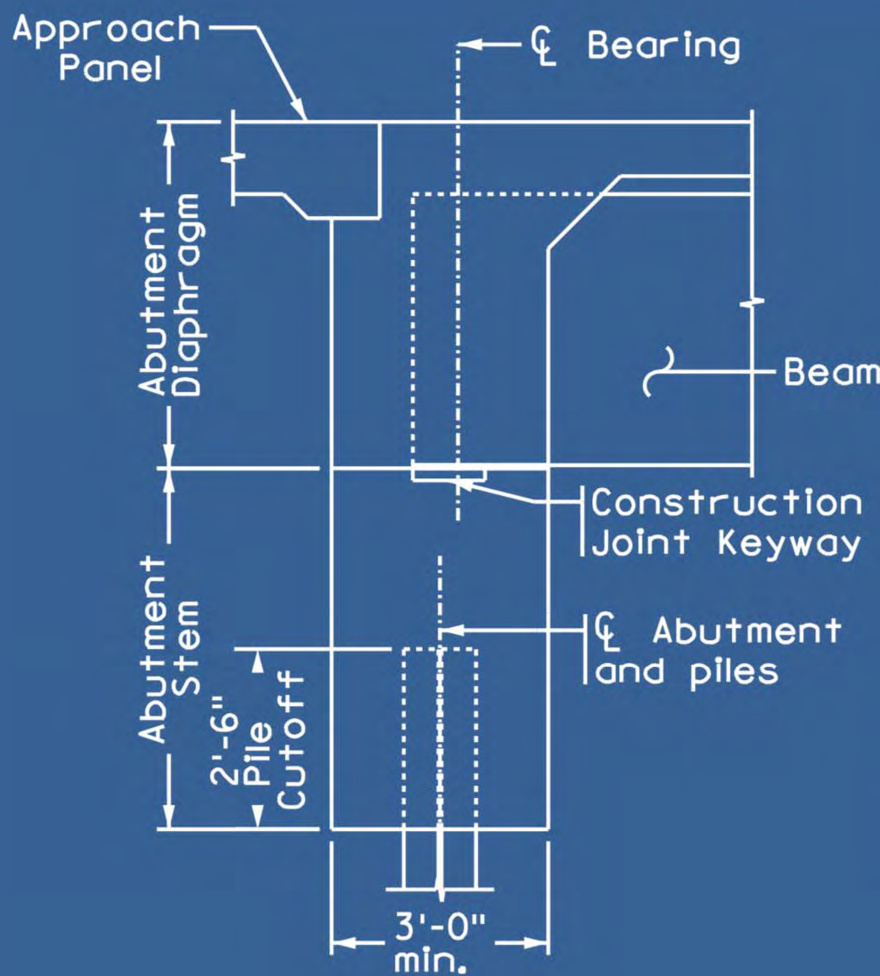
Overview

- Abutment description/selection
  – Integral
  – Semi-integral
  – Parapet
- Abutment design
- Wingwall design
- Barrier location
- End posts

Abutment selection

- Factors contributing to abutment selection
  - Bridge length
  - Bridge skew
  - Horizontal curves
  - Wingwall length
  - Presence of retaining wall which ties into wingwall
  - Front face abutment exposure
  - Beam depth/superstructure type
  - Desired joint location

Selection/description: Integral

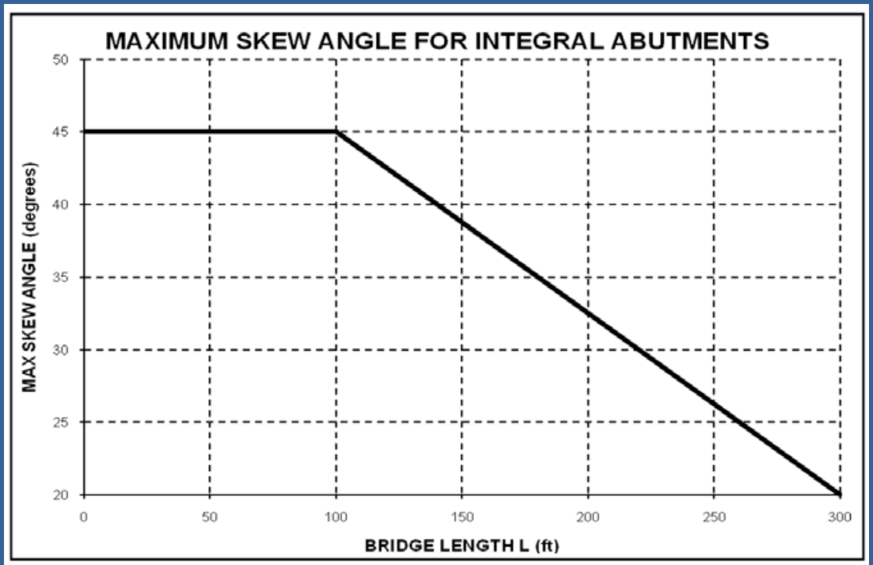


Selection: Integral

- Advantages
  - More cost effective
  - Simplified design
  - Jointless bridge
- Disadvantages
  - Geometric and load restrictions
  - Must be placed on piling

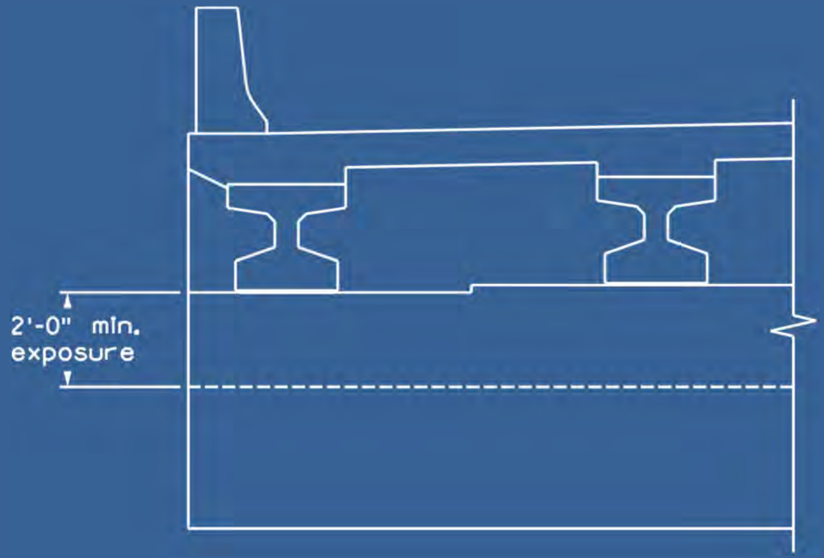
Integral abutment restrictions

- Length restrictions
  - Bridges under 300 ft long can have up to a 20 degree skew
  - Bridges under 100 ft long can have up to a 45 degree skew
  - Bridges between 100 and 300 ft can have skew up to: [45 degrees -0.125*(L-100)]

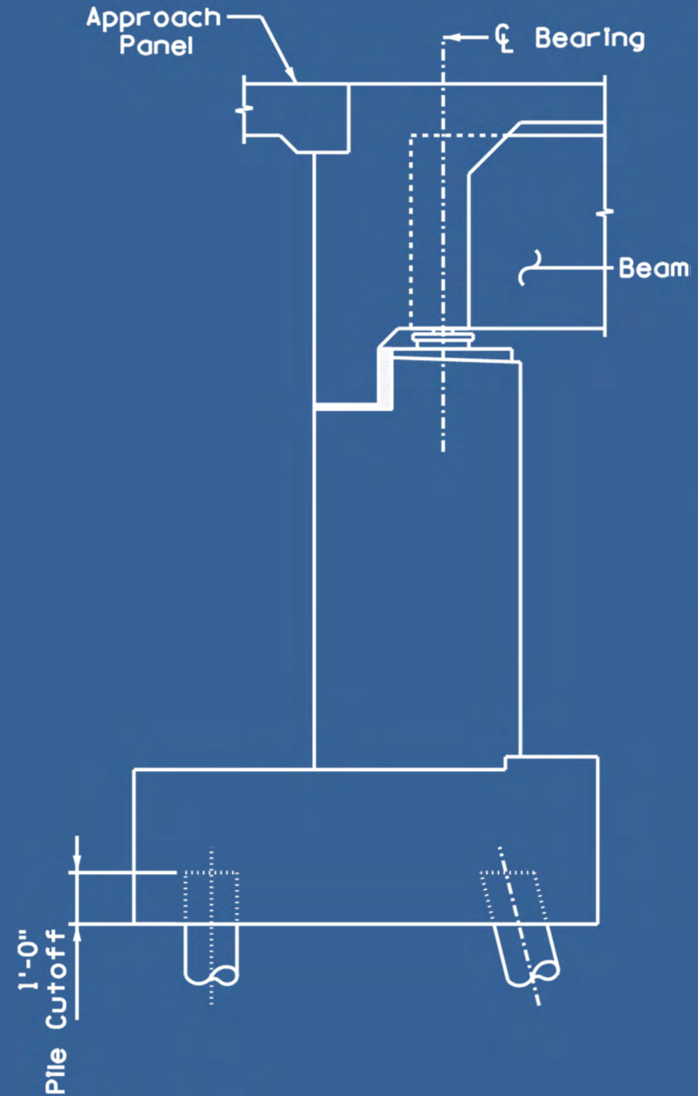


Integral abutment restrictions

- Requires a straight horizontal alignment (Slight curvature can be allowed on a case-by-case basis)
- Length of wingwall cantilevers are ≤ 14 ft
- Wingwalls do not tie into roadway retaining walls
- Minimum front face exposure should be set at 2'-0"
- Depth of beams must be ≤ 72 inches



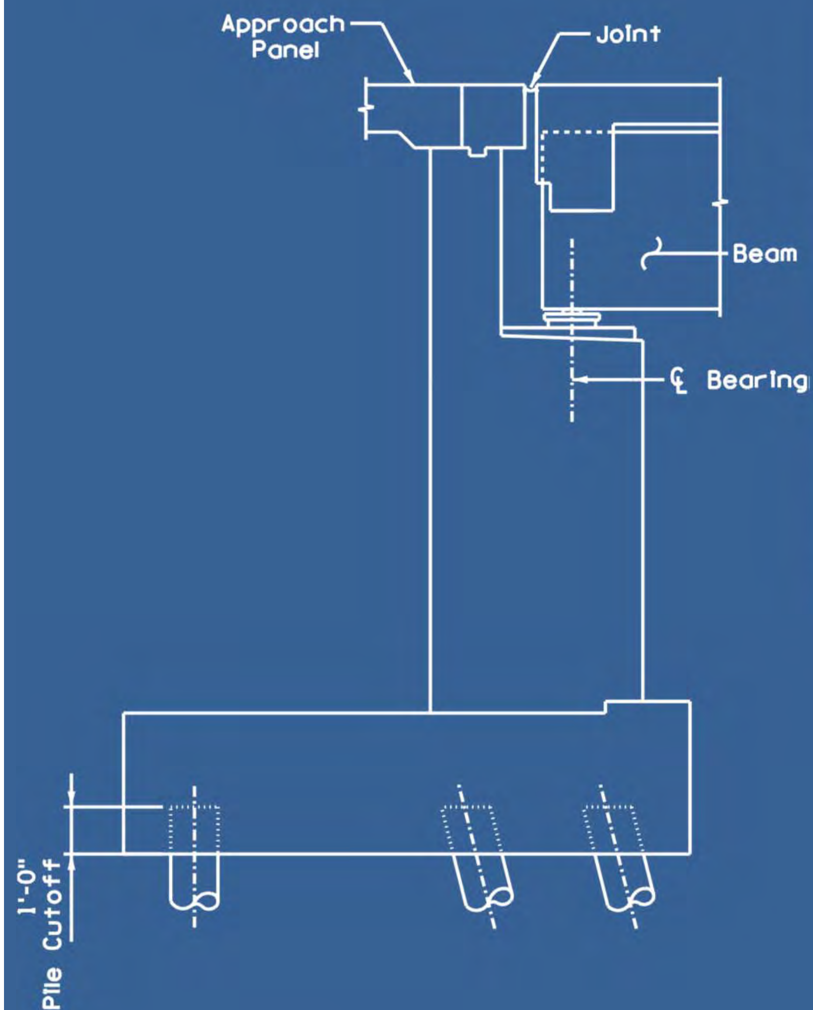
Selection/description: Semi-integral



Selection: Semi-integral

- Advantages
  - Can be placed on piling or spread footings
  - Some (not all) restrictions from integral abutments can be neglected
    - No wingwall length limit
    - No front face exposure height limit
    - No superstructure depth limit
  - Jointless Bridge
- Disadvantages
  - More complicated design in comparison to integral abutments
  - Must still meet all bridge length, skew, and horizontal alignment criteria from integral abutments

Selection/description: Parapet



Selection: Parapet

- Advantages
  - Works for wide variety of applications
  - No more length or curvature restrictions
- Disadvantages
  - Expansion joints are on the bridge over the bearings
    - Creates higher maintenance costs

Design: Integral

- Piles are designed for axial load only
- Follow the "Integral Abutment Reinforcement Design Guide" found in Chapter 11 of the MnDOT LRFD Bridge Design Manual
- Additional requirements for using the "Integral Abutment Reinforcement Design Guide"
  - Beam spacing ≤ 13'-0"
  - Pile spacing ≤ 11'-0"
  - Pile capacity $\phi R_n \leq 165$ tons
  - Max abutment stem height ≤ 7'-0"
  - Deck thickness plus stool height ≤ 15.5"

Design: Integral

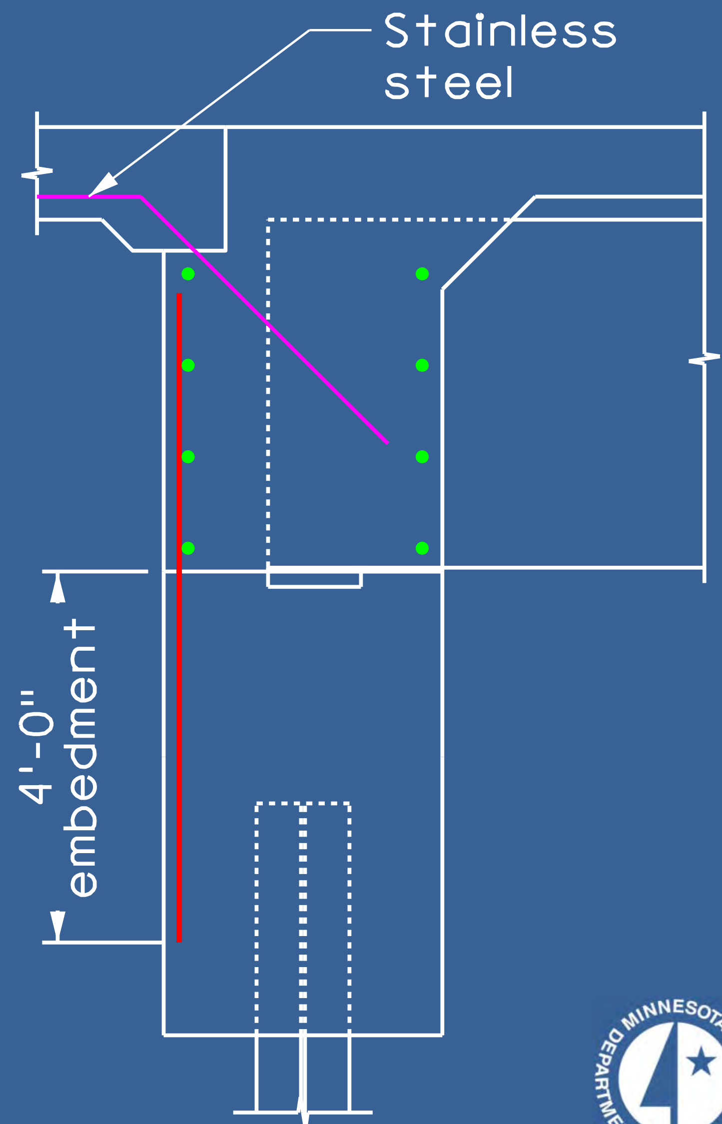
Table 11.1.1.1 Abutment Stem Vertical Dowels (A_04E) Minimum Required Bar Size and Length

Beam Size (in)	Bar Size & Max Spacing	Bar Length
14	#16 @ 12"	*
18	#19 @ 12"	*
22	#19 @ 12"	*
27	#19 @ 12"	5'-6"
36	#22 @ 12"	6'-3"
45	#22 @ 12"	7'-0"
54	#19 @ 6"	7'-6"
63	#19 @ 6"	7'-6"
72	#19 @ 6"	7'-6"

* Hook bar around uppermost B.F. horizontal bar in diaphragm

Table 11.1.1.2 Abutment Diaphragm Horizontal Bars (S1902E & S1903E) Minimum Required Number of #19 Bars, Each Face

Beam Size (in)	Beam Spacing (ft)				
	≤ 9	10	11	12	13
14	2	2	2	2	2
18	2	2	2	2	2
22	2	2	2	2	2
27	3	3	3	3	3
36	3	3	3	3	4
45	4	4	4	4	5
54	5	5	5	5	6
63	6	6	6	7	7
72	7	7	7	8	9



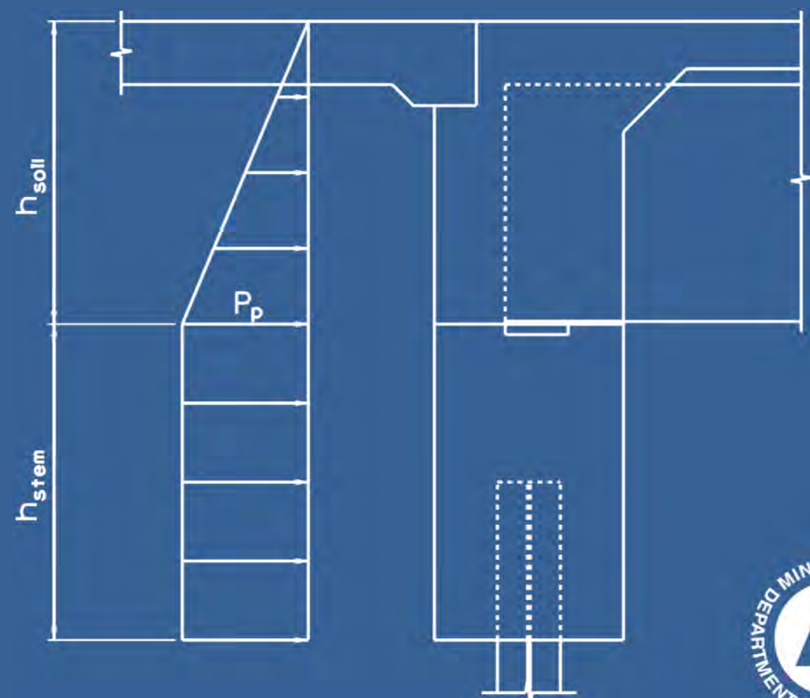
Design: Integral

- Can also perform specific design for abutments that do not meet “Integral Abutment Reinforcement Design Guide”
  - Use passive soil pressure that develops when bridge expands for special design
  - Back face dowels

$$\left(\frac{\qquad}{\qquad}\right)$$

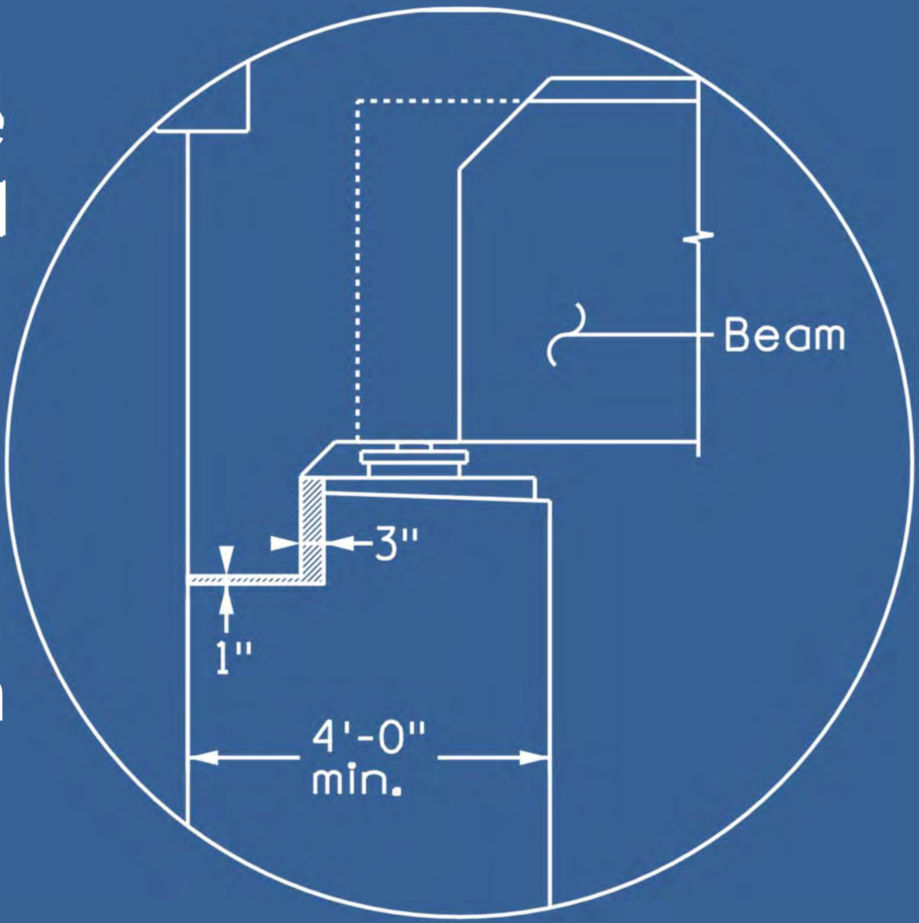
  - Diaphragm horizontals

$$\left(\frac{\quad}{\quad}\right)$$



Design: Semi-integral

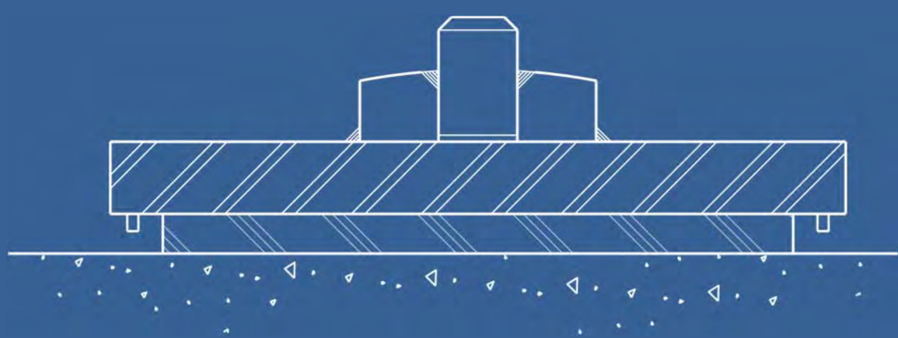
- Skews greater than 30 degrees require a guide lug to reduce unwanted lateral movement
- Minimum stem thickness of 4’-0”
- Provide a 3” minimum horizontal gap between the diaphragm lug and the stem



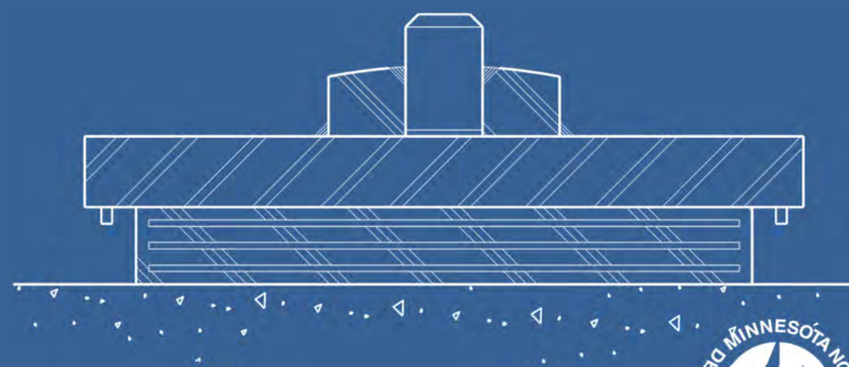
Design: Semi-integral

- Use pedestals and sloped bridge seat
- Requires a detailed bearing design in contrast to ½” elastomeric pad for integral abutments
  - Typically a curved plate bearing assembly is used

Fixed



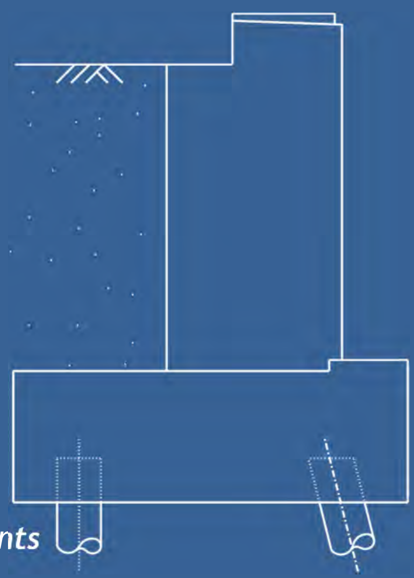
Expansion



Design: Semi-integral

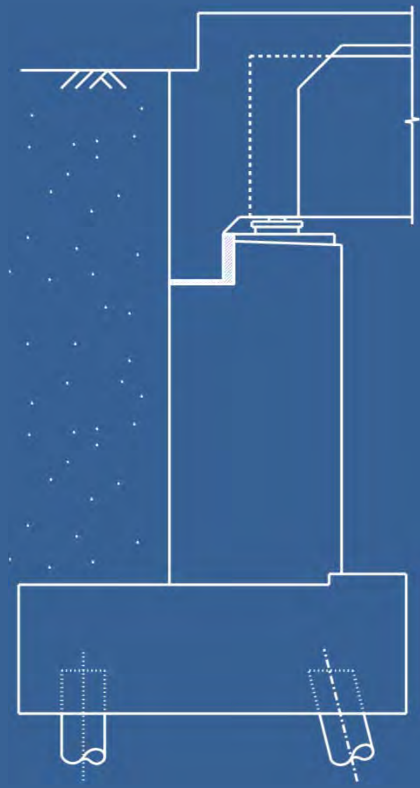
Construction Case 1A

- Stem has been constructed and backfilled but superstructure is not in place



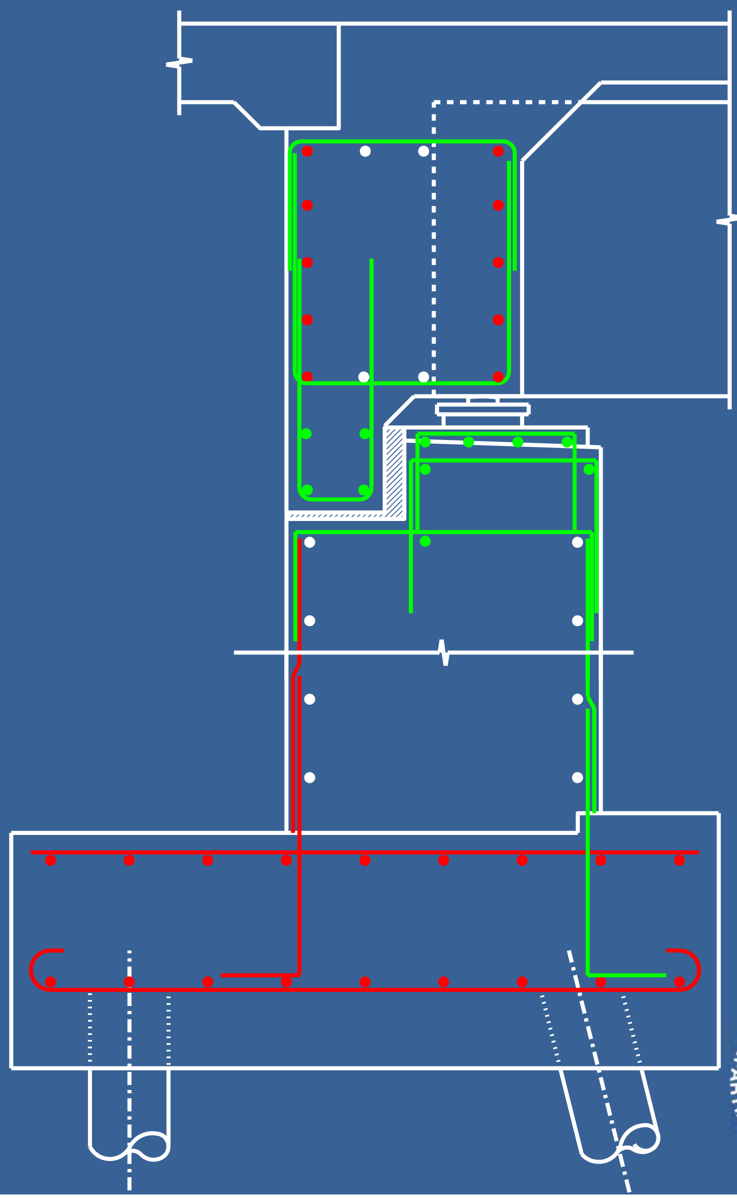
Construction Case 1B

- Abutment stem and superstructure have been constructed and backfilled



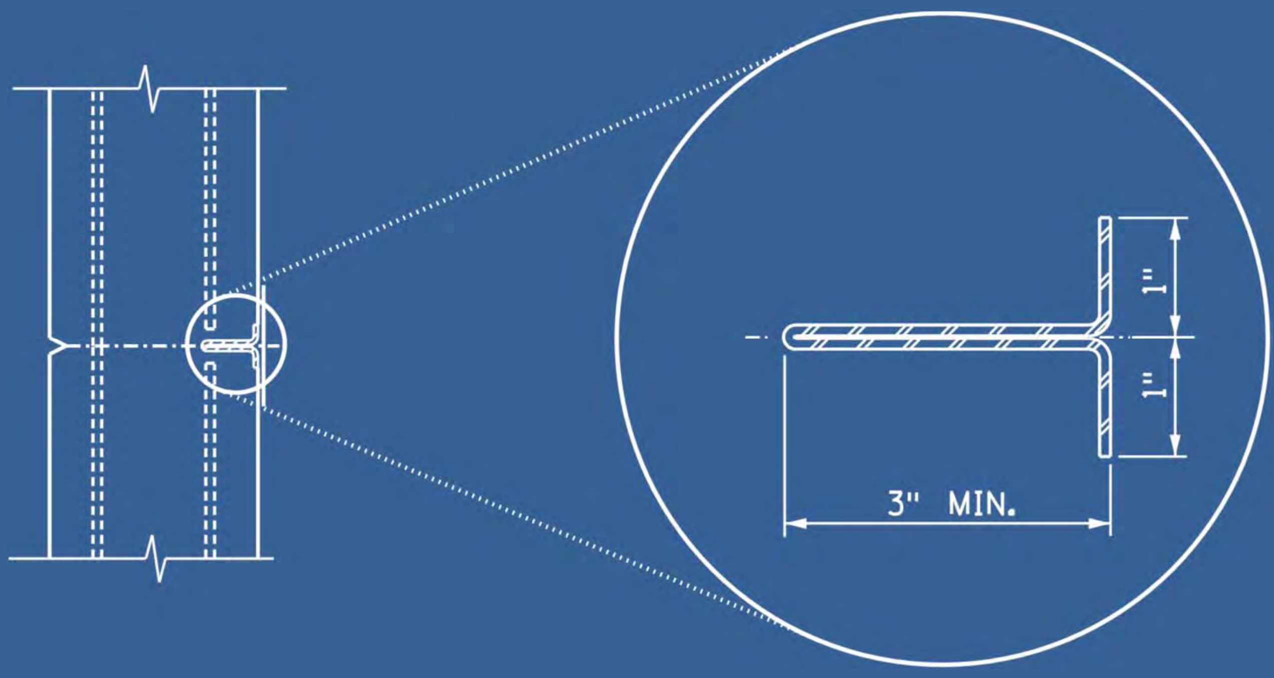
Design: Semi-integral

- Designed bars
  - Diaphragm horizontal
  - Back face vertical stem
  - Footing
- Standard bars
  - Front face stem
  - Diaphragm lug stirrup and horizontal



Design: Parapet

- Low parapet abutment
  - Total height (including footing) ≤ 15 feet
  - Use a contraction joint every 32 feet
  - Typical abutment has standard reinforcement bars found in the MnDOT manual

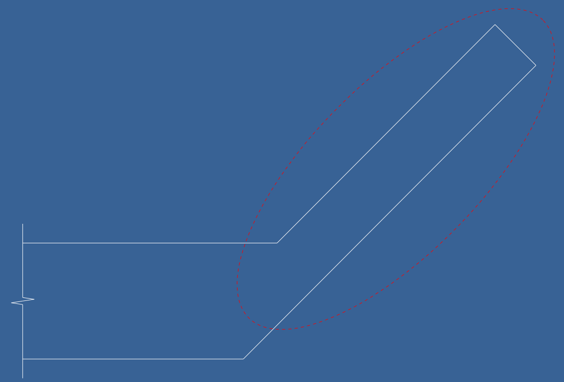


Design: Parapet

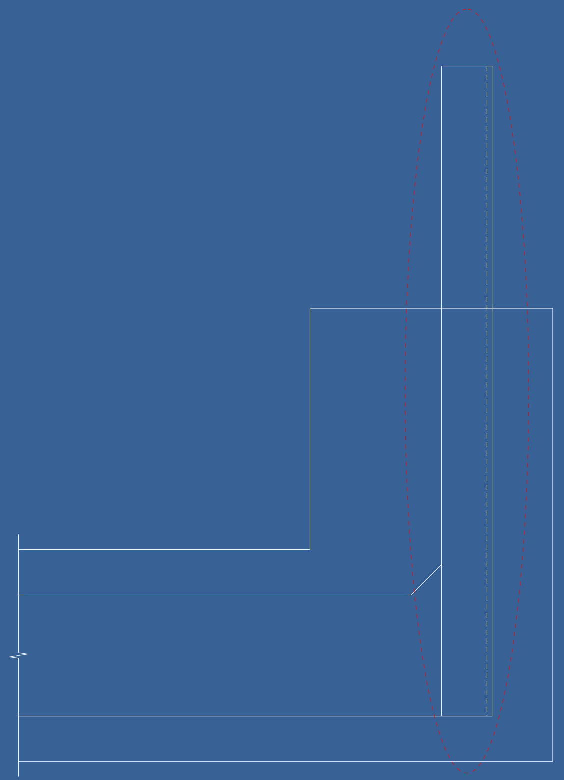
- High parapet abutment
  - Total height (including footing) > 15 feet
  - Use a construction joint (w/keyways) every 32 feet
  - Reinforcement bars designed by engineer
  - When abutments are higher than 40 feet MSE walls may be considered

Wingwalls

Integral



Semi-integral / Parapet

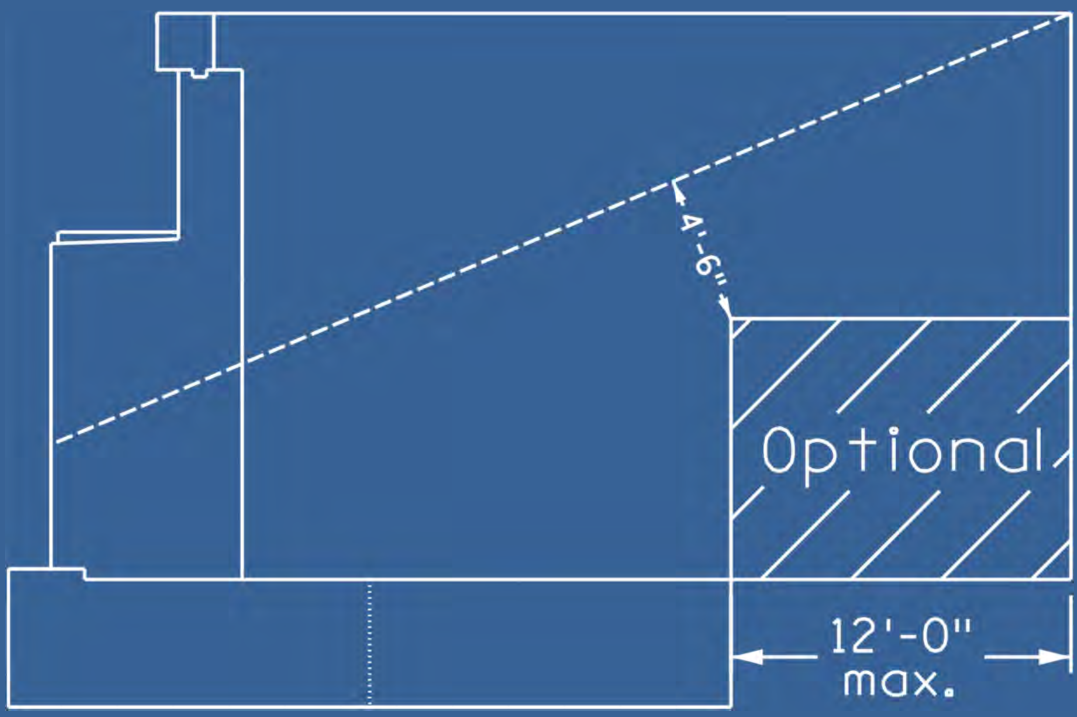


Wingwall design: Integral

- Refer to section 11.1.4 of the MnDOT LRFD Bridge Design Manual for wingwall design
- Wingwall thickness should be 1’-6”
- Back face horizontal reinforcement should be # 16’s at 12” for wingwalls ≤ 8’-0”
  - Consider possible restrictions
- Wingwalls between the lengths of 8’-0” and 14’-0” will need a special design
  - The back face horizontal reinforcement should be designed to resist passive soil pressure

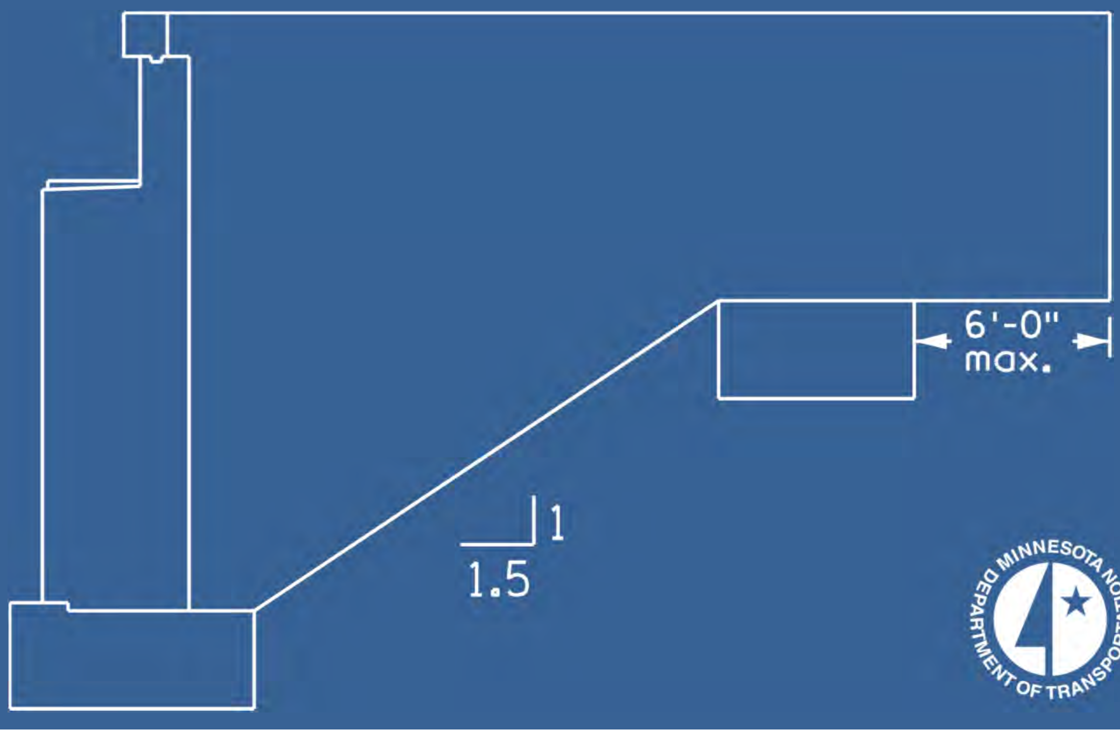
Wingwall design: Layout options

- One footing
  - Preferred option for laying out wingwall geometry
  - Maximum cantilever beyond footing is 12’-0”



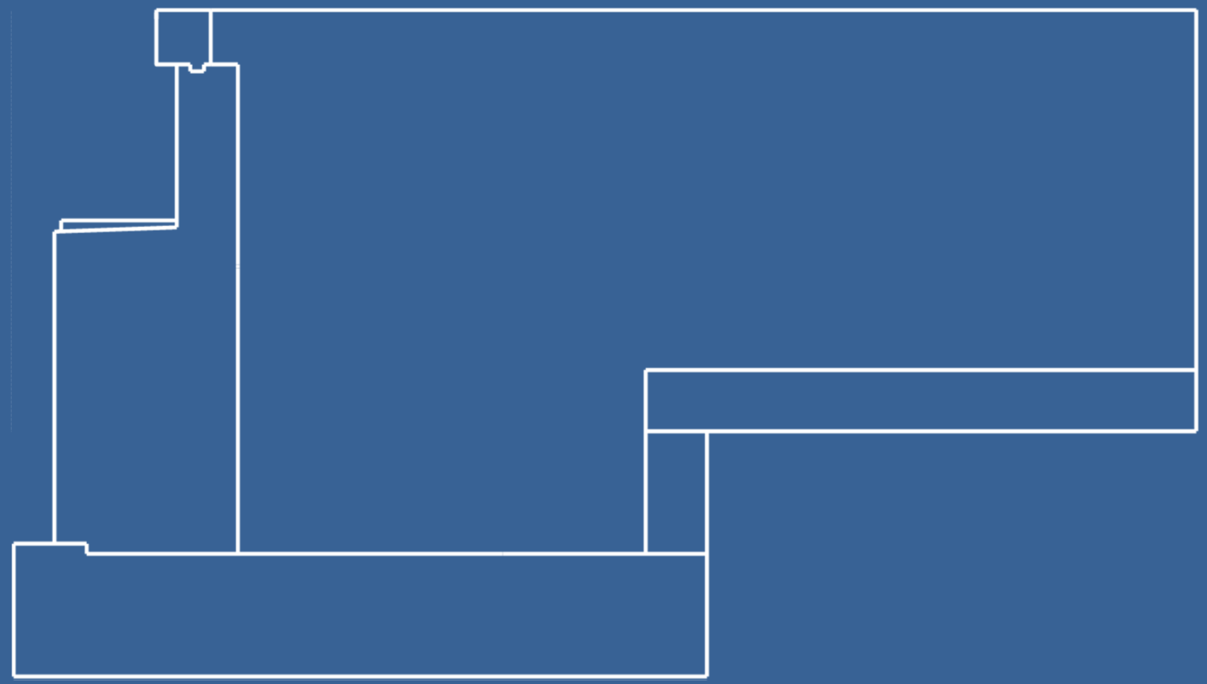
Wingwall design: Layout options

- Separate footing
  - Separate footings may be required for wingwalls over 20'-0"
  - Not recommended for spread footings
  - Must have a 1V:1.5H slope or shallower between footings
  - Limit cantilever beyond the footing to 6'-0"



Wingwall design: Layout options

- Stepped footing
  - Follow maximum step heights set forth by retaining wall standards
  - Not recommended for piled foundations
  - Can delay the contractor significantly

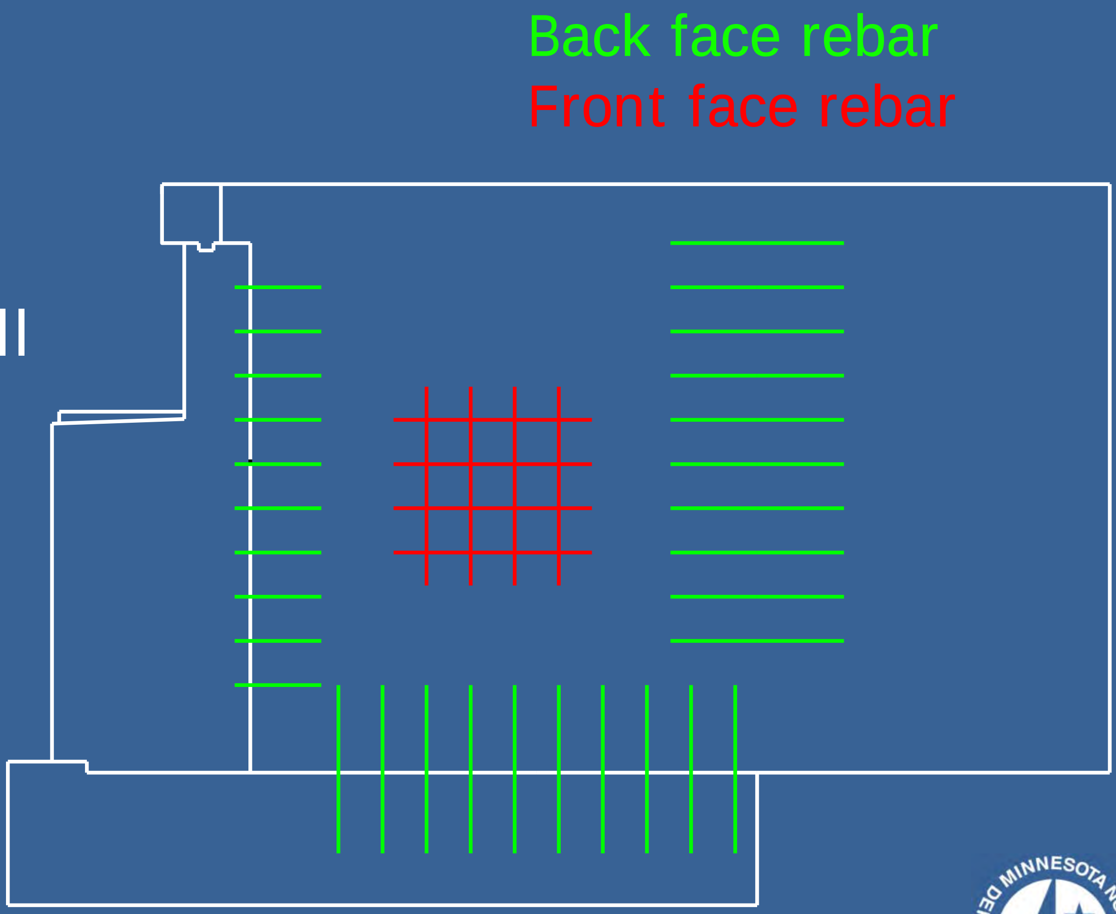


Wingwall design: Semi-integral/Parapet

- Assume back face vertical dowels and reinforcement take the entire moment caused by horizontal loads
- Provide a concrete fillet at wingwall/stem connection
- Cantilevers under 8’-0” can use a standard reinforcement design
- Provide wingwall pile loads in the plan if they are less than 80% of main abutment pile loads

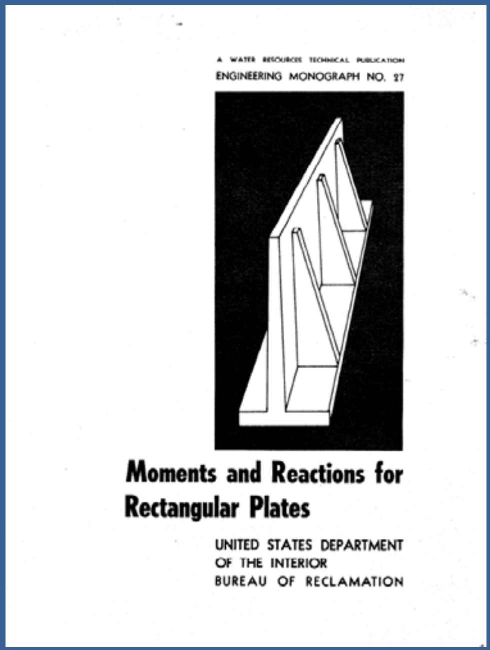
Wingwall design: Semi-integral/Parapet

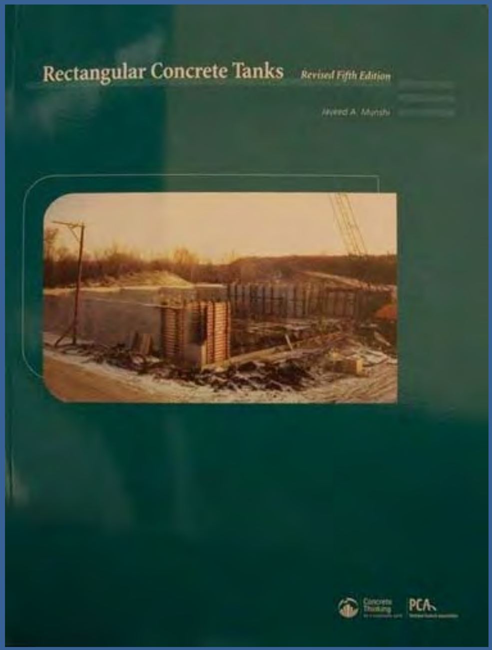
- Rebar design consideration areas due to plate action
  - Stem/wingwall horizontal reinforcement
  - Footing/wingwall vertical reinforcement
  - Center of the wingwall
  - Cantilevered section



Wingwall design: Semi-integral/Parapet

- Many resources available for determining moments and shears for plate action
  - United States Department of the Interior
    - Bureau of Reclamation
  - Portland Cement Association



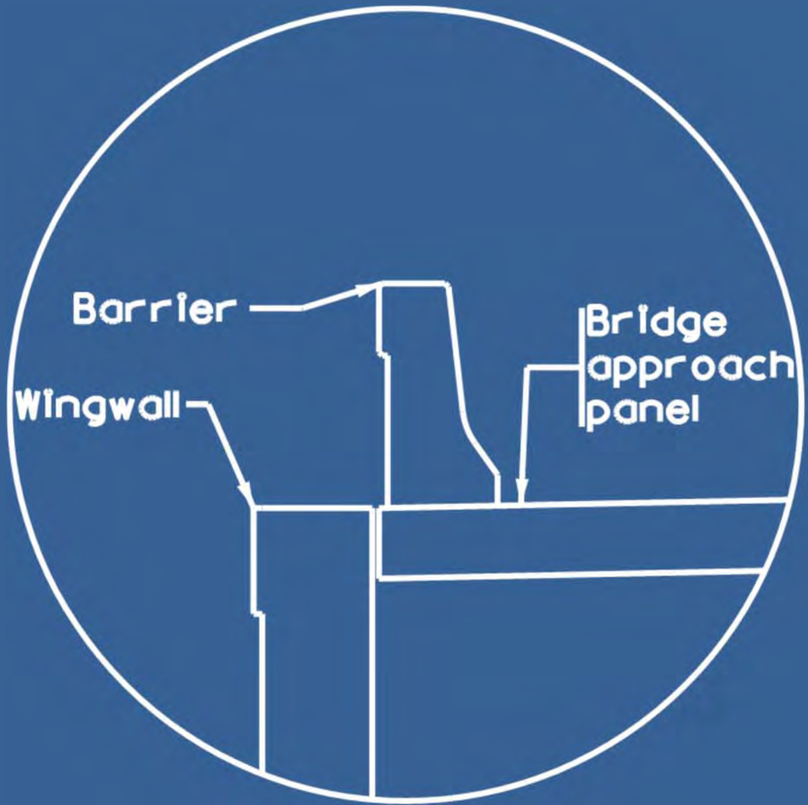


Barrier location

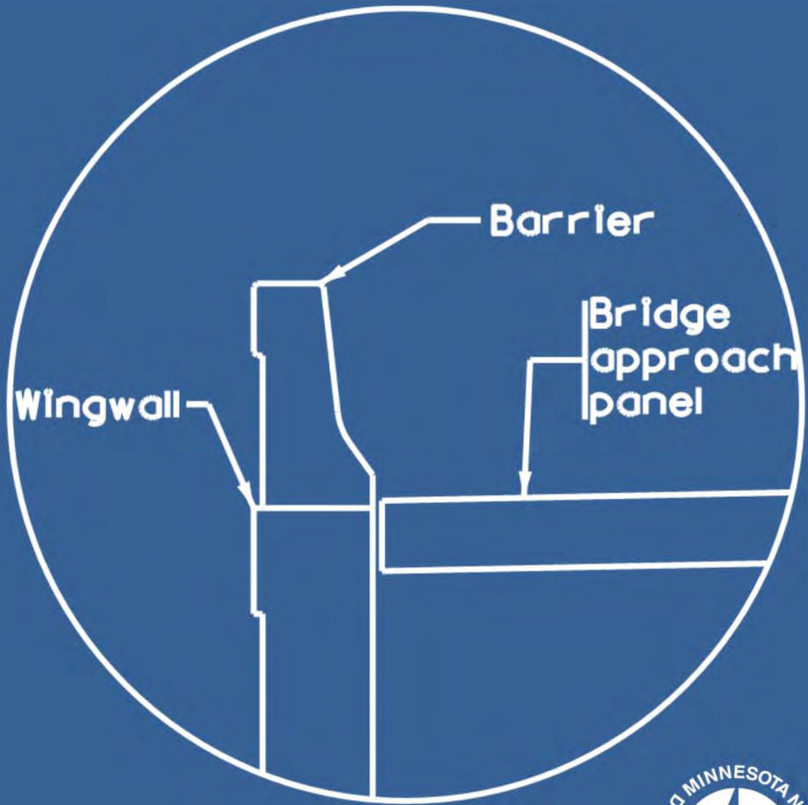
- The barrier should typically be located on the approach panel
- One exception is when wingwalls tie into retaining walls
  - Then coordination is necessary during the preliminary design process with roadway design to determine the barrier’s correct location
- Barrier should extend 7’-0” onto the approach panel (previously 5’-0”) for TL-4 barriers

Barrier location

Typical location

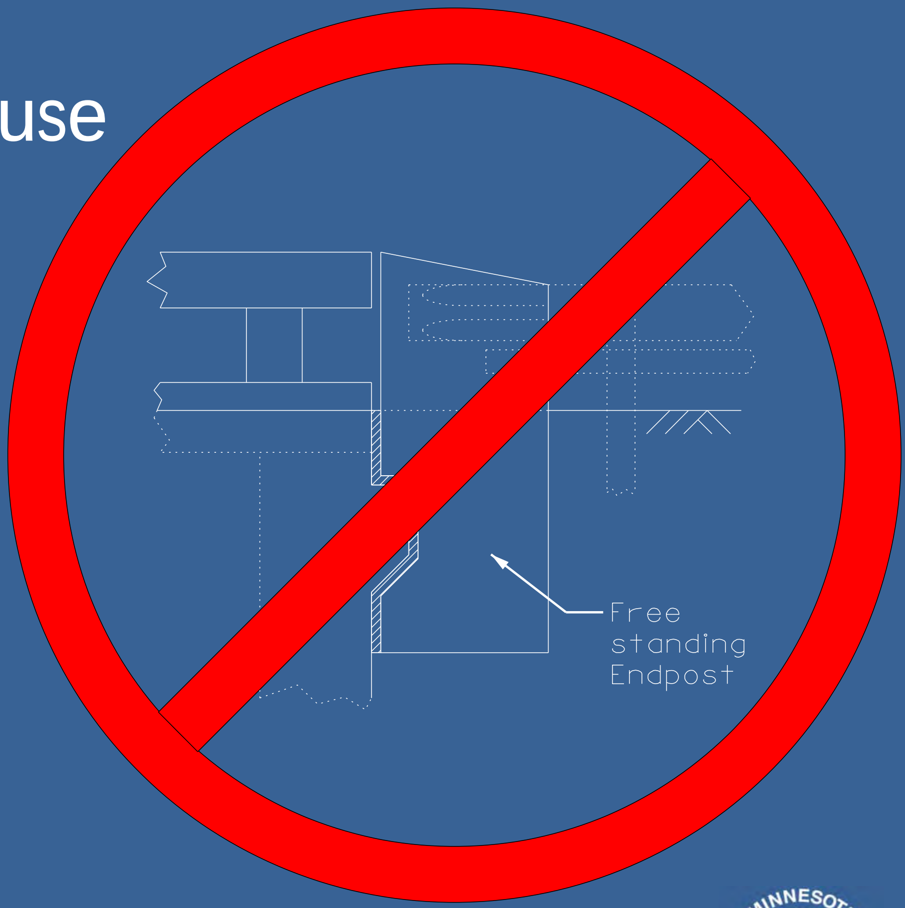


When wingwall ties into retaining wall



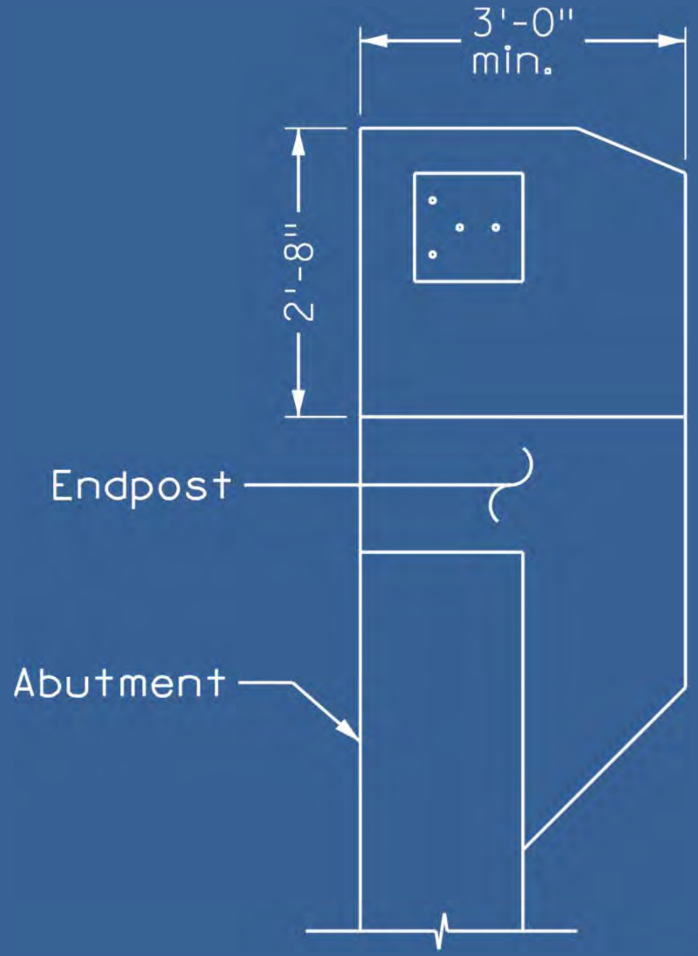
End posts

- MnDOT is no longer allowing the use of free standing end posts because we could not find sufficient crash testing data



End posts

- Typically end posts are connected to the abutment
  - 3’-0” minimum length required
  - Width and reinforcement should be matched to adjoining rail
  - Reinforcement running through abutment-end post interface



Questions?

Quality Management for Structures

Arielle Ehrlich
State Bridge Design Engineer

Outline

- Quality Management
- Software
- Design Personnel
- Drafting of Plans
- Use of Standards
- Independent Technical Reviews (ITRs)
- Bridge Office Quality Manual
- Coordination with Grading Plans
- Time vs. Quality

Quality Management

- Purpose: To assure a consistent, high level of quality in all calculations, plans, and reports generated
- Quality Management Plan (QMP): Plan of how quality will be integrated and achieved for the **specific** project

Quality Management

What belongs in a QMP:

- Project specific details
- QC/QA Process
  - What are the roles to assure quality
  - Who will be filling those roles
- Software usage
- Calculation and plan review process
- Usage and Integration of Independent Technical (ITRs) or Constructability Reviews (CRs)

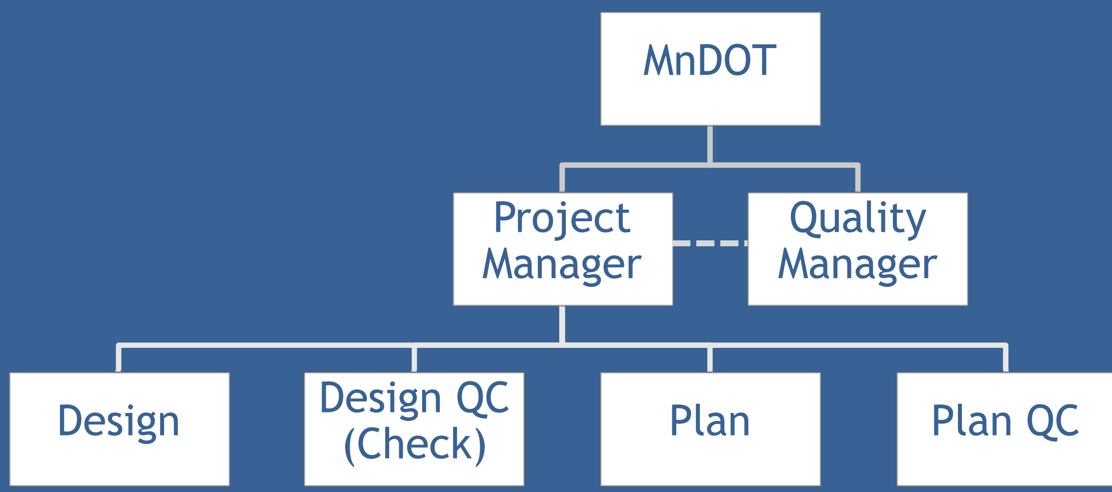
Quality Management

- Quality Control (QC)
  - Checking of plans and calculations
  - Documenting review process
- Quality Assurance (QA)
  - Verifying quality control process was followed

Design Personnel

People involved:

- Designer (QC)
- Checker (QC)
- Quality Manager (QA)



Design Personnel

Checker experience $\geq$ Designer experience

- Calculations
- Plan preparation

- Experience with component design or drafting

Software

- Software must be appropriate for project-specific circumstances.
- Designers need to understand limitations of software and validations.

- MnDOT LRFD Bridge Design Manual Section 4.1
  - Basic
  - Intermediate
  - Complex

Software – Basic

- Bridge elements
  - Abutments
  - Splices
  - Bearings
  - Most cases of prestressed concrete beams
- Methods
  - Independent set of calculations
  - Line-by-line check of calculations
  - Using software that has been validated for a similar situation

Software – Intermediate

- Bridge elements
  - Piers
  - Straight steel girders
  - Prestressed beams – flared or variable overhangs
- Methods
  - Independent design and check each using a different software package
  - Hand check using moderate simplifications with sound engineering judgment

Software – Complex

- Bridge Elements
  - Concrete box girders
  - Steel box girders
  - Curved steel girders
  - Structures requiring a soil-structure interaction model
- Methods
  - Independent design and check each using a different software package only!

Software – Checking methods

- Validated design software/spreadsheets
  - Assess all input.
  - Review output to confirm a reasonable answer.
- Line-by-line check
  - Every line of calculations must be verified.
- Non-independent checking methods
  - Handwritten initials on each page reviewed
  - Not preprinted!

Software – Checking methods

- Independent checks
  - Must use different software packages or spreadsheets
  - Compare
    - Input
    - Intermediate and final output values
      - Section properties
      - Dead load moments and shears
      - Live load moments and shears
      - Code checks

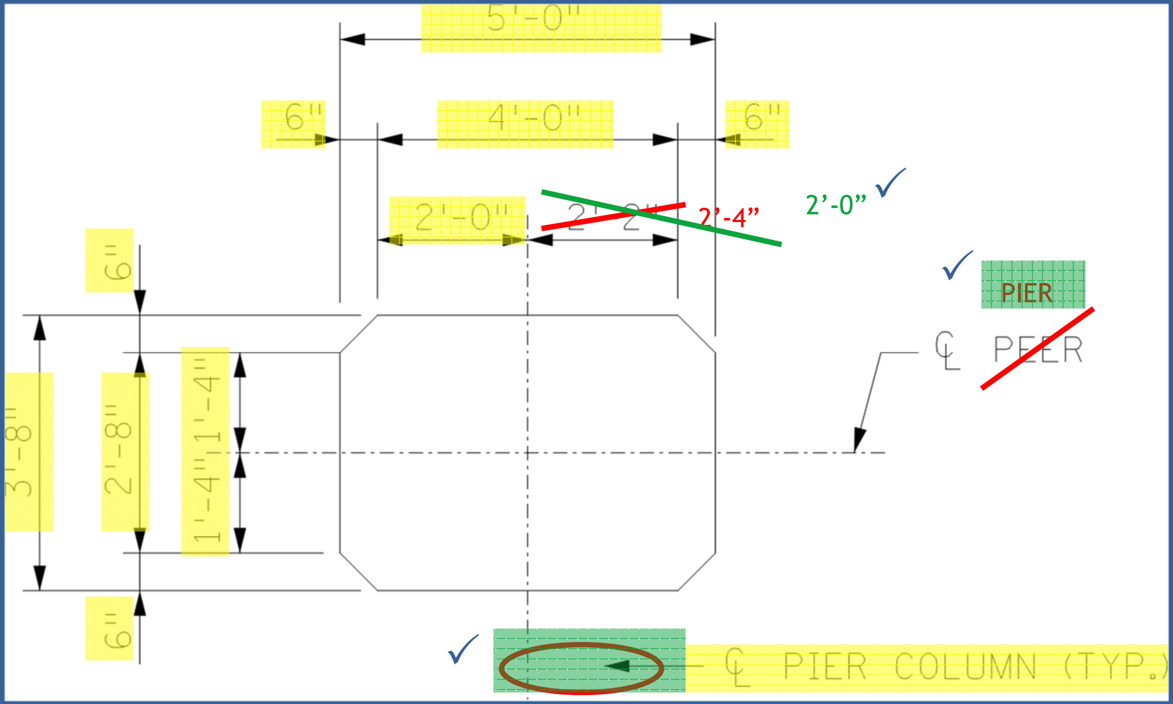
Software

Software

	1,957	Year Built
	356,000	Square Footage
+	1,016	Employees
	~~458,967~~	Meaningless!
	358,973	

Drafting of Plans

- Utilize appropriate procedures:
  - Drafting
  - Checking
  - Modifying
- Checklists

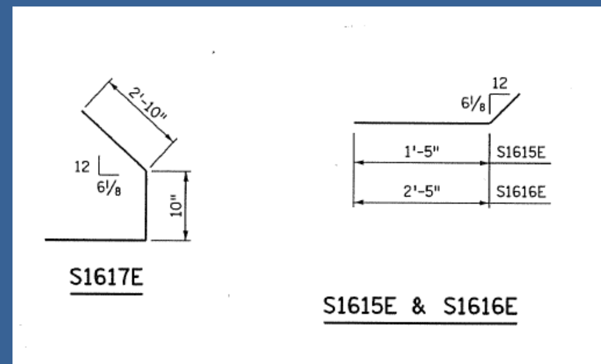


Drafting of Plans

- Rebar

BILL OF REINFORCEMENT FOR SUPERSTRUCTURE

BAR	NO.	LENGTH	SHAPE	LOCATION
S1901E	583	40'-6"		SLAB TRANSVERSE BOT.
S1902E	583	28'-7"		SLAB TRANSVERSE BOT.
S1903E	2 SER. OF 50	FROM 3'-4" TO 59'-4"		SLAB TRANSVERSE BOT.
S1604E	741	47'-0"		SLAB TRANSVERSE TOP
S1605E	741	21'-6"		SLAB TRANSVERSE TOP
S1606E	2 SER. OF 64	FROM 3'-6" TO 60'-0"		SLAB TRANSVERSE TOP
S1307E	414	40'-0"		SLAB LONGITUDINAL TOP
S1308E	46	18'-3"		SLAB LONGITUDINAL TOP
S1609E	606	60'-0"		SLAB LONGITUDINAL BOT.
S1610E	101	19'-0"		SLAB LONGITUDINAL BOT.
S1911E	270	15'-0"		SLAB LONGIT. TOP OVER PIER
S1312E	144	3'-6"		END BLOCK TIE
S1313E	4	3'-11"		END BLOCK TIE
S1314E	4	3'-4"		END BLOCK TIE
S1615E	4	3'-0"		END BLOCK TIE
S1616E	4	4'-0"		END BLOCK TIE
S1617E	4	6'-8"		SLAB TIE
S1618E	8	10'-0"		END BLOCK TRANSVERSE
S1619E	32	38'-7"		END BLOCK TRANSVERSE



- Quantities
  - Independent check

SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE

BRIDGE SLAB CONCRETE (3Y36)	24972	SQ. FT.
CONCRETE WEARING COURSE (3U17A)	29030	SQ. FT.
TYPE MOD F (TL-4) RAILING CONCRETE (3Y46)	798	LIN. FT.
REINFORCEMENT BARS (EPOXY COATED)	198480	POUND
DIAPHRAGMS FOR TYPE MN54 PRESTRESSED BEAMS	744	LIN. FT.
EXP. CURVED PLATE BRG. ASS'Y TYPE E1	6	EACH
EXP. CURVED PLATE BRG. ASS'Y TYPE E2	24	EACH
EXP. CURVED PLATE BRG. ASS'Y TYPE E3	6	EACH
EXP. CURVED PLATE BRG. ASS'Y TYPE E4	6	EACH
FIXED CURVED PLATE BRG. ASS'Y TYPE F1	6	EACH
BEARING ASSEMBLY	48	EACH
EXPANSION JOINT DEVICES TYPE 4	147	LIN. FT.
PRESTRESSED CONCRETE BEAMS MN54	2190	LIN. FT.
BENCH MARK DISK	2	EACH
BRIDGE NAME PLATE	1	EACH
1" LOW DENSITY POLYSTYRENE	13	SQ. FT.

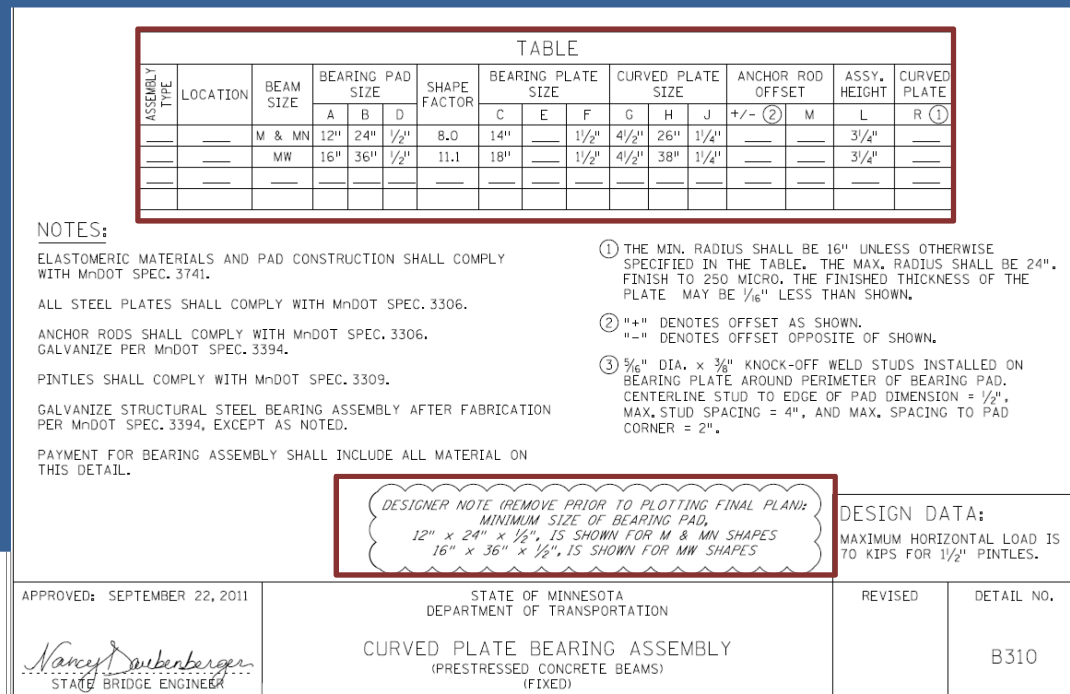
Use of Standards

- Standards should be added late in plan production.
- Add from the MnDOT website, not old projects.

  http://www.dot.state.mn.us/bridge
- Questions on usage should go through MnDOT Project Manager (Unit Leader)

Use of Standards

- Fill in information where necessary.



TABLE

ASSEMBLY TYPE	LOCATION	BEAM SIZE	BEARING PAD SIZE A	BEARING PAD SIZE B	BEARING PAD SIZE D	SHAPE FACTOR	BEARING PLATE SIZE C	BEARING PLATE SIZE E	BEARING PLATE SIZE F	CURVED PLATE SIZE G	CURVED PLATE SIZE H	CURVED PLATE SIZE J	ANCHOR ROD OFFSET +/- (2)	ANCHOR ROD OFFSET M	ASSY. HEIGHT L	CURVED PLATE R (1)
___	___	M & MN	12"	24"	1/2"	8.0	14"	___	1 1/2"	4 1/2"	26"	1 1/4"	___	___	3 1/4"	___
___	___	MW	16"	36"	1/2"	11.1	18"	___	1 1/2"	4 1/2"	38"	1 1/4"	___	___	3 1/4"	___
___	___	___	___	___	___	___	___	___	___	___	___	___	___	___	___	___

NOTES:

ELASTOMERIC MATERIALS AND PAD CONSTRUCTION SHALL COMPLY WITH MnDOT SPEC. 3741.

ALL STEEL PLATES SHALL COMPLY WITH MnDOT SPEC. 3306.

ANCHOR RODS SHALL COMPLY WITH MnDOT SPEC. 3306. GALVANIZE PER MnDOT SPEC. 3394.

PINTLES SHALL COMPLY WITH MnDOT SPEC. 3309.

GALVANIZE STRUCTURAL STEEL BEARING ASSEMBLY AFTER FABRICATION PER MnDOT SPEC. 3394, EXCEPT AS NOTED.

PAYMENT FOR BEARING ASSEMBLY SHALL INCLUDE ALL MATERIAL ON THIS DETAIL.

(1) THE MIN. RADIUS SHALL BE 16" UNLESS OTHERWISE SPECIFIED IN THE TABLE. THE MAX. RADIUS SHALL BE 24". FINISH TO 250 MICRO. THE FINISHED THICKNESS OF THE PLATE MAY BE 1/16" LESS THAN SHOWN.

(2) "+" DENOTES OFFSET AS SHOWN. "−" DENOTES OFFSET OPPOSITE OF SHOWN.

(3) 5/16" DIA. x 3/8" KNOCK-OFF WELD STUDS INSTALLED ON BEARING PLATE AROUND PERIMETER OF BEARING PAD. CENTERLINE STUD TO EDGE OF PAD DIMENSION = 1/2", MAX. STUD SPACING = 4", AND MAX. SPACING TO PAD CORNER = 2".

DESIGNER NOTE (REMOVE PRIOR TO PLOTTING FINAL PLAN): MINIMUM SIZE OF BEARING PAD, 12" x 24" x 1/2", IS SHOWN FOR M & MN SHAPES 16" x 36" x 1/2", IS SHOWN FOR MW SHAPES

DESIGN DATA:
MAXIMUM HORIZONTAL LOAD IS 70 KIPS FOR 1 1/2" PINTLES.

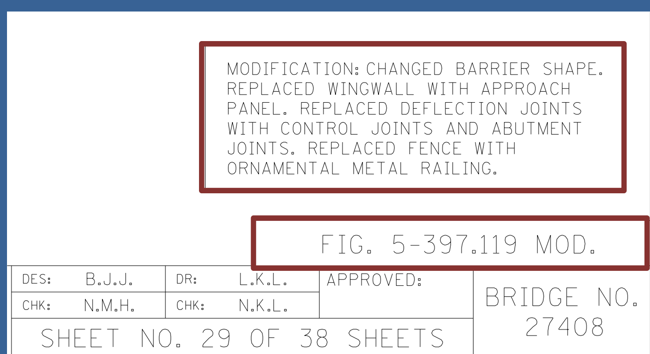
APPROVED: SEPTEMBER 22, 2011
Nancy Daubenberger
STATE BRIDGE ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION
CURVED PLATE BEARING ASSEMBLY
(PRESTRESSED CONCRETE BEAMS)
(FIXED)

REVISED

DETAIL NO. B310

- Indicate modifications as applicable.



MODIFICATION: CHANGED BARRIER SHAPE. REPLACED WINGWALL WITH APPROACH PANEL. REPLACED DEFLECTION JOINTS WITH CONTROL JOINTS AND ABUTMENT JOINTS. REPLACED FENCE WITH ORNAMENTAL METAL RAILING.

FIG. 5-397.119 MOD.

DES: B.J.J. | DR: L.K.L. | APPROVED:
CHK: N.M.H. | CHK: N.K.L.
SHEET NO. 29 OF 38 SHEETS
BRIDGE NO. 27408

- Sign the sheet.

Independent Technical Reviews

- Use ITRs for complex or unusual details
- People to involve:
  - Unit Leader
  - Regional Construction Engineer
  - State Bridge Design Engineer
  - Others as needed

- Not the same as a peer review
  - See MnDOT LRFD Bridge Design Manual Section 1.3.3

Bridge Office Quality Manual

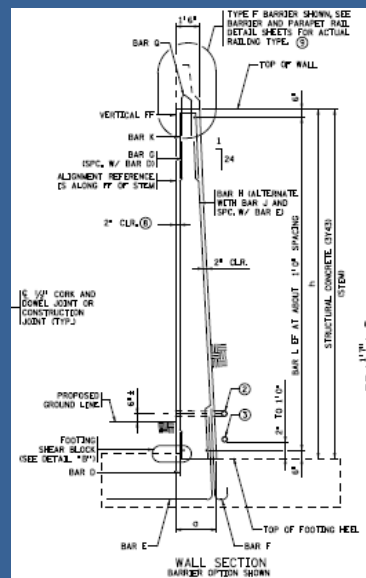
- Coming soon!

- Similar to Roadway's *Quality Management Process For Design-Bid-Build Final Plan Development*

http://www.dot.state.mn.us/design/qmp/index.html

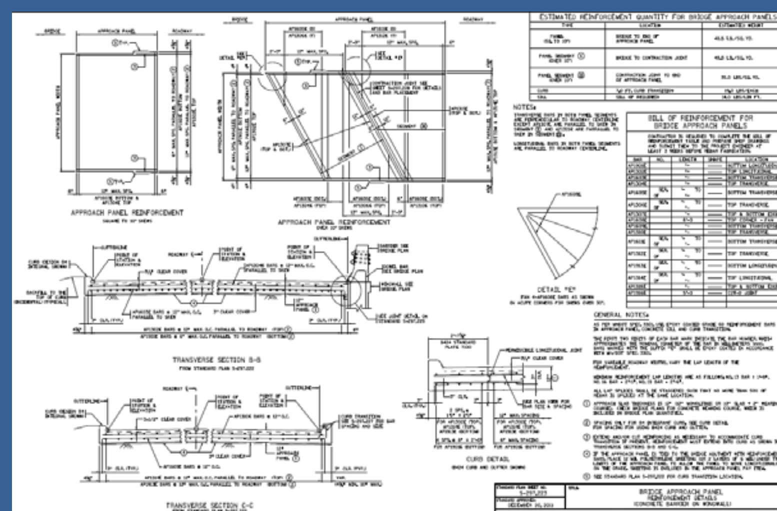
Coordination with Grading Plans

- Retaining Walls
  - Standard
  - Non-standard



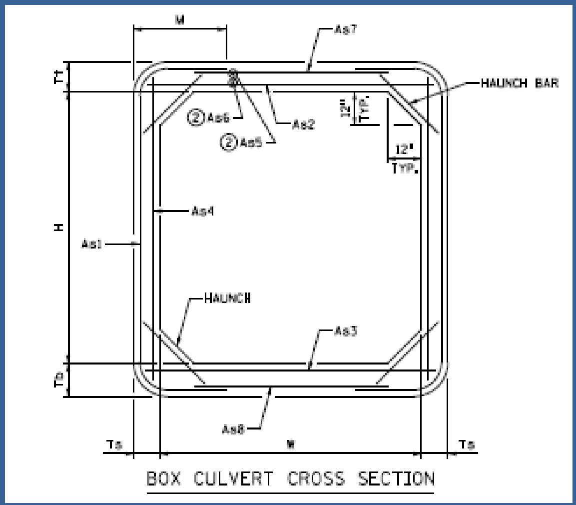
BAR	MARK	NO.	LENGTH	A	LOCATION	WT.	DIMENSIONS & QUANTITIES			
h = 26' PANELS:							L=30'-6"			
SPREAD FOOTING REINFORCEMENT							DIMENSIONS			
							SPREAD FOOTING			
A	F1901	26	33'-5"	STR.	LONG T & B	1305				
B	F1902	31	12'-4"	STR.	TRANS BOT	574	b	5'-3"	e	1' 4"
C	F2503	31	12'-4"	STR.	TRANS TOP	1021	c	2'-3"	f	7' 6-1/8"
							d	12'-10"	g	5' 5-5/16"
PILE FOUNDATION REINFORCEMENT							PILE FOUNDATION			
A	F__01	26		STR.	LONG T & B		b	5'-3"	d	13'-0"
B	F__02	31		12'-6"	TRANS BOT		c		g	5' 5-5/16"
C	F2503	31	14'-4"	12'-6"	TRANS TOP	1186				
							STEM			
							a	2'-7"	k	5'-3"
							j	2' 2-1/8"		
FOOTING DOWELS & STEM REINFORCEMENT							QUANTITIES			
D	F1604E	31	3'-0"	STR.	DOWEL FF	97	STRUCTURAL CONCRETE (1A43)			
E	F2905E	31	14'-5"	7'-4"	DOWEL BF	1520	(FOOTING)			
F	F2906E	30	9'-10"	8'-7"	DOWEL BF	969	SPREAD	36.5		CU YD
G	S1301E	31	23'-3"	STR.	VERT FF	481	PILE			CU YD
H	S2202E	31	23'-3"	STR.	VERT BF	1473	STRUCTURAL CONCRETE (3Y43)			
J	S2203E	30	13'-6"	STR.	VERT BF	828	(STEM)			
K	S1604E	31	10'-7"	4'-9"	TIE	342		59.9		CU YD
L	S1305E	52	30'-0"	STR.	HORIZ EF	1042	REINFORCEMENT (PLAIN)			
M	S1606E	20	7'-4"	1'-4"	EXP JT TIE	153	SPREAD	2900		LB
N	S1607E	20	7'-9"	1'-9"	EXP JT TIE	162	PILE			LB
P	S1608E	12	8'-2"	2'-2"	EXP JT TIE	102	REINFORCEMENT (EPOXY)			
Q	S1609E	——	8'-7"	4'-0"	RAIL DOWEL	——		7203		LB
Q	S1609E	——	6'-1"	2'-8"	F-RAILDOWEL	——				

- Approach Panels



Coordination with Grading Plans

- Utilities (MnDOT LRFD Bridge Design Manual 2.4.1.6)
  - On bridges
  - Near foundations
- Box Culverts



- Special Hydraulic Structures

Time vs. Quality

- Do NOT skip QC process to save time!
- Use over-the-shoulder (OTS) reviews.
- Project manager responsibilities:
  - Follow the steps in order: Final design comes after preliminary design
  - Communicate potential issues with MnDOT ASAP
  - Involve all stakeholders

QUESTIONS?

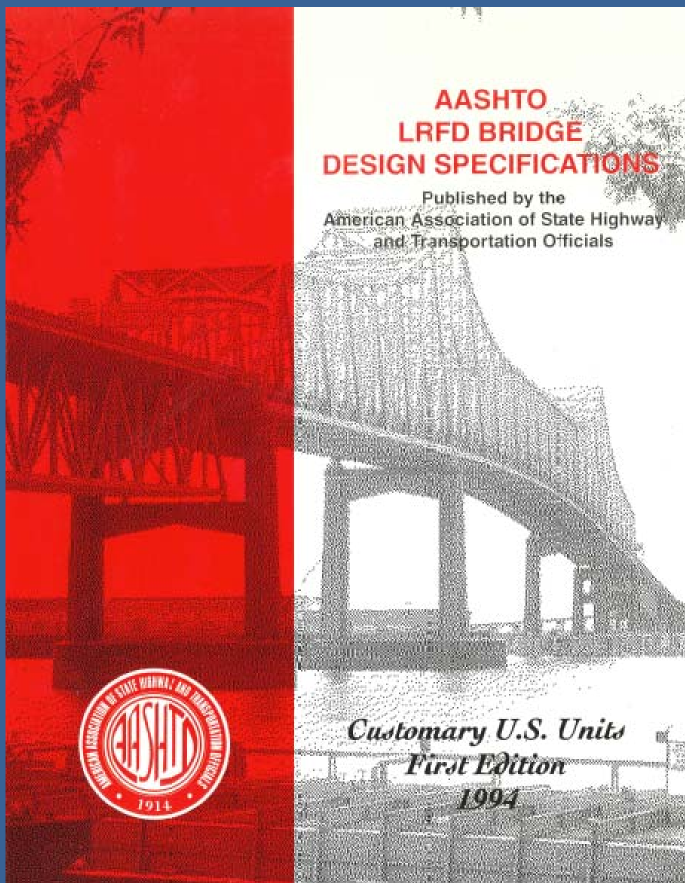
Piers

David Dahlberg
Bridge Design Manual & Policy Engineer

Presentation Overview

- Pier Protection
  - Introduction
  - Original AASHTO LRFD Specification requirements
  - MnDOT Substructure Protection Policy
  - Changes to AASHTO LRFD Specifications
  - Changes to MnDOT policy
- Design & Detailing Issues

Pier Protection - Introduction



AASHTO LRFD Article 3.6.5

expected to brake out of phase.

3.6.5 Vehicular Collision Force: CT

3.6.5.1 PROTECTION OF STRUCTURES

The provisions of Article 3.6.5.2 need not be considered for structures which are protected by:

- an embankment,
- a structurally independent, crashworthy ground-mounted 54.0-IN high barrier, located within 10.0 FT from the component being protected, or
- a 42.0-IN high barrier located at more than 10.0 FT from the component being protected.

In order to qualify for this exemption, such barrier shall be structurally and geometrically capable of surviving the crash test for Performance Level 3, as specified in Section 13.

C3.6.5.1

For the purpose of this article, a barrier may be considered structurally independent if it does not transmit loads to the bridge.

Full scale crash tests have shown that some vehicles have a greater tendency to lean over, or partially cross over, a 42.0-IN high barrier than a 54.0-IN high barrier. This behavior would allow more significant collision of the vehicle with the component being protected if located within a few FT of the barrier. If the component is more than about 10.0 FT behind the barrier, the difference between the two barrier heights is no longer important.

3.6.5.2 VEHICLE AND RAILWAY COLLISION WITH STRUCTURES

Unless otherwise permitted in Article 3.6.5.1, abutments and piers located within a distance of 30.0 FT to the edge of roadway, or within a distance of 50.0 FT to the centerline of a railway track, shall be designed for an equivalent static force of 400 KIP, assumed to act in any direction in a horizontal plane, at a distance of 4.0 FT above ground.

C3.6.5.2

The equivalent static force of 400 KIP is based on the information resulting from full-scale crash tests of barriers for redirecting 80.0-KIP tractor trailers and from analysis of other truck collisions. The 400-KIP train collision load is based on recent, physically unverified, analytical work, Hirsch (1989). For individual column shafts, the 400-KIP load should be considered a point load. For wall piers, the load may be considered to be a point load or may be distributed over an area deemed suitable for the size of the structure and the anticipated impacting vehicle, but not greater than 5.0 FT wide by 2.0 FT high. These dimensions were determined by considering the size of a truck frame.

Pier Protection - Introduction

Figure 2.12. Truck Accident – Mile Post 519 Bridge over IH-20, Canton, Texas.

Pier Protection - Introduction

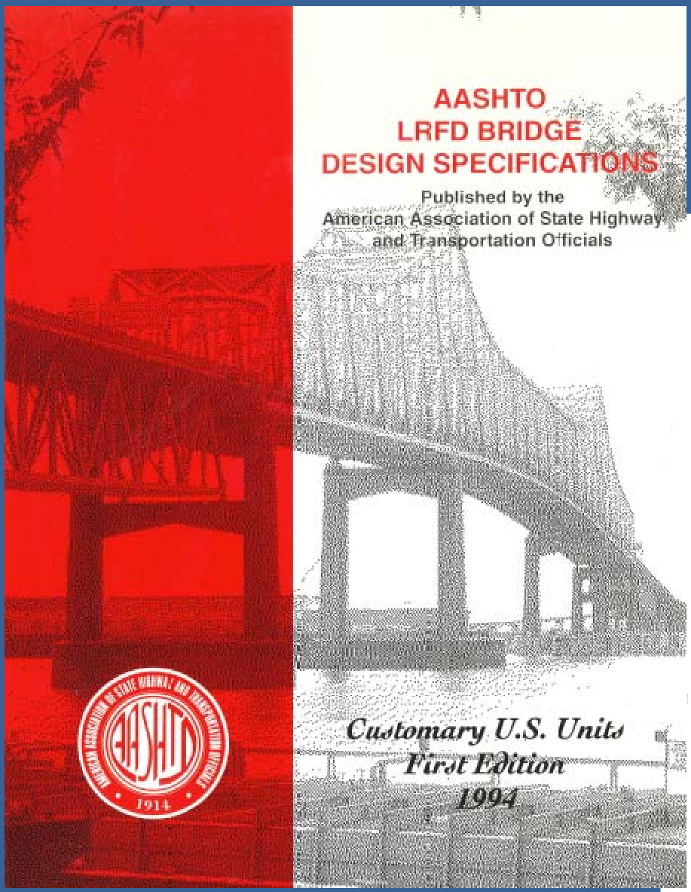
Pier Protection - Introduction

Figure 2.7. Truck Accident – SH 14 Bridge over IH-45, Corsicana, Texas.

Pier Protection - Introduction

I-90 near
Worthington, MN

AASHTO Spec Requirements



AASHTO LRFD Article 3.6.5

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AASHTO Spec Requirements

- Three options for protection given in Article 3.6.5
    1) Locate pier outside of clear zone (30 ft for roadway & 50 ft for railway)
    2) Protect pier by placing a TL-5 barrier in front, with barrier height dependent on clear distance
    3) Design pier to resist a collision load
        - 400 kip load for truck or train
        - Load applied at any angle
        - Load applied at 4 ft above ground

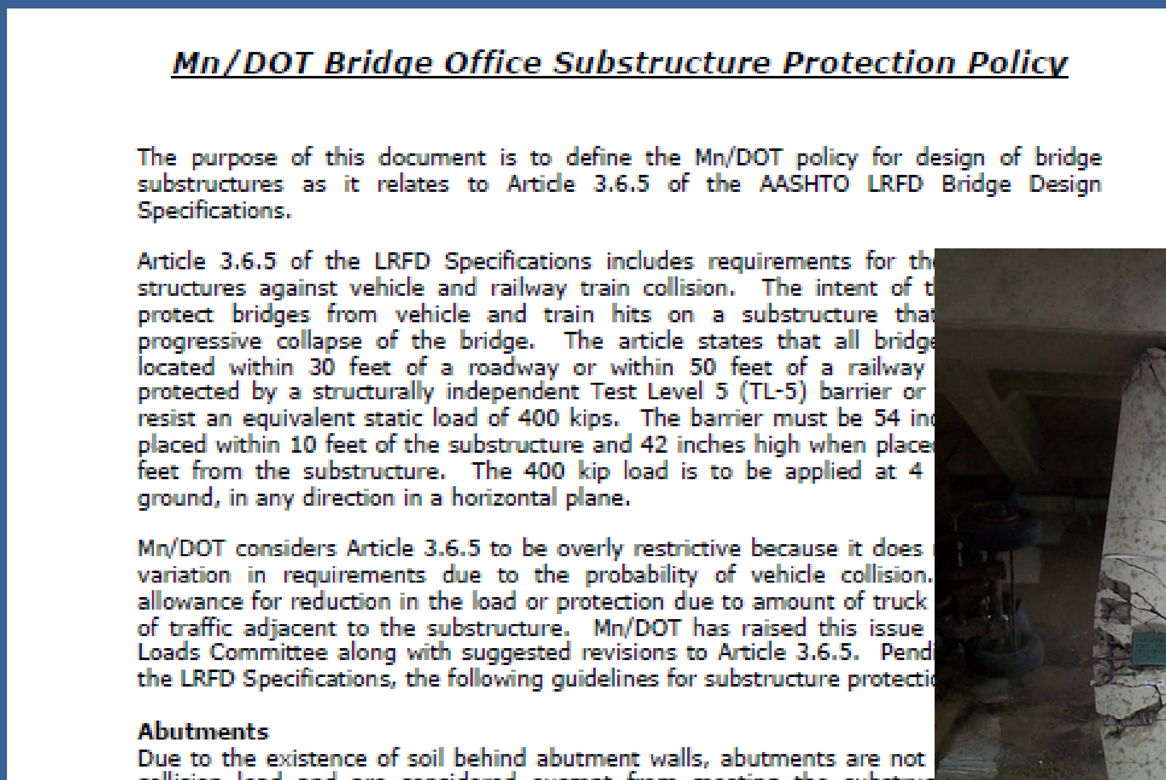
AASHTO Spec Requirements

- Applied to all substructures, with no variation in requirements
- No consideration of the probability of a vehicle collision
- No reduction in collision load or required protection for low speeds and low truck traffic

MnDOT Substructure Protection Policy

Designer Memo 2007-01

http://www.dot.state.mn.us/bridge/manuals/LRFD/index.html



Mn/DOT Bridge Office Substructure Protection Policy

The purpose of this document is to define the Mn/DOT policy for design of bridge substructures as it relates to Article 3.6.5 of the AASHTO LRFD Bridge Design Specifications.

Article 3.6.5 of the LRFD Specifications includes requirements for th
structures against vehicle and railway train collision. The intent of t
protect bridges from vehicle and train hits on a substructure that
progressive collapse of the bridge. The article states that all bridge
located within 30 feet of a roadway or within 50 feet of a railway
protected by a structurally independent Test Level 5 (TL-5) barrier or
resist an equivalent static load of 400 kips. The barrier must be 54 inc
placed within 10 feet of the substructure and 42 inches high when place
feet from the substructure. The 400 kip load is to be applied at 4
ground, in any direction in a horizontal plane.

Mn/DOT considers Article 3.6.5 to be overly restrictive because it does
variation in requirements due to the probability of vehicle collision.
allowance for reduction in the load or protection due to amount of truck
of traffic adjacent to the substructure. Mn/DOT has raised this issue
Loads Committee along with suggested revisions to Article 3.6.5. Pendi
the LRFD Specifications, the following guidelines for substructure protecti

Abutments

Due to the existence of soil behind abutment walls, abutments are not
collision load and are considered exempt from meeting the substruc

MnDOT Substructure Protection Policy

- Exemptions for substructure protection given to the following:
  - All abutments, due to soil behind them
  - Piers with redundancy (3 or more columns) adjacent to roadways with design speeds ≤ 40 mph
  - Piers with redundancy (3 or more columns) adjacent to roadways with design speeds > 40 mph that are not on the National Highway System and have an ADTT < 250

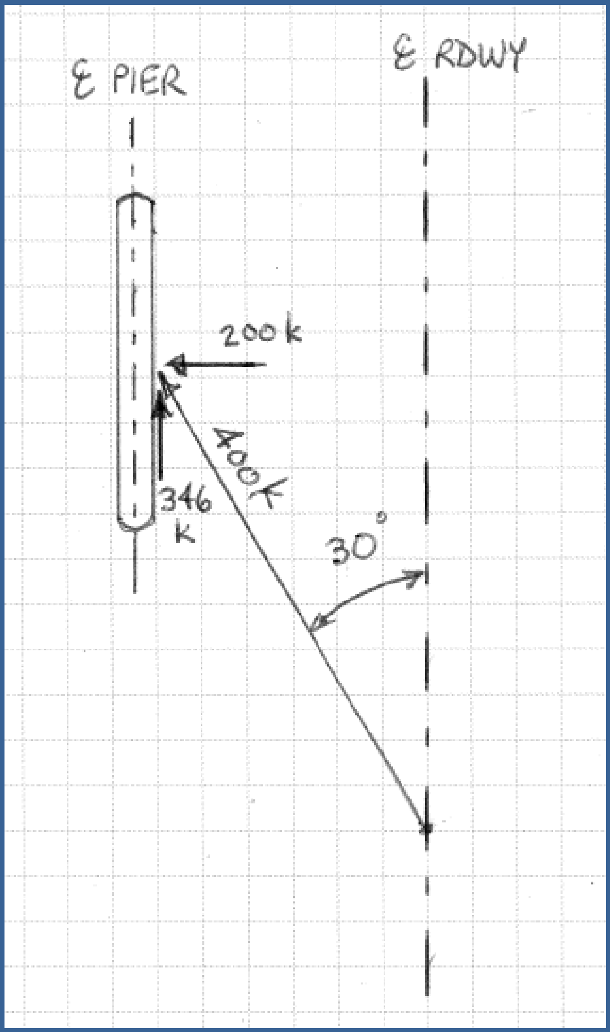
MnDOT Substructure Protection Policy

- All other new piers must meet the AASHTO LRFD Article 3.6.5 requirements modified as follows:
  – Spread footing, pile, and drilled shaft foundations are considered adequate to survive a collision and need not be analyzed
  – For piers designed to resist collision loading, apply the 400 kip load at a maximum angle of 30 degrees from the direction of the roadway or railway tangent

MINNESOTA DEPARTMENT OF TRANSPORTATION

MnDOT Substructure Protection Policy

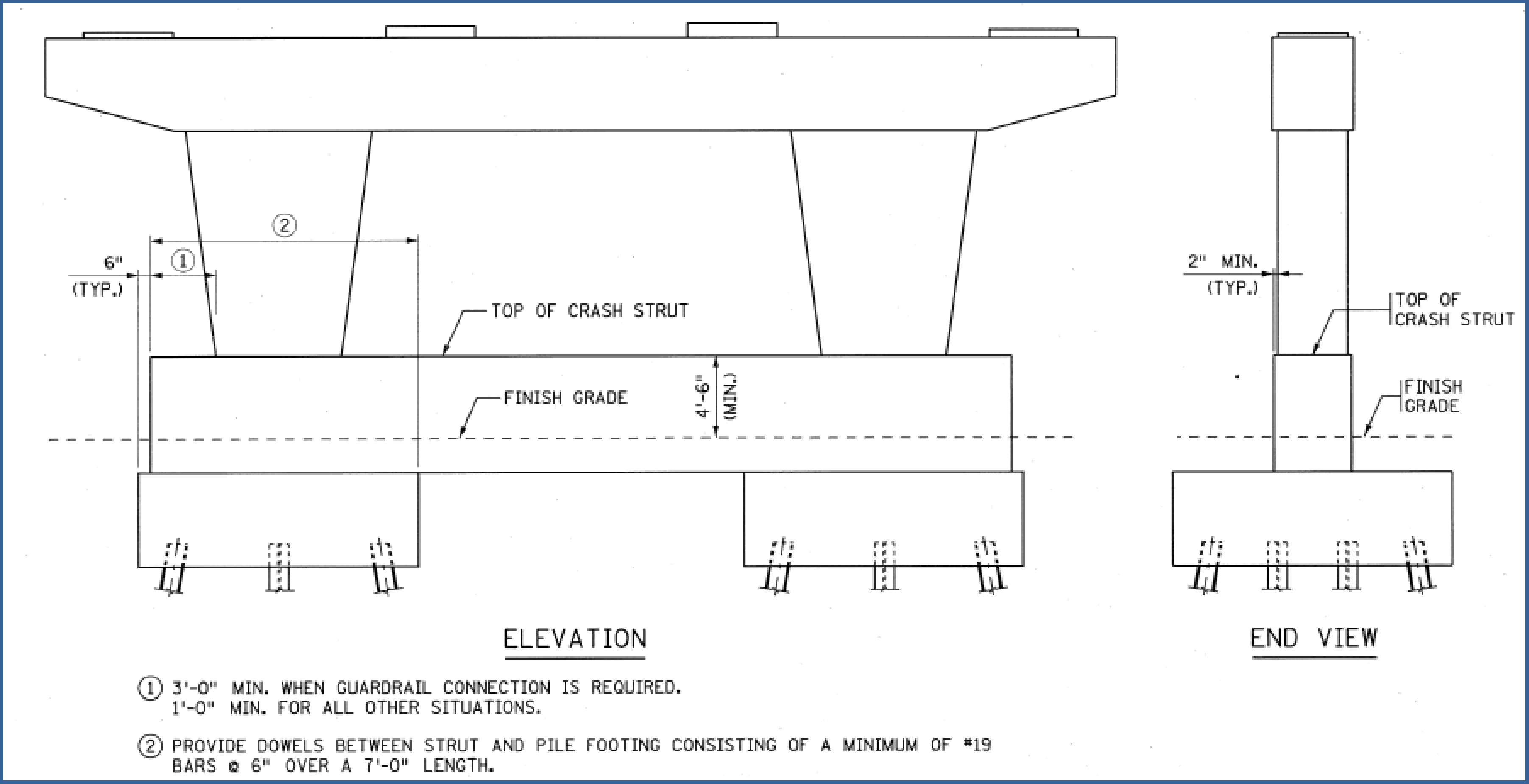
- Results in max transverse collision load component = 200 kips



MnDOT Substructure Protection Policy

- For new piers designed to resist collision loading:
  - Design columns to resist the collision load
  - Provide a crash strut designed to resist the collision load and having a height of 54 inches above the ground

MnDOT Substructure Protection Policy



MnDOT Substructure Protection Policy

- Existing piers on bridge repair projects that include substructure widening must meet the AASHTO LRFD Article 3.6.5 requirements (as modified by MnDOT)
- Existing piers on other bridge repair projects will typically be considered exempt

AASHTO Pier Protection Changed

- Other states wrestled with this issue
- Was discussed in AASHTO T-5 Loads Committee
- Pooled fund study formed
- In 2010 AASHTO LRFD 5th Edition, revision made that allowed owner discretion:

  "Unless the Owner determines that site conditions indicate otherwise…"

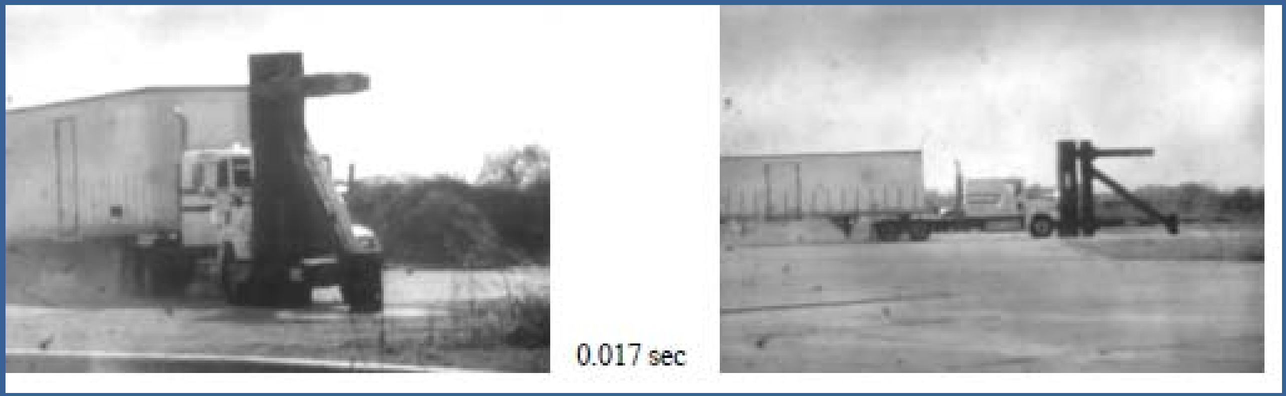
AASHTO Pier Protection Changed

- TPF-5(106) Guidelines for Designing Bridge Piers & Abutments for Vehicle Collisions

Texas Transportation Institute

AASHTO Pier Protection Changed

- TPF-5(106) objectives:
  - Determine what risks warrant application of pier protection requirements
  - Determine whether magnitude of 400 kip load is appropriate



AASHTO Pier Protection Changed

- Collision loads found to be significantly higher

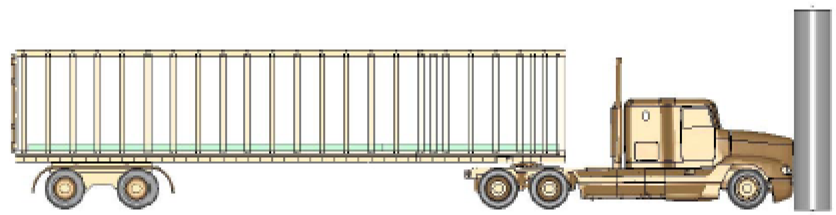
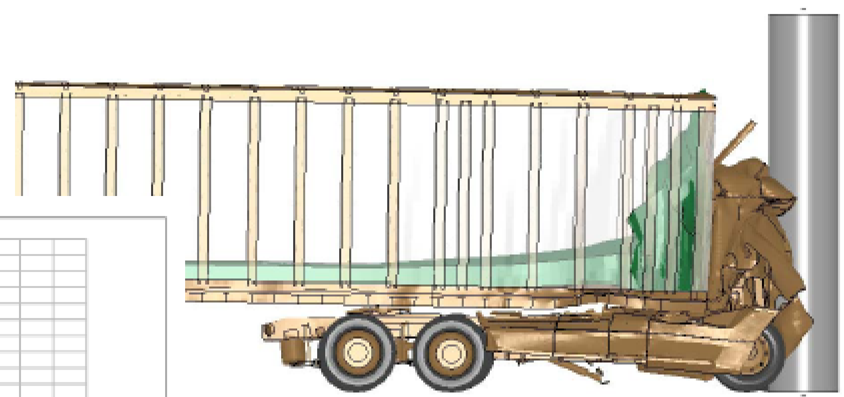


Figure 4.58. Trailer with Deformable Cargo Pre-Impact (Right View).



ure 4.59. Sloshing of Tractor-Trailer Cargo (Right View).

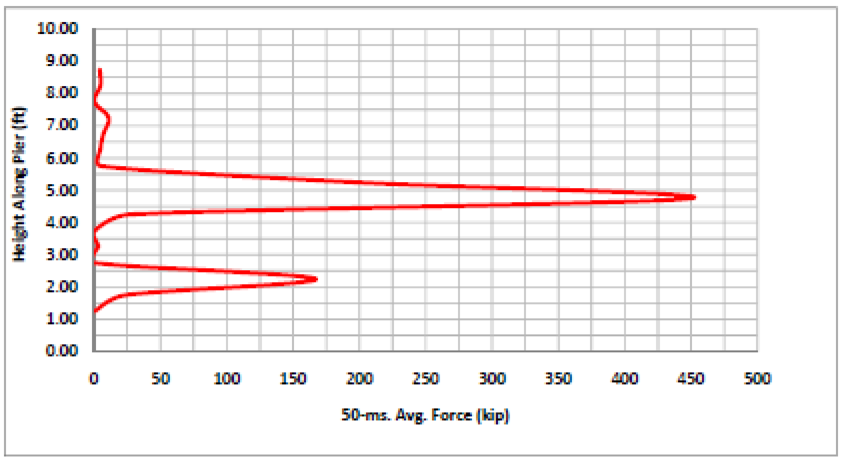


Figure 4.64. Tractor-Trailer Impact Force Distribution along the Height of the Pier at 0.2 sec.

What are the AASHTO Changes?

- 5th Edition
  - 400 k load
  - Load applied at any angle
  - Load applied at 4 ft above ground

- 6th Edition
  - 600 k load
  - Load applied at up to 15 degrees from roadway tangent
  - Load applied at 5 ft above ground

What are the AASHTO Changes?

- 5^{th} Edition
  - Requirements applied for roadways within 30 ft and railways within 50 ft

- 6^{th} Edition
  - Train collision provisions removed
  - Commentary suggests following:

    American Railway Engineering and Maintenance-of-way Association (AREMA) Manual for Railway Engineering

What are the AASHTO Changes?

- 6th Edition
  - Commentary now includes discussion on what site conditions warrant exemption from pier protection requirements
  - Exemption based on AF_{HBP} = annual frequency of bridge pier hits by a heavy vehicle
  - Commentary would not require pier protection when:
    - $AF_{HBP} < 0.0001$ for critical or essential bridges
    - $AF_{HBP} < 0.001$ for typical bridges

What are the AASHTO Changes?

- 6th Edition

Table C3.6.5.1-1—Typical Values of AF_{HBP}

		Undivided	Divided Curved	Divided Tangent
ADT (Both Directions)	ADTT* (One Way)	P_{HBP}=3.457E-09	P_{HBP}=2.184E-09	P_{HBP}=1.09E-09
		$AF_{HPB} = 2 \times ADTT \times 365 \times P_{HBP}$		
1000	50	0.0001	0.0001	0.0000
2000	100	0.0003	0.0002	0.0001
3000	150	0.0004	0.0002	0.0001
4000	200	0.0005	0.0003	0.0002
6000	300	0.0008	0.0005	0.0002
8000	400	0.0010	0.0006	0.0003
12000	600	0.0015	0.0010	0.0005
14000	700	0.0018	0.0011	0.0006
16000	800	0.0020	0.0013	0.0006
18000	900	0.0023	0.0014	0.0007
20000	1000	0.0025	0.0016	0.0008
22000	1100	0.0028	0.0018	0.0009
24000	1200	0.0030	0.0019	0.0010
26000	1300	0.0033	0.0021	0.0010
28000	1400	0.0035	0.0022	0.0011

*Assumes ten percent of ADT is truck traffic.

CRITICAL

TYPICAL

What are the AASHTO Changes?

- 6th Edition
  - Design speed is not a consideration in the latest revisions
  - Redundancy is also not a consideration

What is MnDOT's Policy now?

Mn/DOT Bridge Office Substructure Protection Policy

The purpose of this document is to define the Mn/DOT policy for design of bridge substructures as it relates to Article 3.6.5 of the AASHTO LRFD Bridge Design Specifications.

Article 3.6.5 of the LRFD Specifications includes requirements for the protection of structures against vehicle and
protect bridges from vehicle
progressive collapse of the br
located within 30 feet of a r
protected by a structurally ind
resist an equivalent static load
placed within 10 feet of the sub
feet from the substructure. T
ground, in any direction in a ho

Mn/DOT considers Article 3.6.5
variation in requirements due
allowance for reduction in the l
of traffic adjacent to the subst
Loads Committee along with su
the LRFD Specifications, the foll

Abutments

Due to the existence of soil be
collision load and are conside

Figure 2.10. Truck Accident – IH-90 Bridge, #53812, Minnesota.

Policy Considerations

- New bridges
  - ADTT of roadway under
  - Design speed of roadway under
  - Redundancy
  - Critical roadway under or over
  - Pier distance to roadway
  - Side pier or median pier
  - Roadway alignment

Policy Considerations

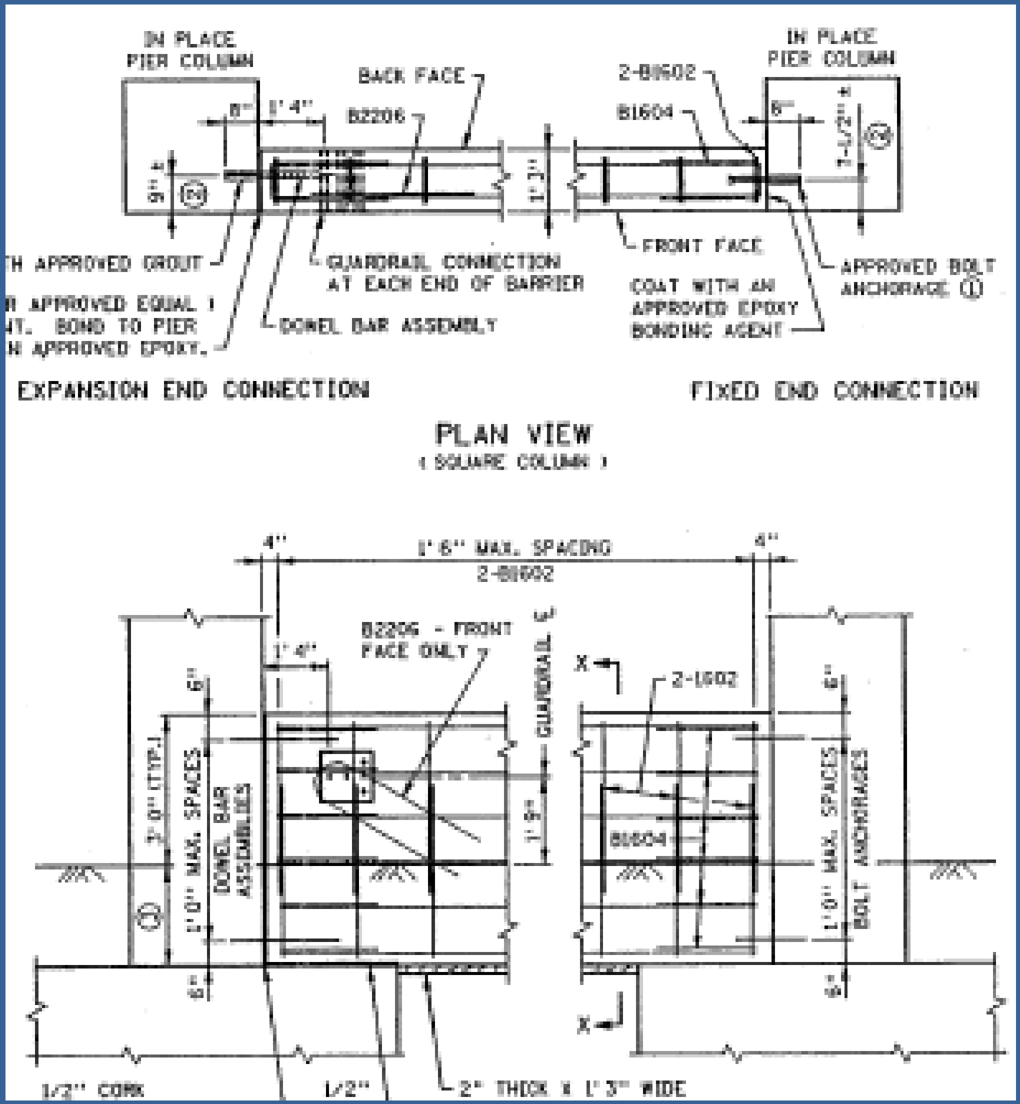
- Existing bridges
  - Everything mentioned for new bridges

    plus
  - Scope of the construction project
  - Existing median barrier
  - Existing in-fill wall

Policy Considerations

- In-fill wall based on archived standard plan 5-297.610

- Height is 36” and does not meet current AASHTO



Revised Policy for New Bridges

- Bridges over roadways
  - Will adopt 600 kip load with load application at up to 15 degrees maximum from tangent to roadway
  - Will continue exemption for all abutments, due to soil behind them
  - Will continue exemption for redundant piers (3 or more columns) adjacent to roadways with design speeds ≤ 40 mph

Revised Policy for New Bridges

- Bridges over roadways
  - Other criteria still being studied
    - Design speed > 40 mph
    - Exemption based on AF_{HBP}
    - Definition of critical bridge
    - Increase in height of collision load impact

Revised Policy for New Bridges

- Bridges over railroads
  - Will follow requirements found in

    AREMA Manual for Railway Engineering

    Chapter 8, Article 2.1.5

    - Pier protection required when distance from centerline of railway to face of pier < 25 ft
    - When pier protection is required, can provide crash wall (minimum of 2.5 ft x 12 ft) with height of 6 ft or 12 ft above top of rail depending on clearance to rail

      or

      pier shall be "of heavy construction"

      (minimum cross-sectional area of 30 sq ft)

Revised Policy for New Bridges

- Bridges over railroads

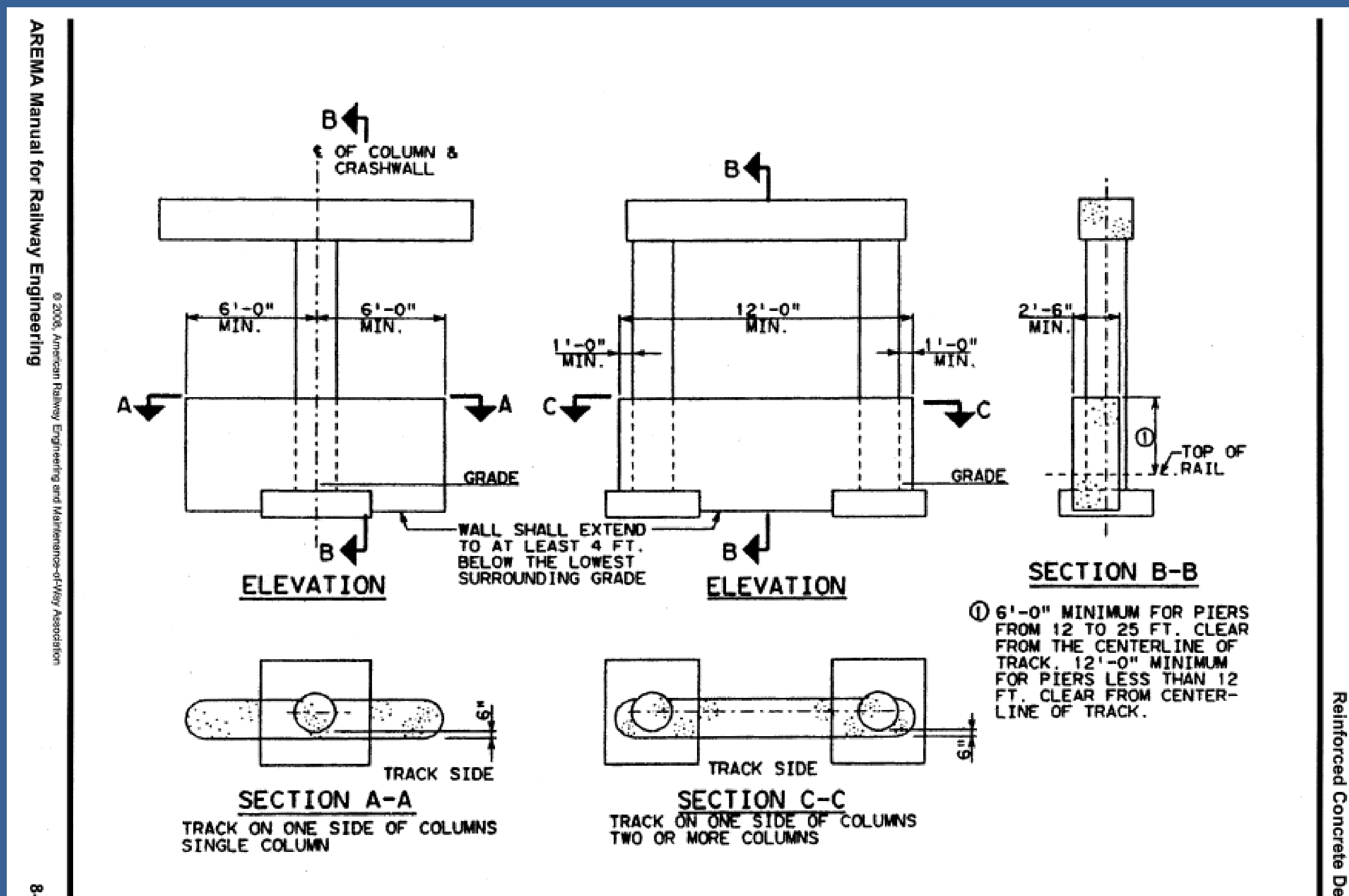


Figure C-8-2-1. Pier Protection: Minimum Crash Wall Requirements (Not To Scale)

Revised Policy for Existing Bridges

- Retrofitting of piers to meet current pier protection policy will be required for:
  - Bridge repair projects that include substructure widening
  - Roadway projects beneath bridges that move the edge of travel lane within 30 feet of the pier

Revised Policy for Existing Bridges

- Retrofitting of piers to meet current pier protection policy will be considered for bridge repair projects in the following situations:
  - High speed limit
  - High ADTT
  - Curved alignment
  - Piers with less than 3 columns & non-continuous superstructure

Revised Policy for Existing Bridges

- Retrofitting of piers to meet current pier protection policy will be considered for roadway projects in the following situations:
  - Profile grade raise resulting in significant reduction of current in-fill wall height
  - Guardrail replacement where new connections to piers are required

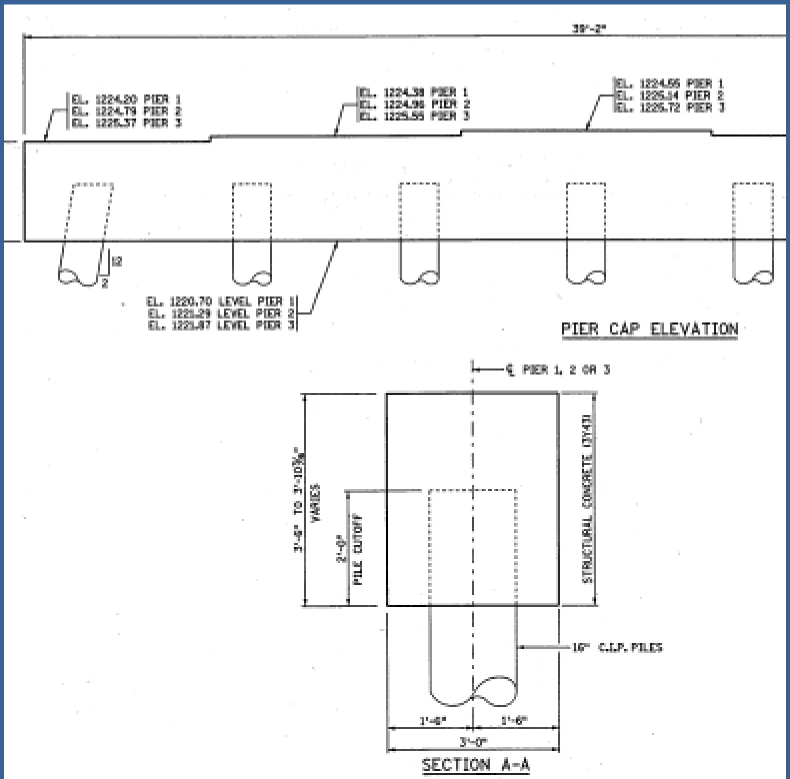
Future Changes?

- NCHRP 12-90 Guidelines for Shielding Bridge Piers
  - Develop risk-based guidelines that quantify when pier protection investigation is needed considering site conditions, traffic, etc.
  - Develop guidelines for barrier selection, length, and placement to shield bridge piers

- 3 year project

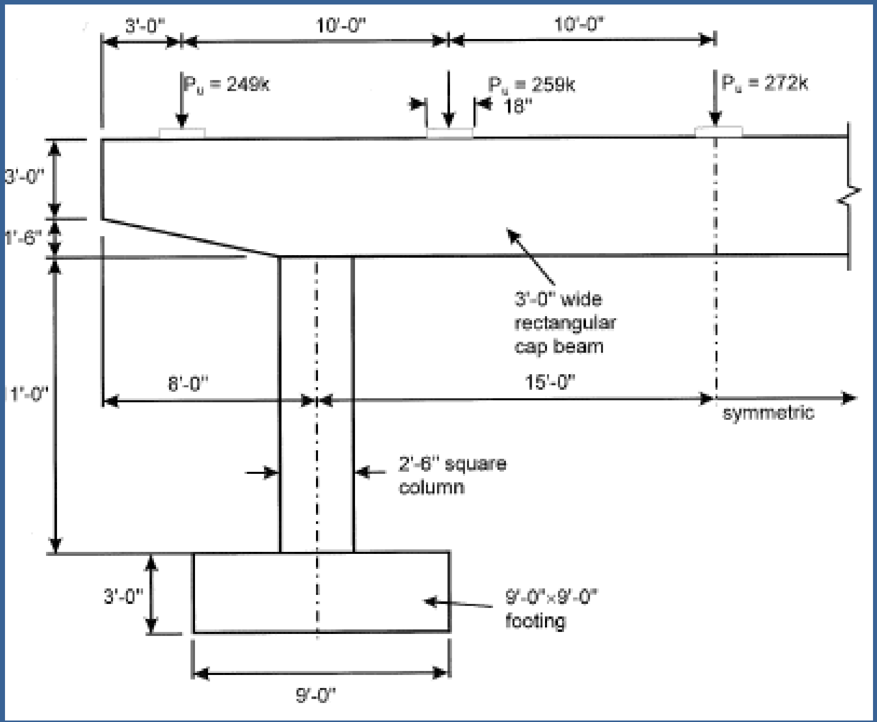
Design & Detailing Issues

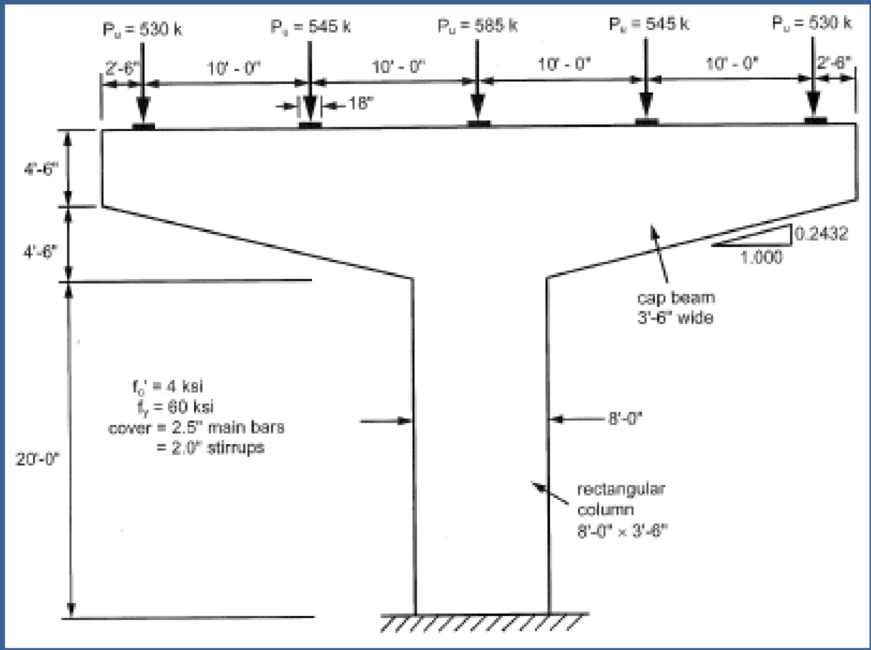
- Pile bent piers
  - Check stability
    - Consider scour
    - Do not use MnDOT Bridge Design Manual (BDM) Article 10.6



Design & Detailing Issues

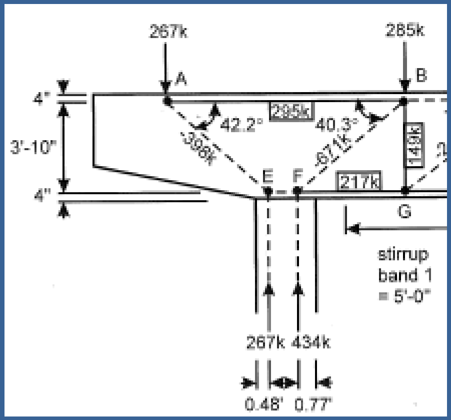
- Pier caps
  - Strut and tie

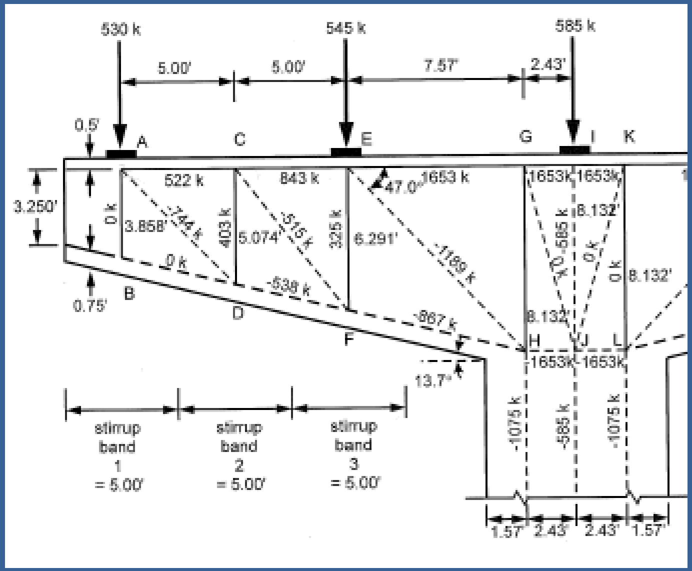


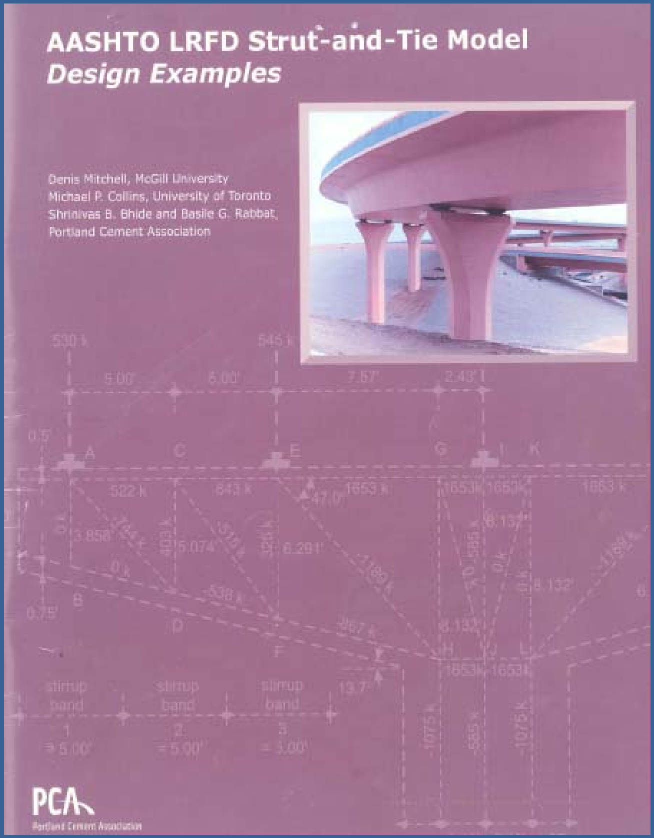


Design & Detailing Issues

- Pier caps
  - Strut and tie

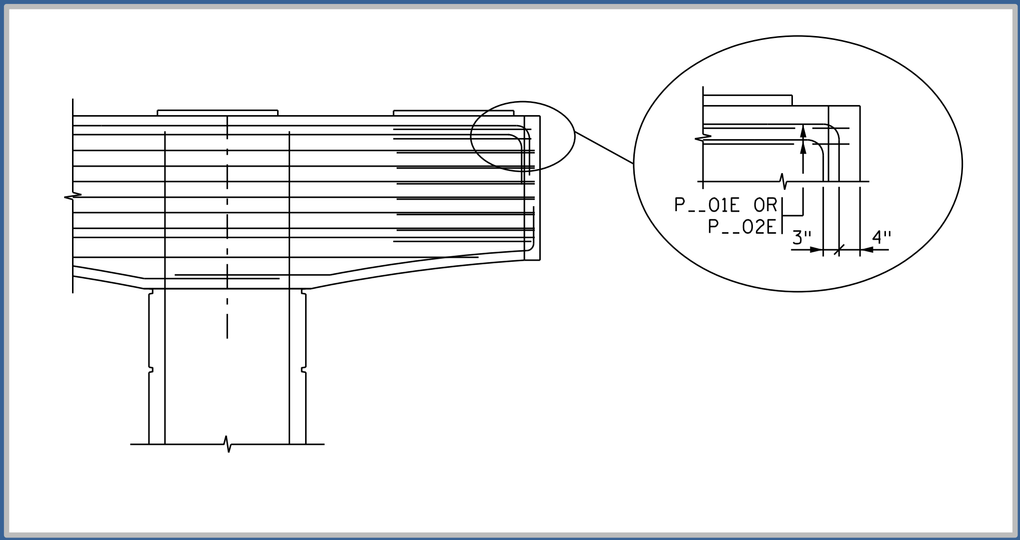






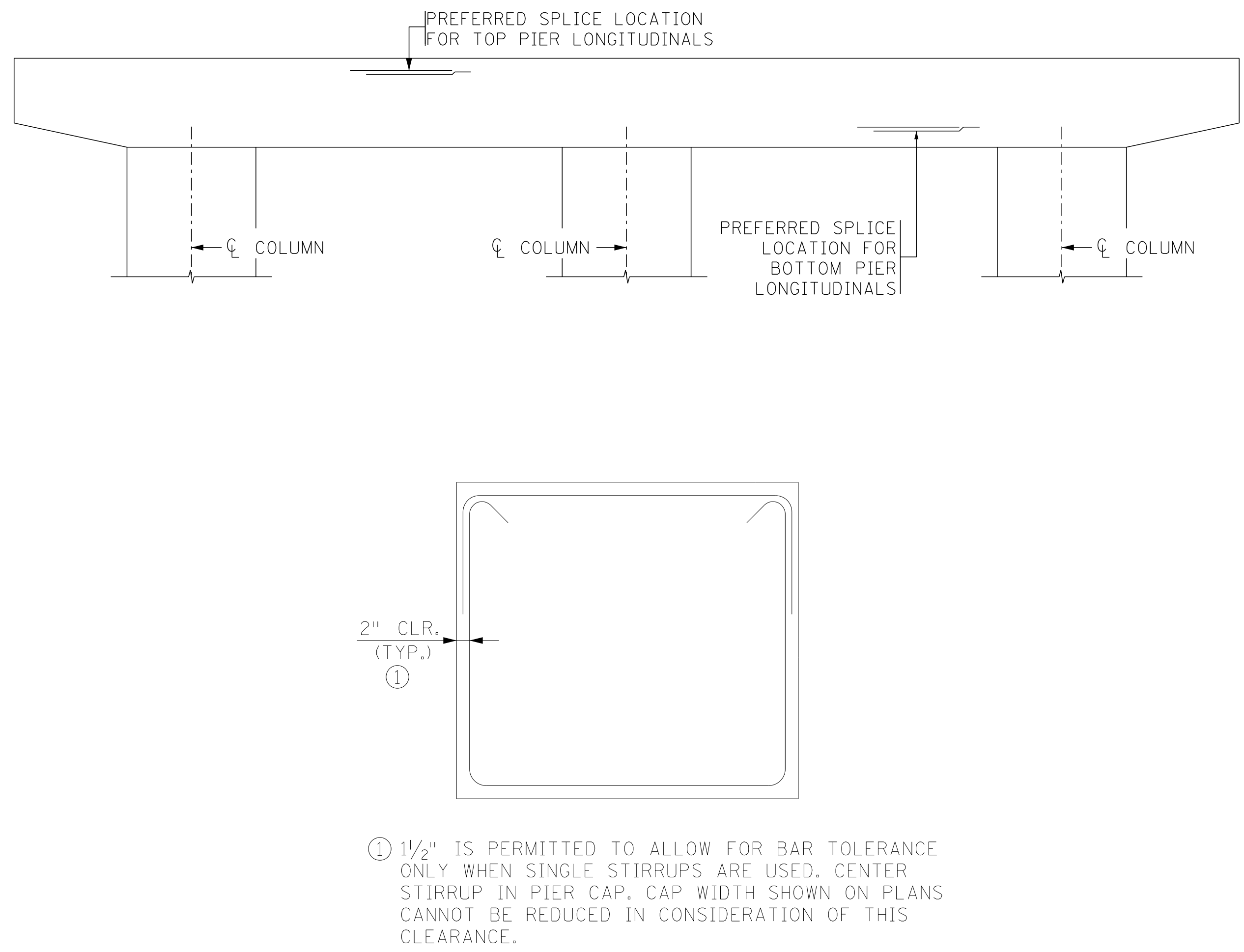
Design & Detailing Issues

- Pier caps
  - Provide standard hooks at ends of longitudinal bars & detail bars to avoid conflicts



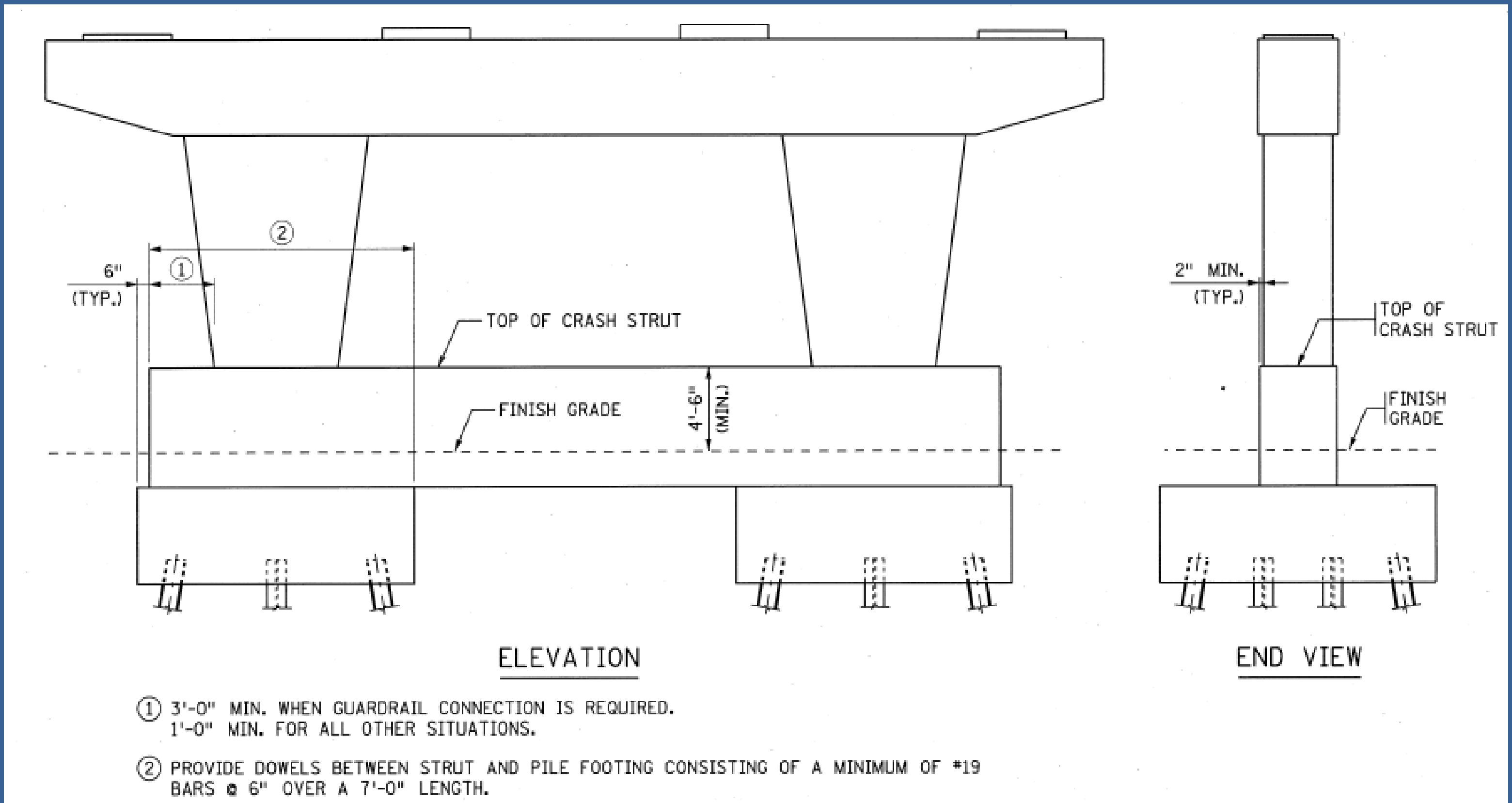
Design & Detailing Issues

- Pier caps
  - Provide spliced longitudinal bars
  - For single stirrups, provide note



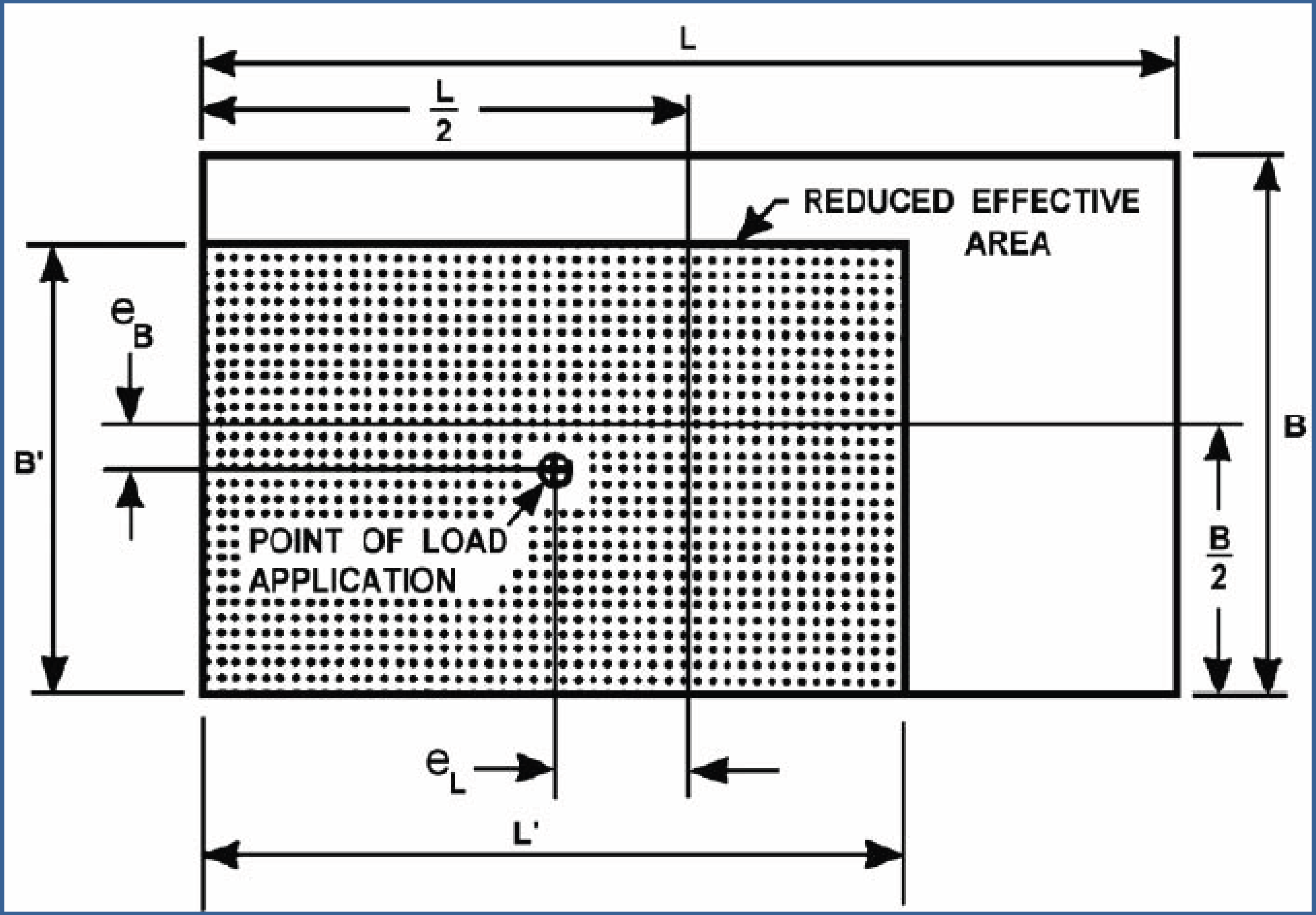
Design & Detailing Issues

- Pier columns
  - Thermal loads



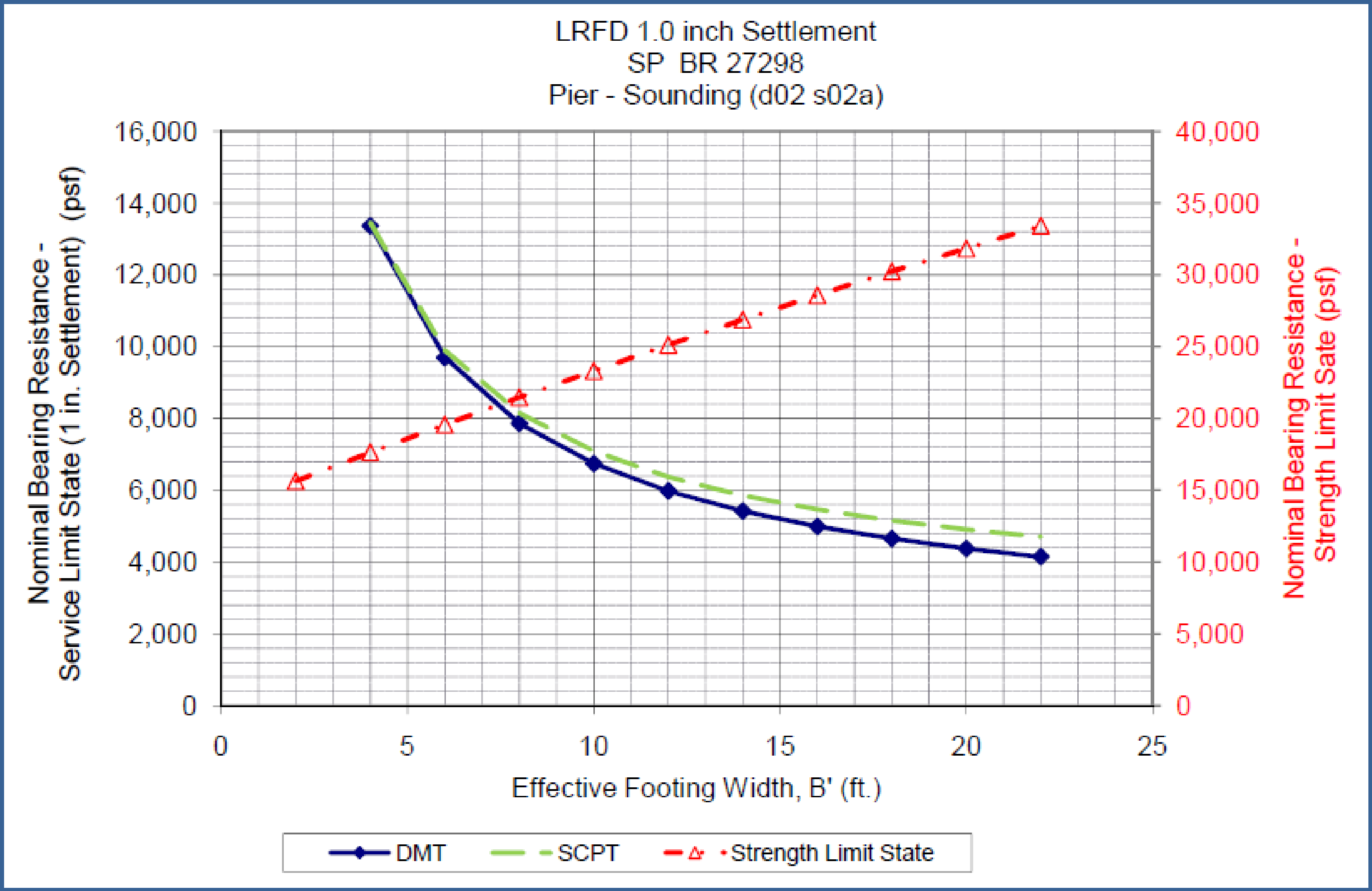
Design & Detailing Issues

- Piers on spread footings

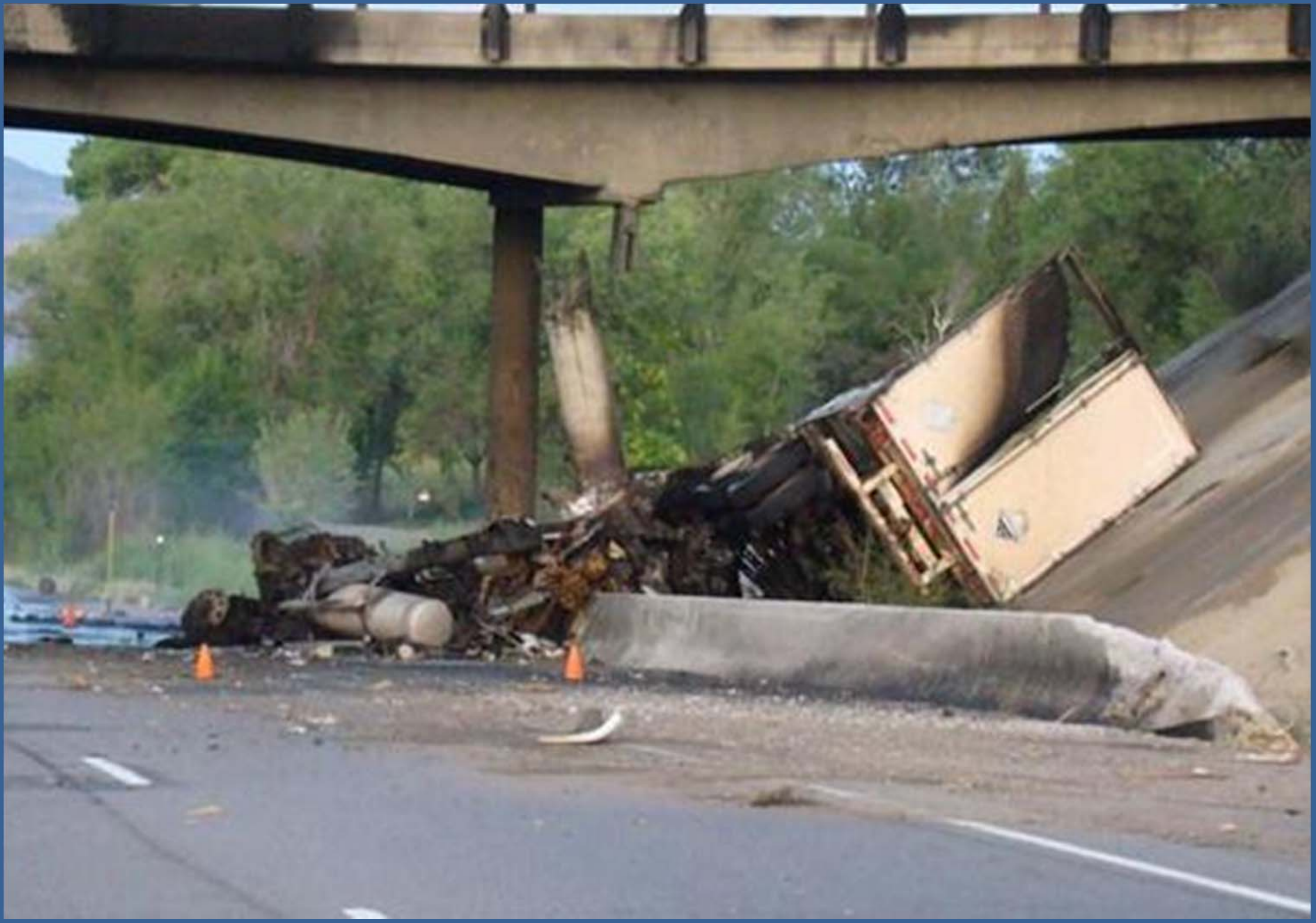


Design & Detailing Issues

- Piers on spread footings



Questions?



Prestressed Elements

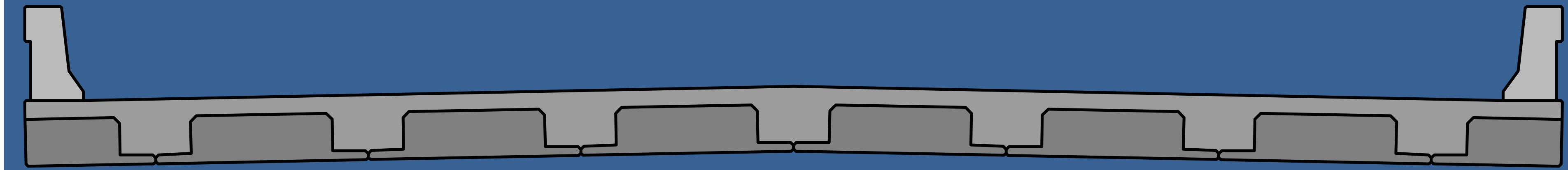
Ben Jilk
Bridge Design Engineer

Outline

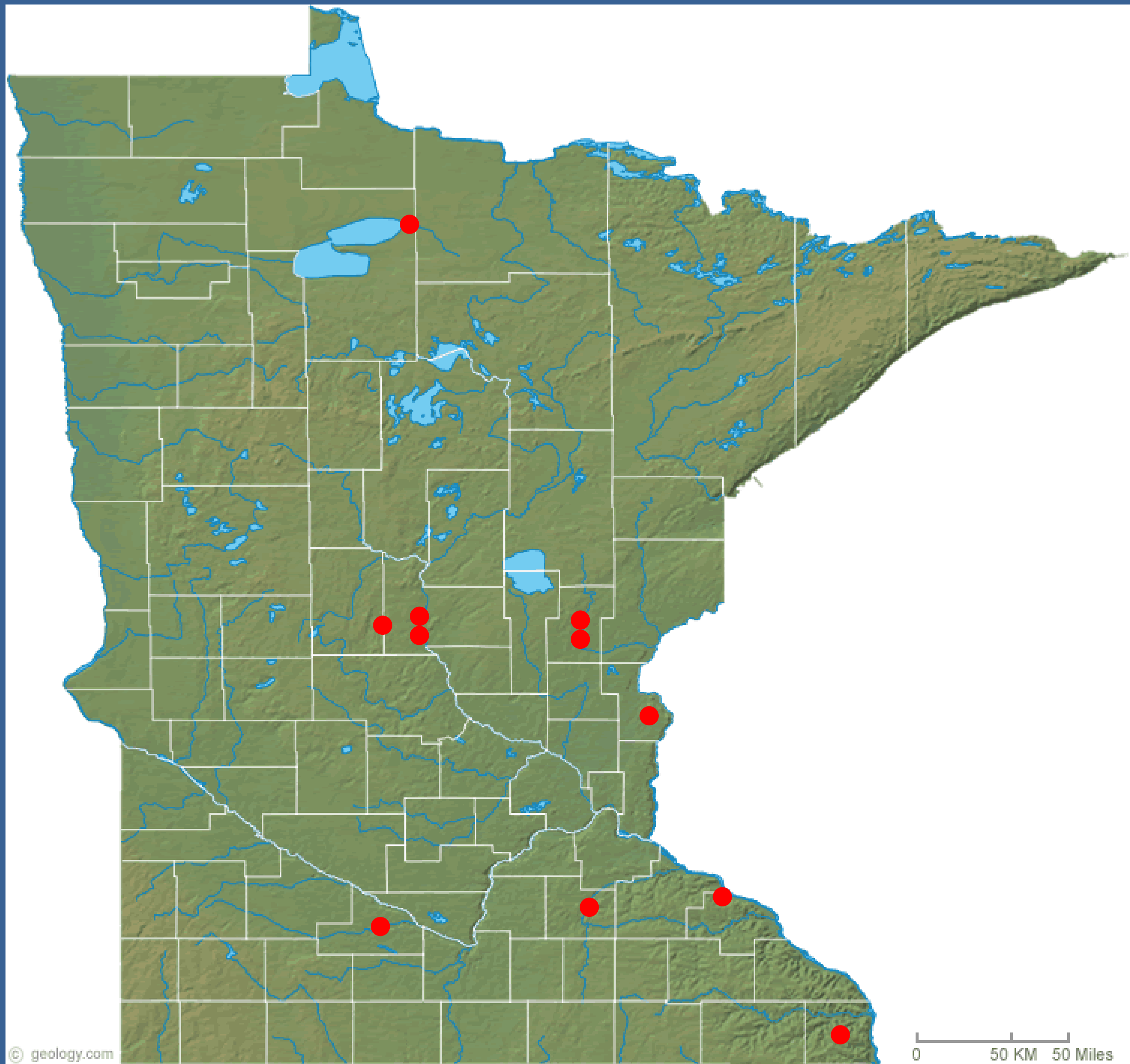
- Inverted tees
- New MW-shapes and archiving M-shapes
- Camber study
- Curved bridge design

Inverted Tees

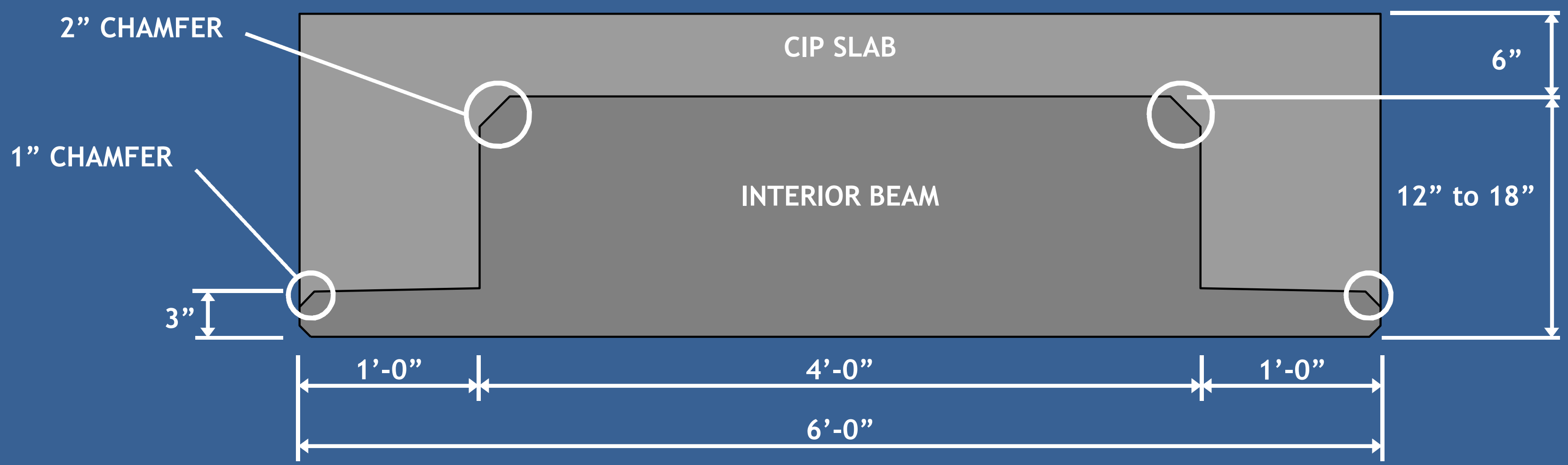
- Developed in 2004 as an alternative to slab span bridges
- Spans up to ≈45’
- Typically not used on skewed bridges
- Intended to speed up construction
- 4 generations built, 5th to be designed this summer

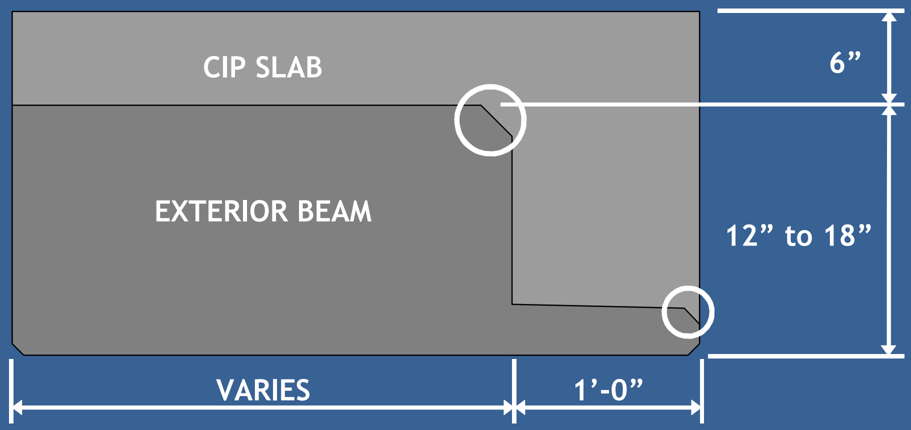


Inverted Tees - Locations

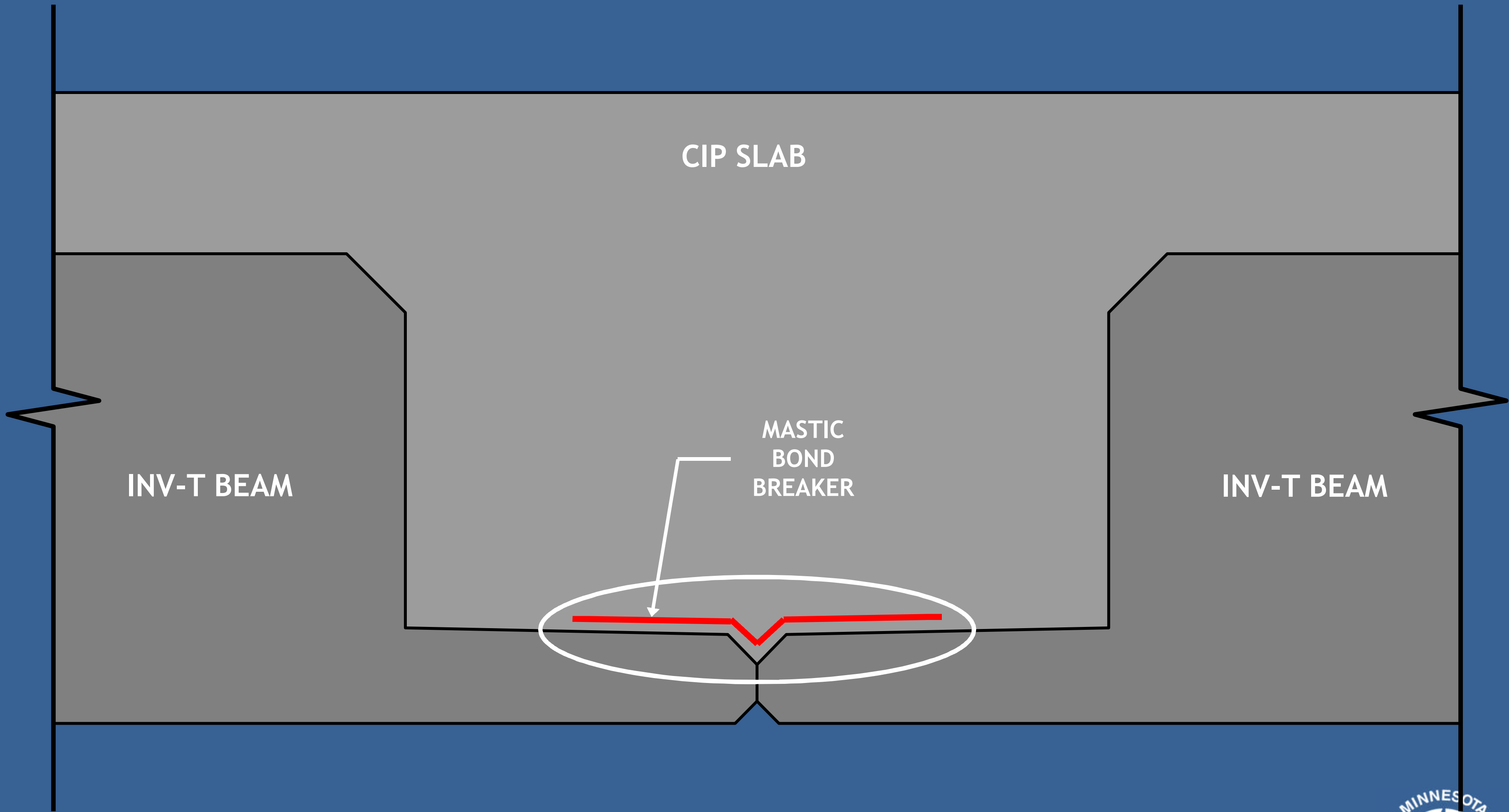


Inverted Tees - Geometry

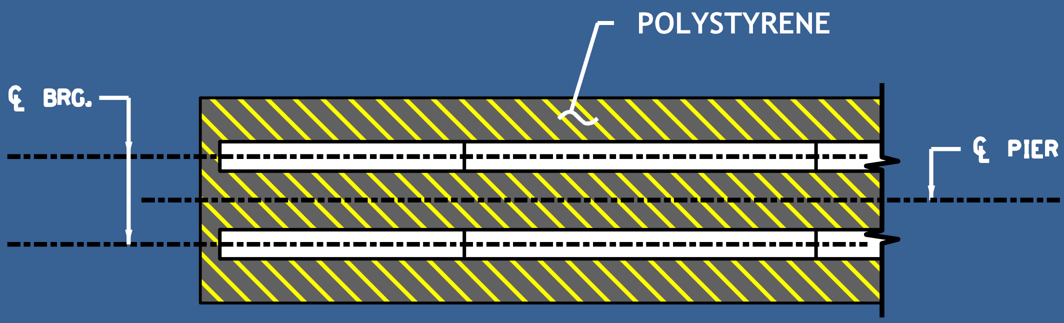




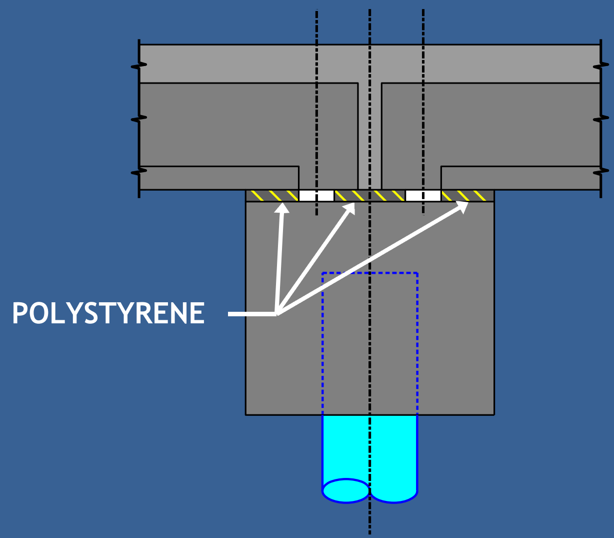
Inverted Tees - Geometry



Inverted Tees



PIER



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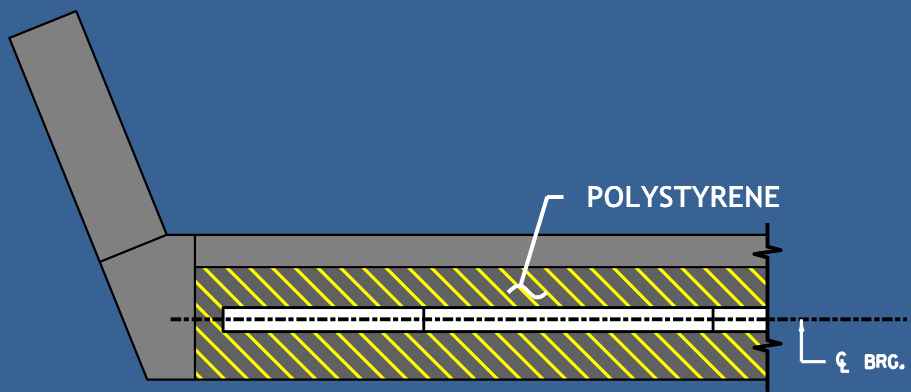
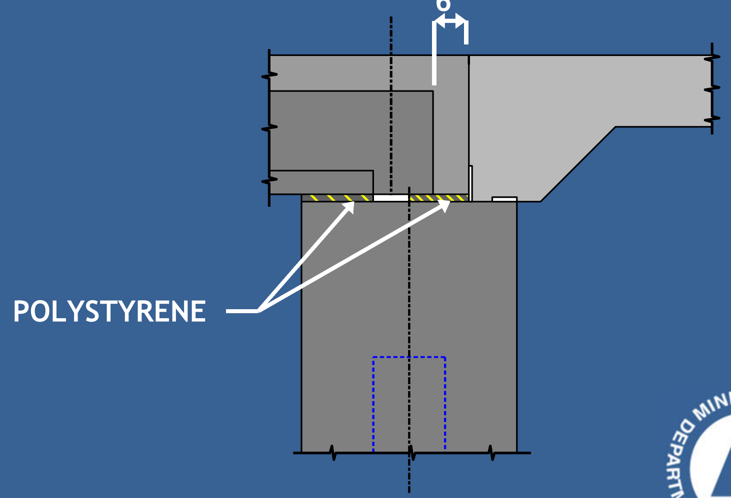


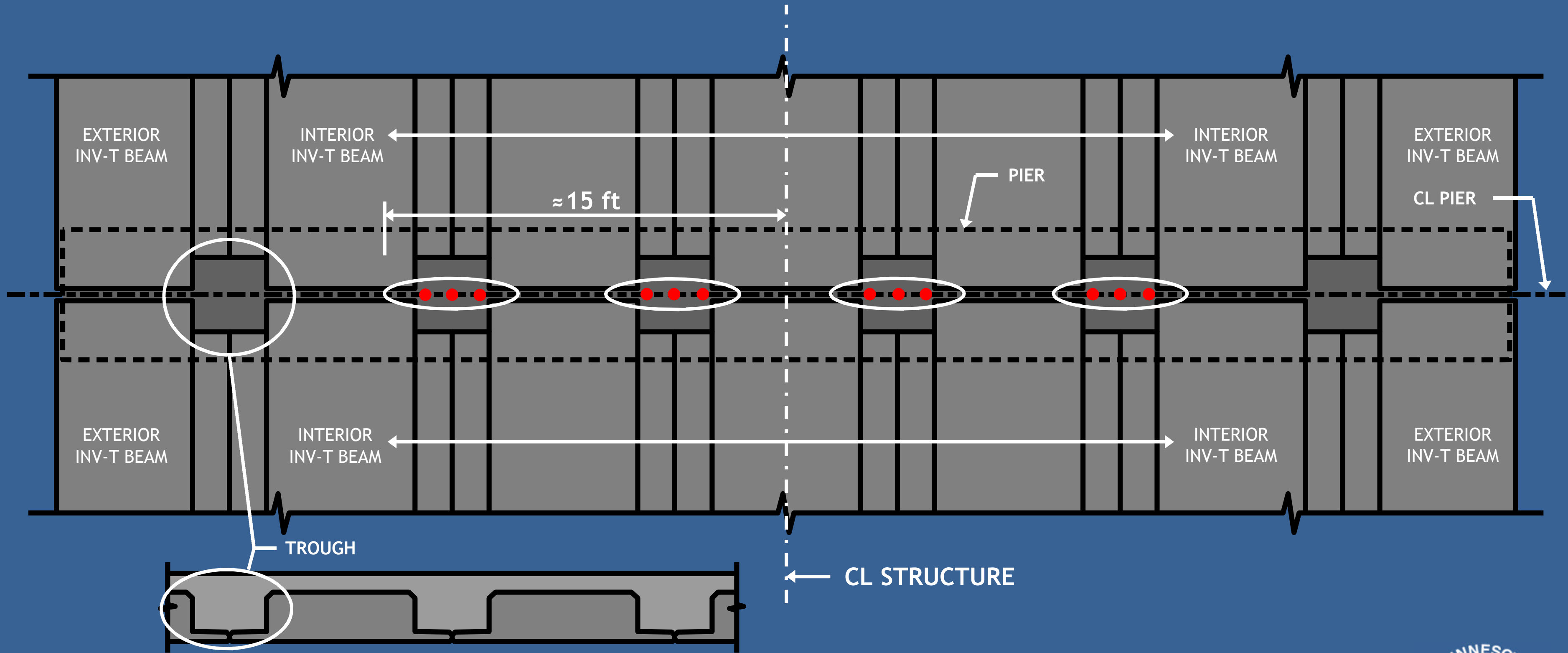
ABUTMENT



ABUTMENT

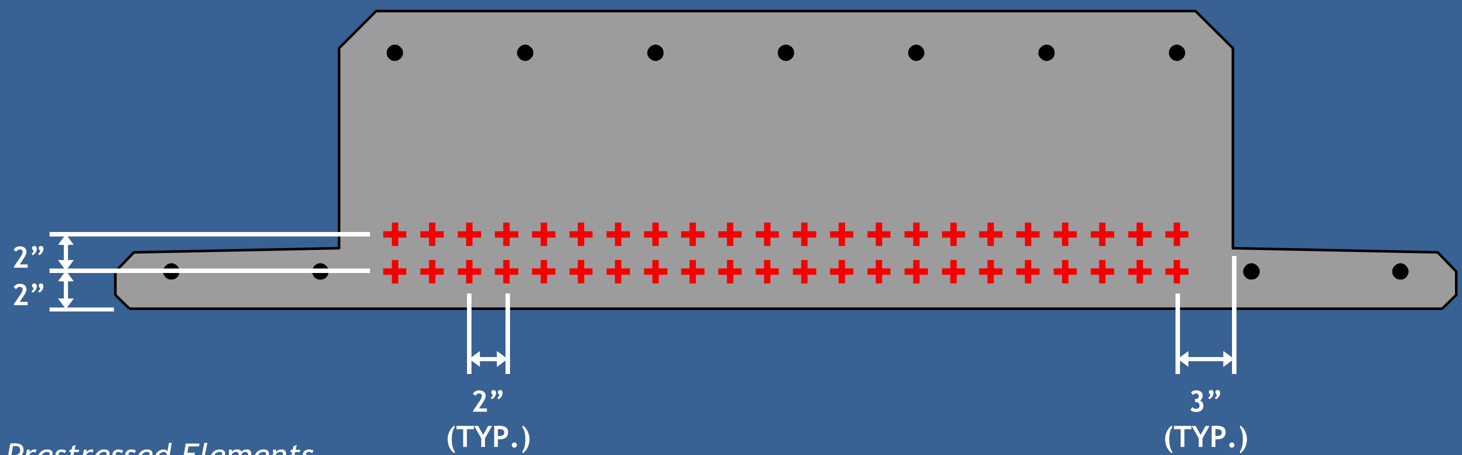
Inverted Tees

- Stainless steel
- Wrapped at piers, not abutments



Inverted Tees - Materials

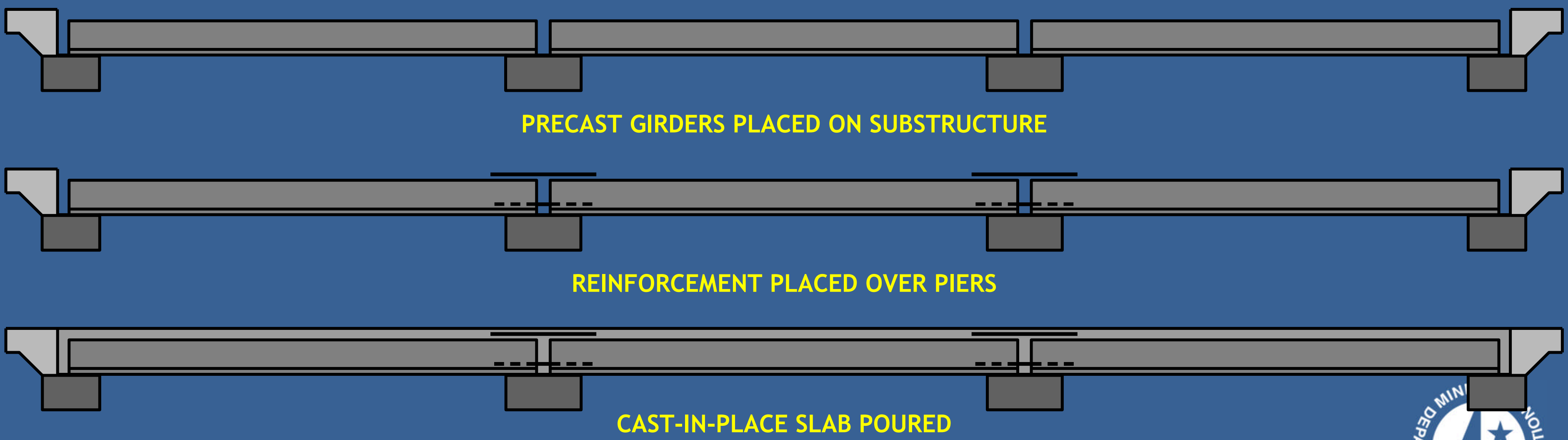
- Beam Concrete
  - f'_{ci} = 4 ksi
  - f'_c = 6 ksi
- Slab Concrete
  - f'_c = 4 ksi
- ½" diameter 7-wire low-relaxation strands



Inverted Tees – Design

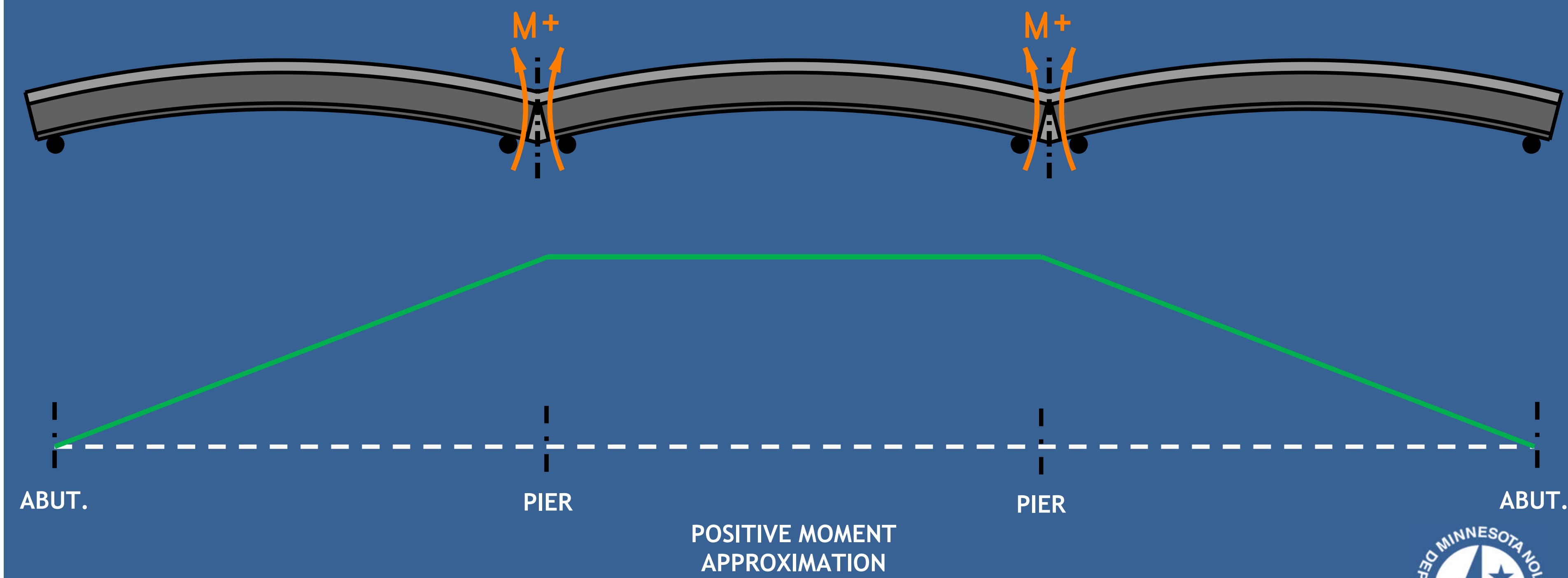
- LLDF calculated assuming slab-type bridge
- Additional loads:
  - Restraint moment (time dependent)
  - Thermal gradient

CONSTRUCTION SEQUENCE FOR THREE-SPAN BRIDGE WITH INVERTED TEES MADE CONTINUOUS FOR LIVE LOADS



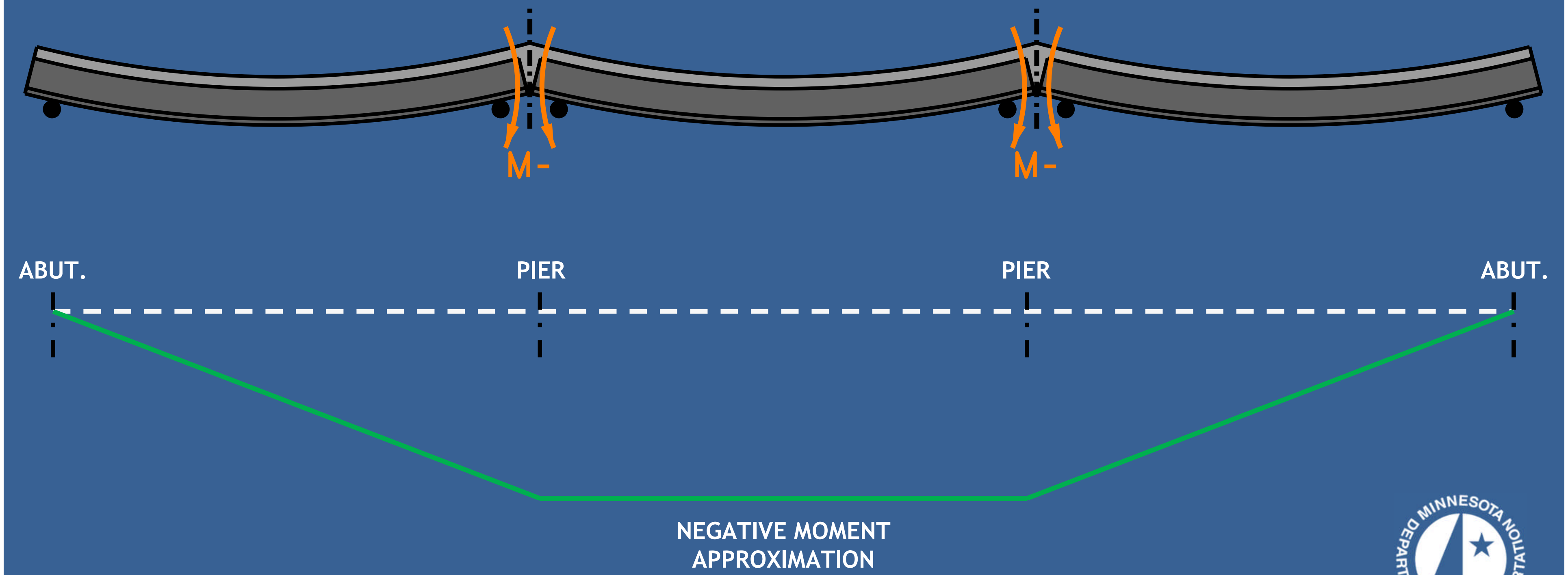
Inverted Tees - Design

- Positive restraint moments
  - Beam prestress creep
- Positive thermal gradient



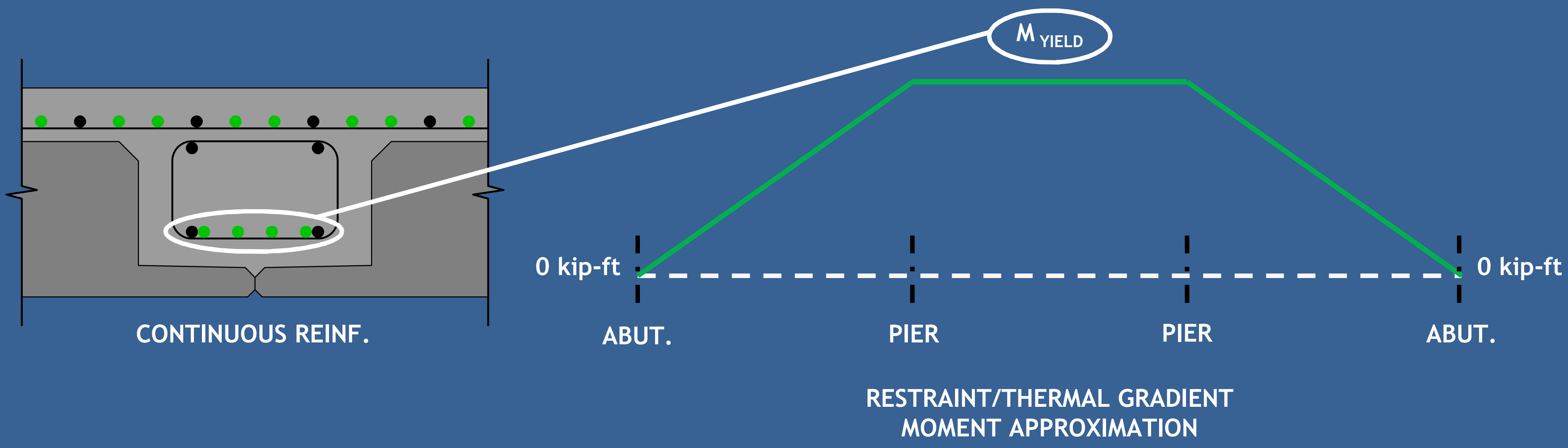
Inverted Tees - Design

- Negative restraint moments
  - Dead load creep (beam self-weight, CIP deck weight)
  - Deck shrinkage
- Negative thermal gradient



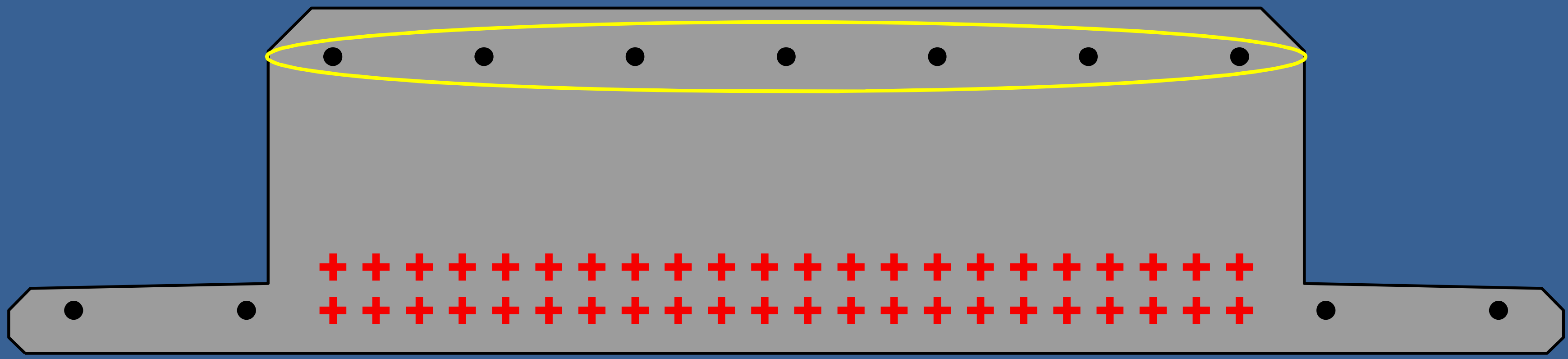
Inverted Tees – Design

- Designed as simple-span
- Restraint moments and thermal gradient included by taking yield moment of trough reinforcement continuous over the piers



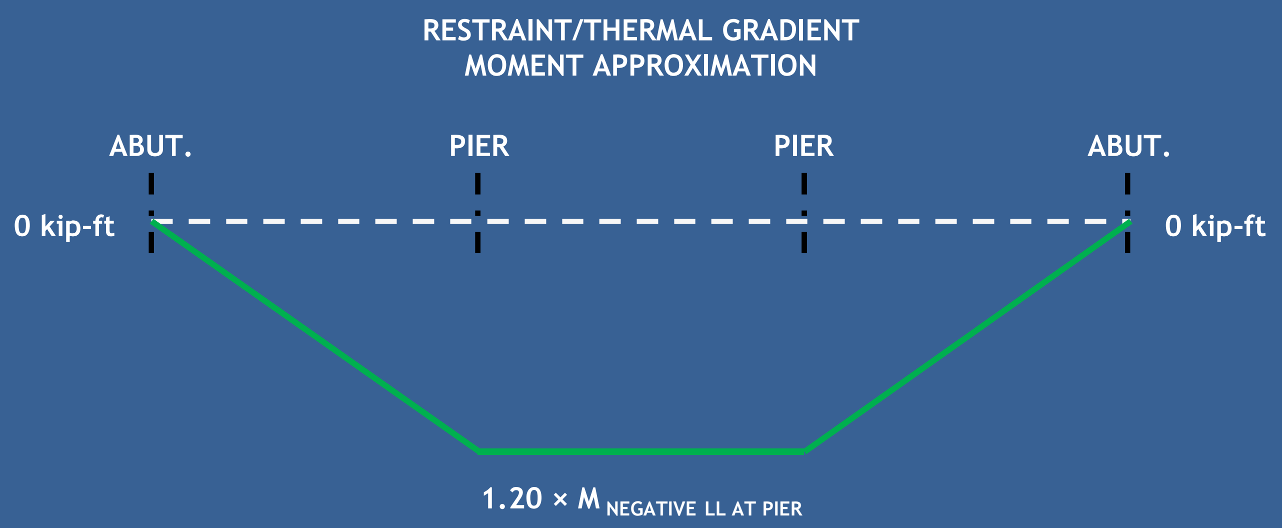
Inverted Tees – Beam Design

- Tension at release limited to $0.24\sqrt{f'_{ci}}$ rather than $0.0948\sqrt{f'_{ci}}$ or 200 psi used for typical prestressed beams



Inverted Tees – Slab Design

- Designed as continuous for loads applied after slab cures (barrier, FWS, LL)
- Restraint moments and thermal gradient included by applying a factor of 1.20 to the negative LL moment at the piers

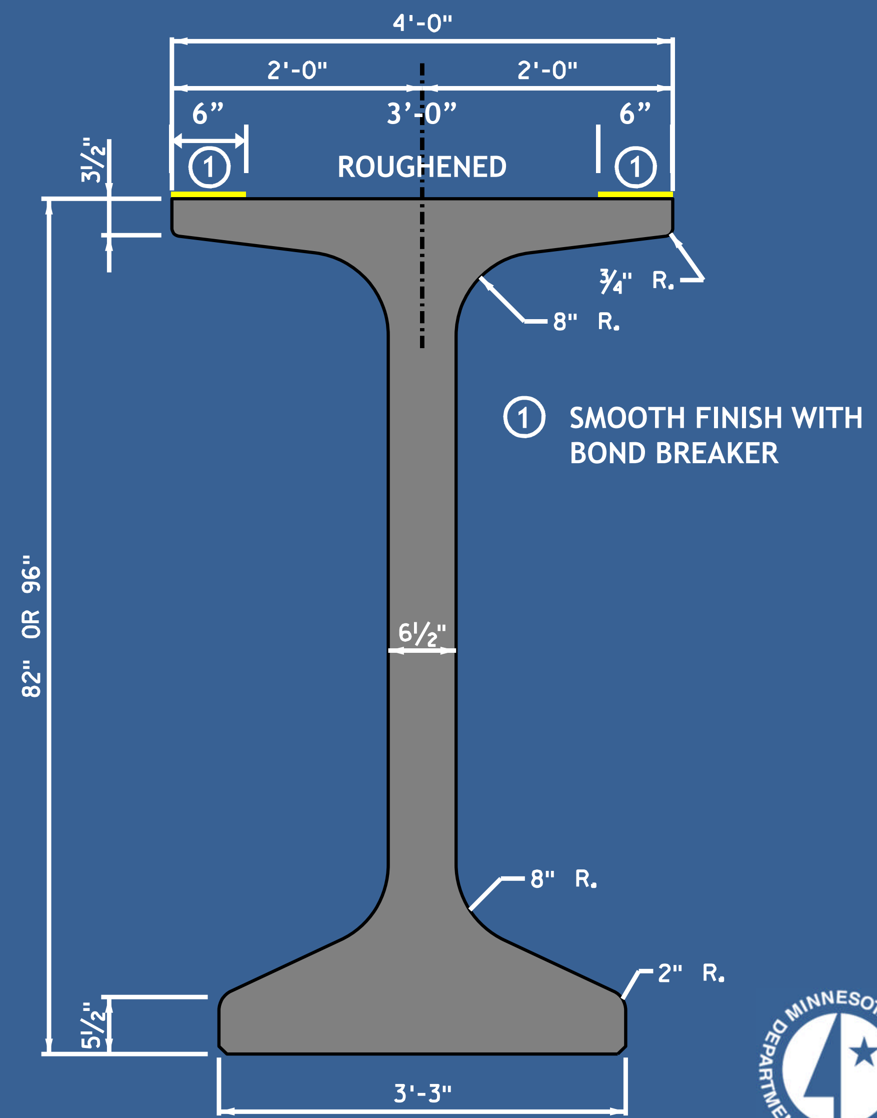


Inverted Tees

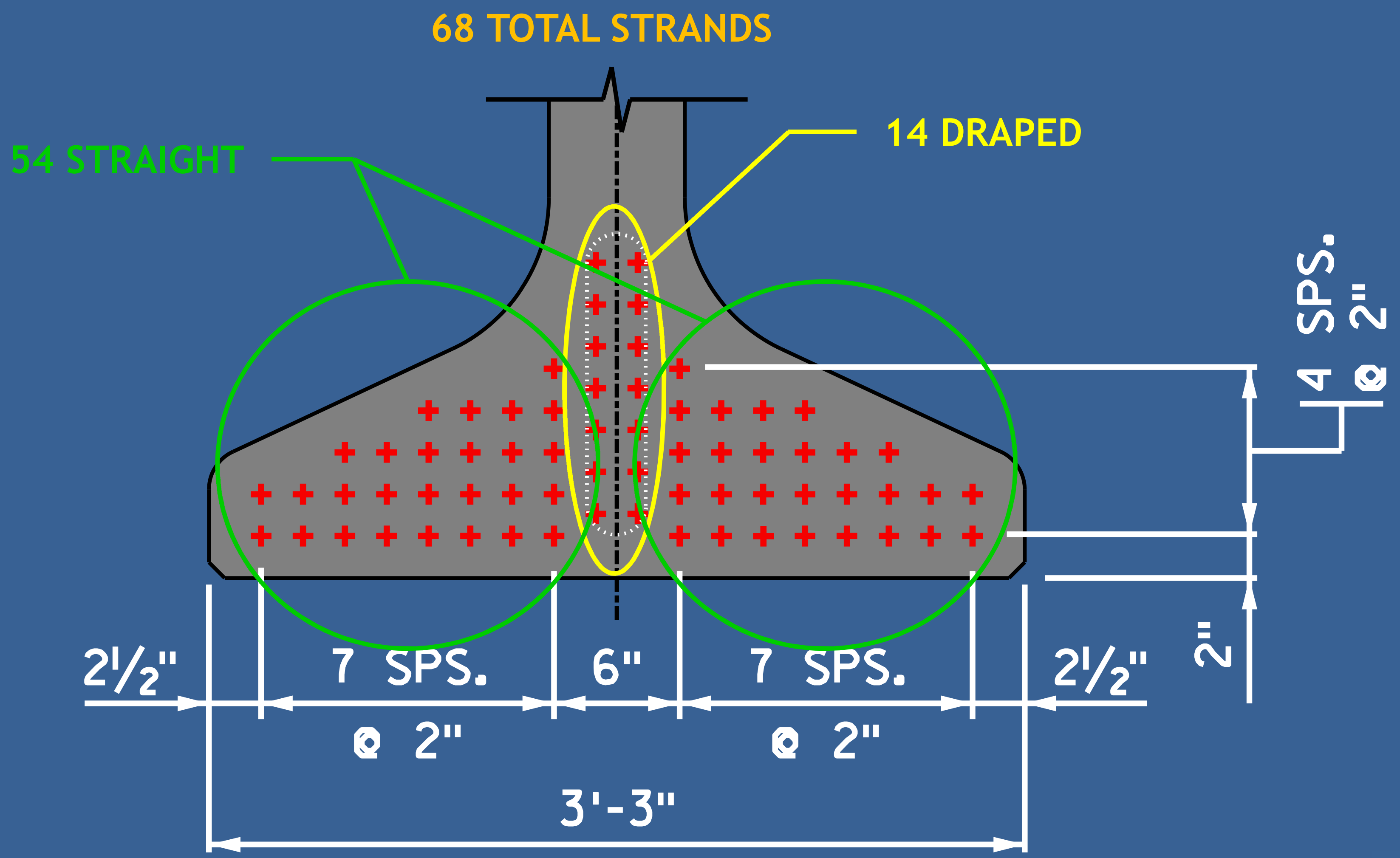
- MnDOT is currently in the process of developing guidelines for Inverted Tees which will be released once completed.

MW Shapes

- Goal to develop:
  - Beams that span farther than existing shapes OR
  - Beams that could be used at a wider spacing
- 82” and 96” MW Beams
- MnDOT Memo to Designers (2011-01), July 29, 2011

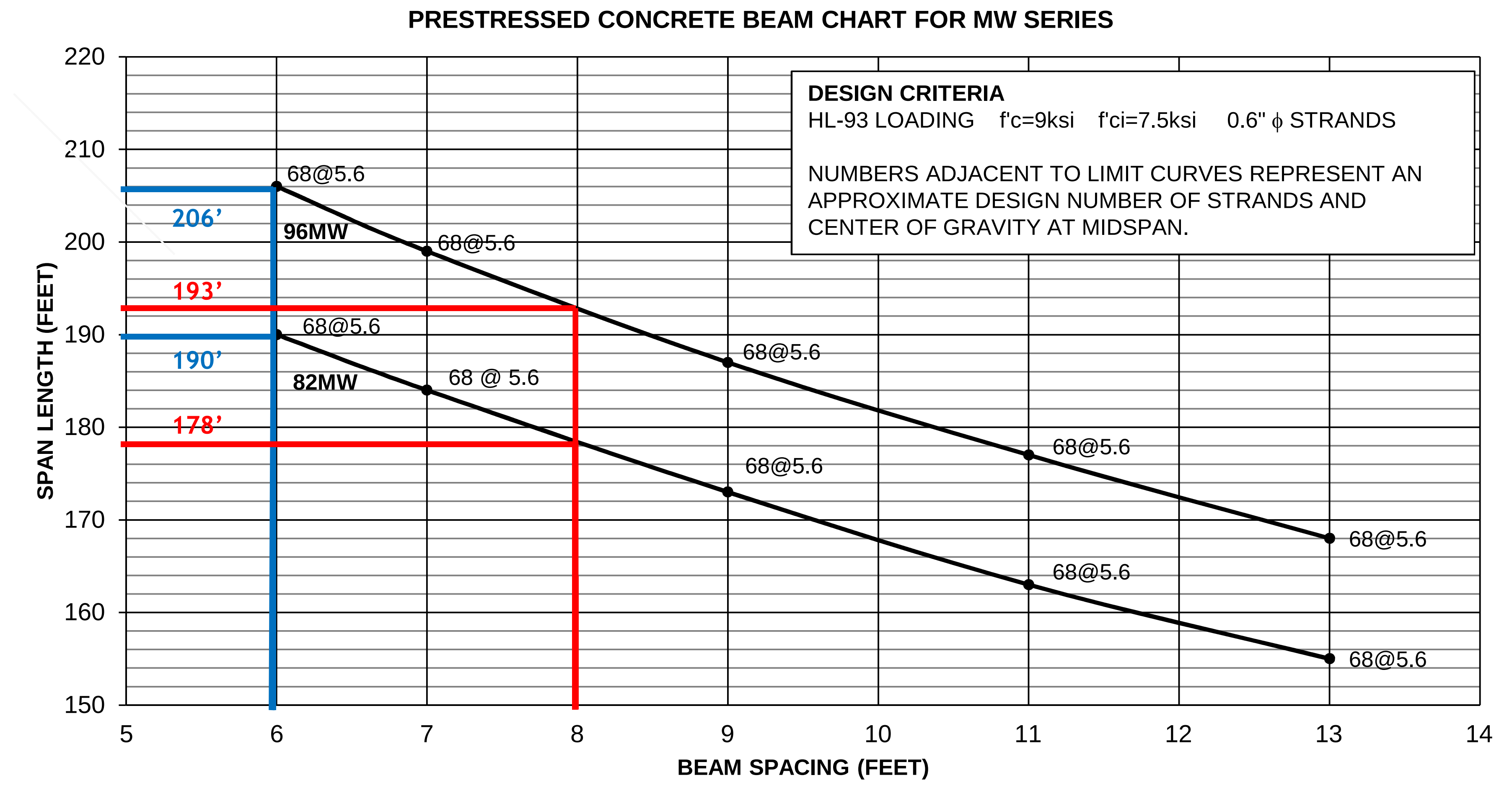


MW Shapes



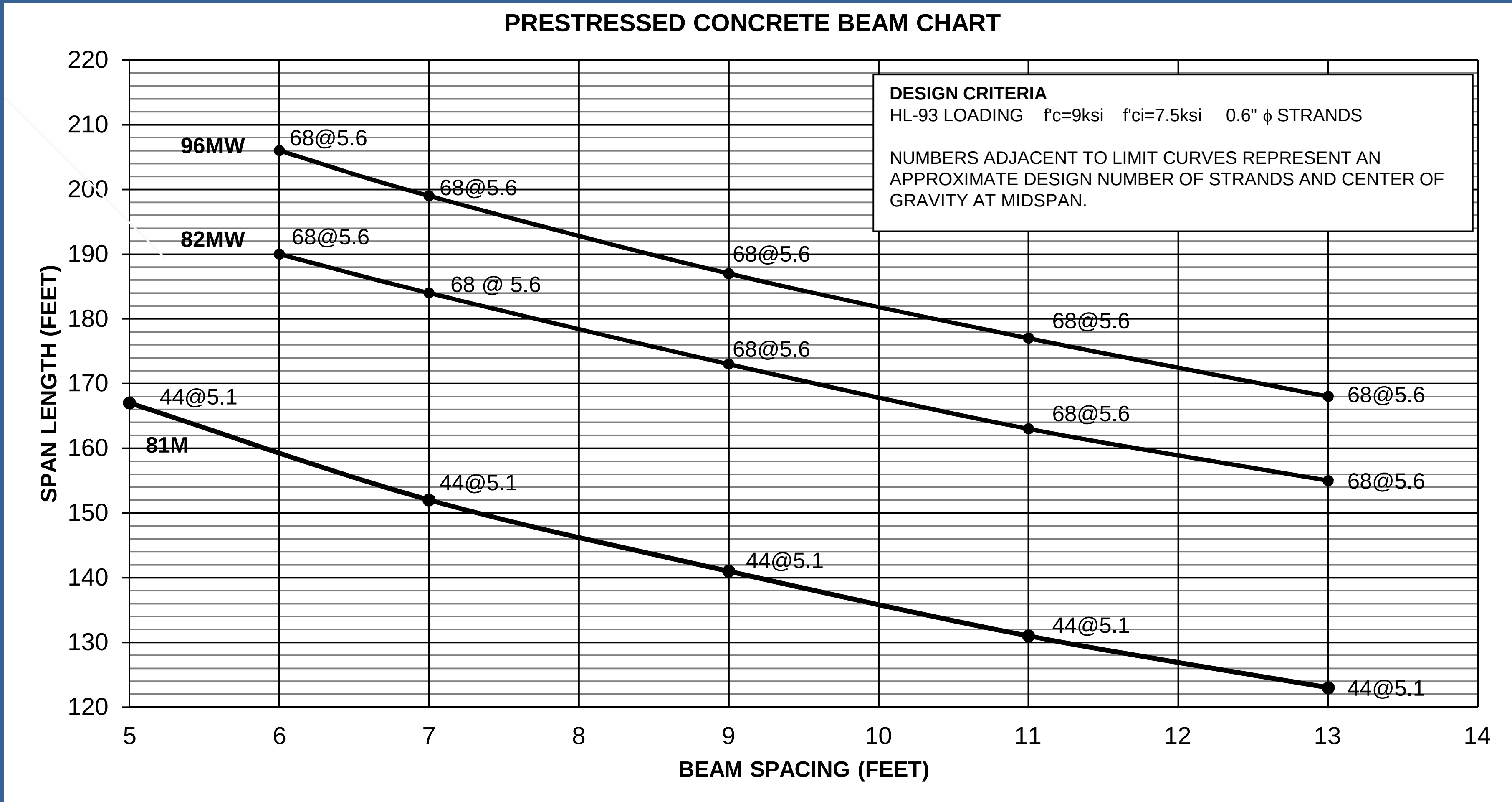
68 TOTAL STRANDS
54 STRAIGHT
14 DRAPED
4 SPS. @ 2"
2"
2½"
7 SPS. @ 2"
6"
7 SPS. @ 2"
2½"
3'-3"

MW Shapes



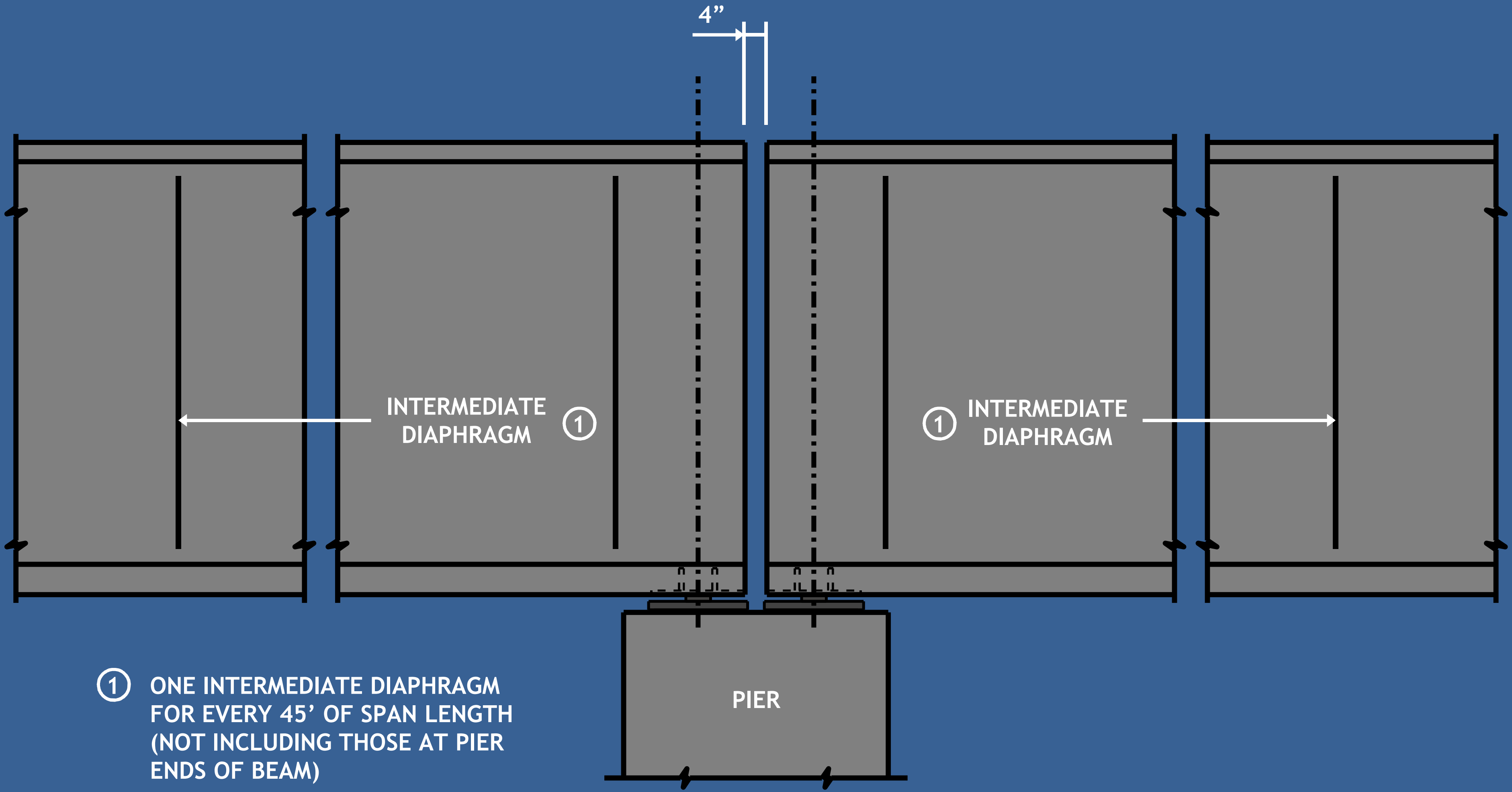
PRESTRESSED CONCRETE BEAM CHART FOR MW SERIES
DESIGN CRITERIA
HL-93 LOADING f'c=9ksi f'ci=7.5ksi 0.6" ϕ STRANDS
NUMBERS ADJACENT TO LIMIT CURVES REPRESENT AN APPROXIMATE DESIGN NUMBER OF STRANDS AND CENTER OF GRAVITY AT MIDSPAN.
SPAN LENGTH (FEET)
BEAM SPACING (FEET)
96MW
82MW
206’
193’
190’
178’
68@5.6
68 @ 5.6
220
210
200
190
180
170
160
150
5
6
7
8
9
10
11
12
13
14

MW Shapes



PRESTRESSED CONCRETE BEAM CHART
DESIGN CRITERIA
HL-93 LOADING f'c=9ksi f'ci=7.5ksi 0.6" ϕ STRANDS
NUMBERS ADJACENT TO LIMIT CURVES REPRESENT AN APPROXIMATE DESIGN NUMBER OF STRANDS AND CENTER OF GRAVITY AT MIDSPAN.
96MW
82MW
81M
68@5.6
68 @ 5.6
44@5.1
SPAN LENGTH (FEET)
BEAM SPACING (FEET)
220
210
200
190
180
170
160
150
140
130
120
5
6
7
8
9
10
11
12
13
14

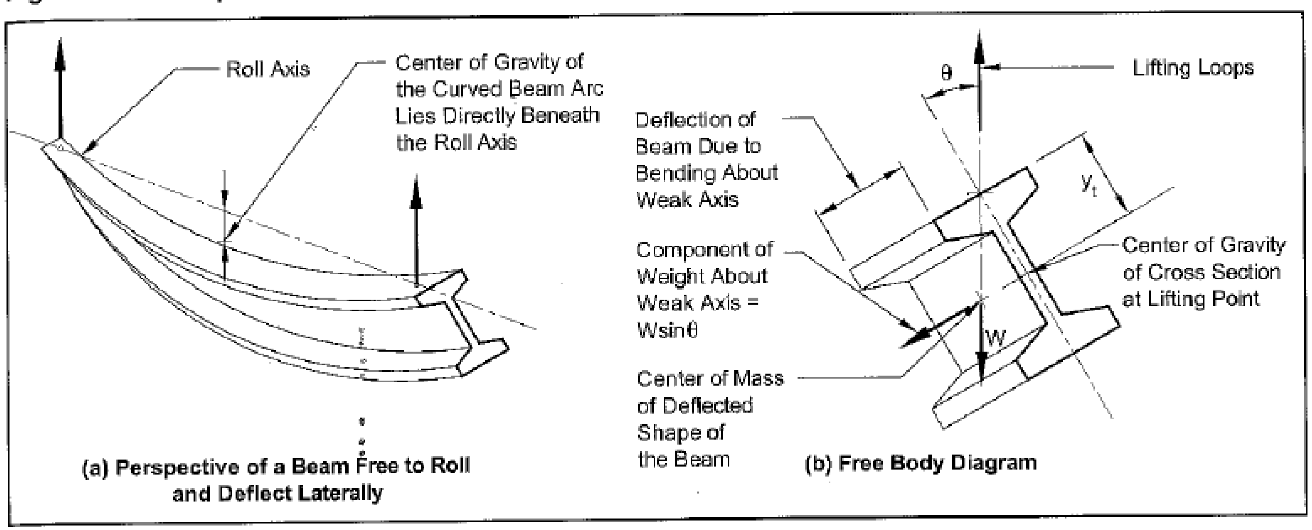
MW Shapes


4"
INTERMEDIATE DIAPHRAGM ①
① INTERMEDIATE DIAPHRAGM
PIER
① ONE INTERMEDIATE DIAPHRAGM FOR EVERY 45' OF SPAN LENGTH (NOT INCLUDING THOSE AT PIER ENDS OF BEAM)

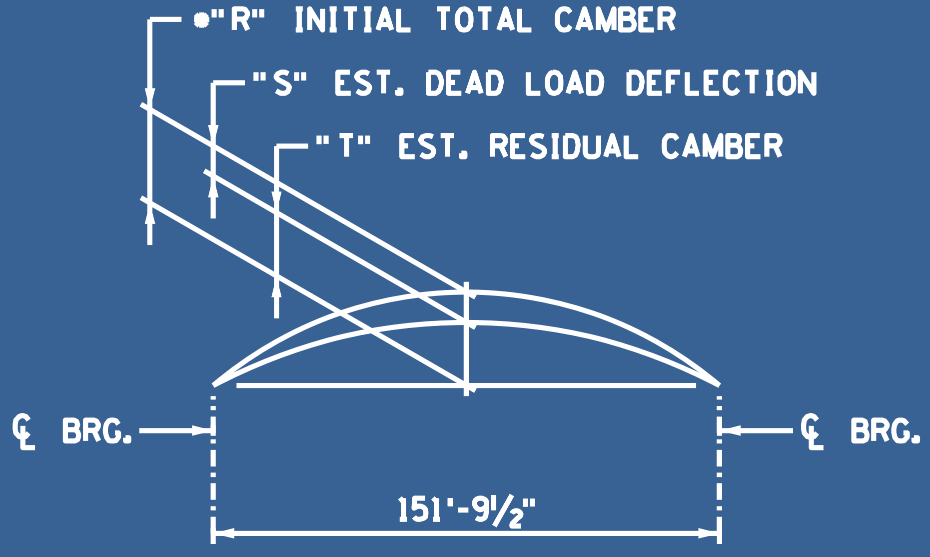
MW Shapes

- Shipment/handling of beams - lateral instability
- Deck pour sequence should be investigated
- Camber tracking required
  - Estimated cambers given in tabular form varying with age of girder

Figure 5.4.1.1 Equilibrium of beam in tilted position



MW Shapes – Camber Example



ESTIMATED CAMBER			
DAYS	"R"	"S"	"T"
30	5.37"	4.08"	1.29"
60	5.79"	4.08"	1.71"
90	5.99"	4.08"	1.91"
180	6.17"	4.08"	2.09"
360	6.28"	4.08"	2.20"

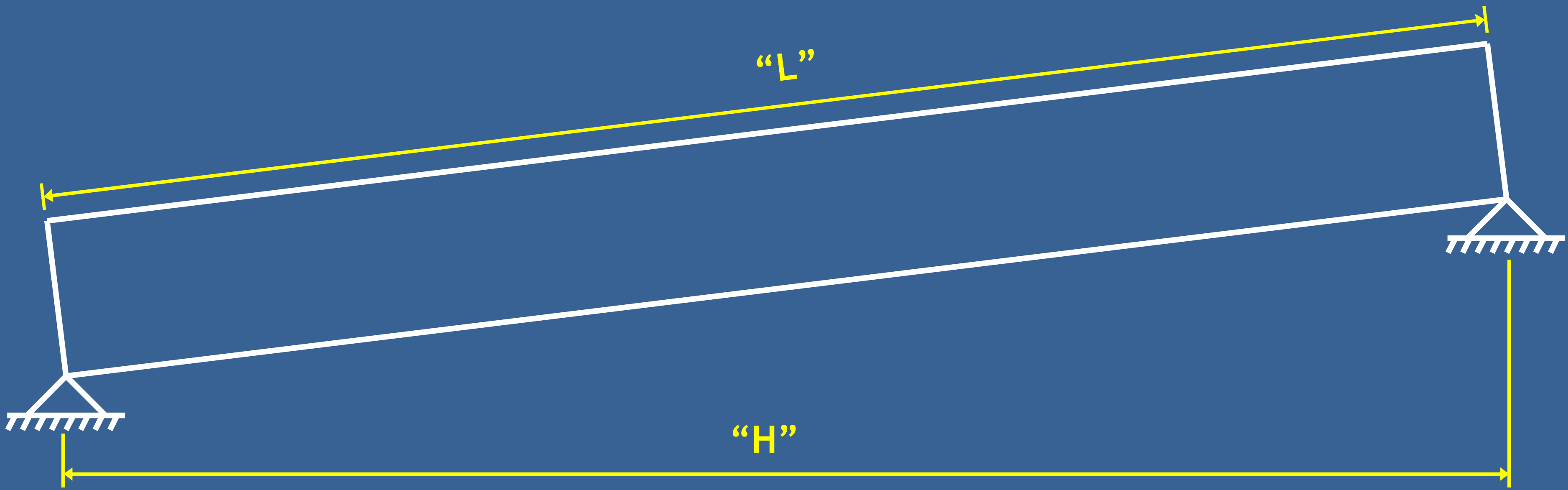
CAMBER NOTES

●CONTRACTOR SHALL MONITOR CAMBER OF BEAMS PRIOR TO ERECTION AND TAKE PRECAUTIONS TO ENSURE ACUTAL CAMBER AT ERECTION IS WITHIN 1" OF INITIAL TOTAL CAMBER.

BEARING SEAT ELEVATIONS BASED ON 180 DAY CAMBER. IF CAMBER GREATER THAN REPORTED, ADJUST BEARING SEAT ELEVATIONS.

MW Shapes

- Beam length on slopes
  - Use “L” in plan sheets when “L” - “H” ≥ ½”

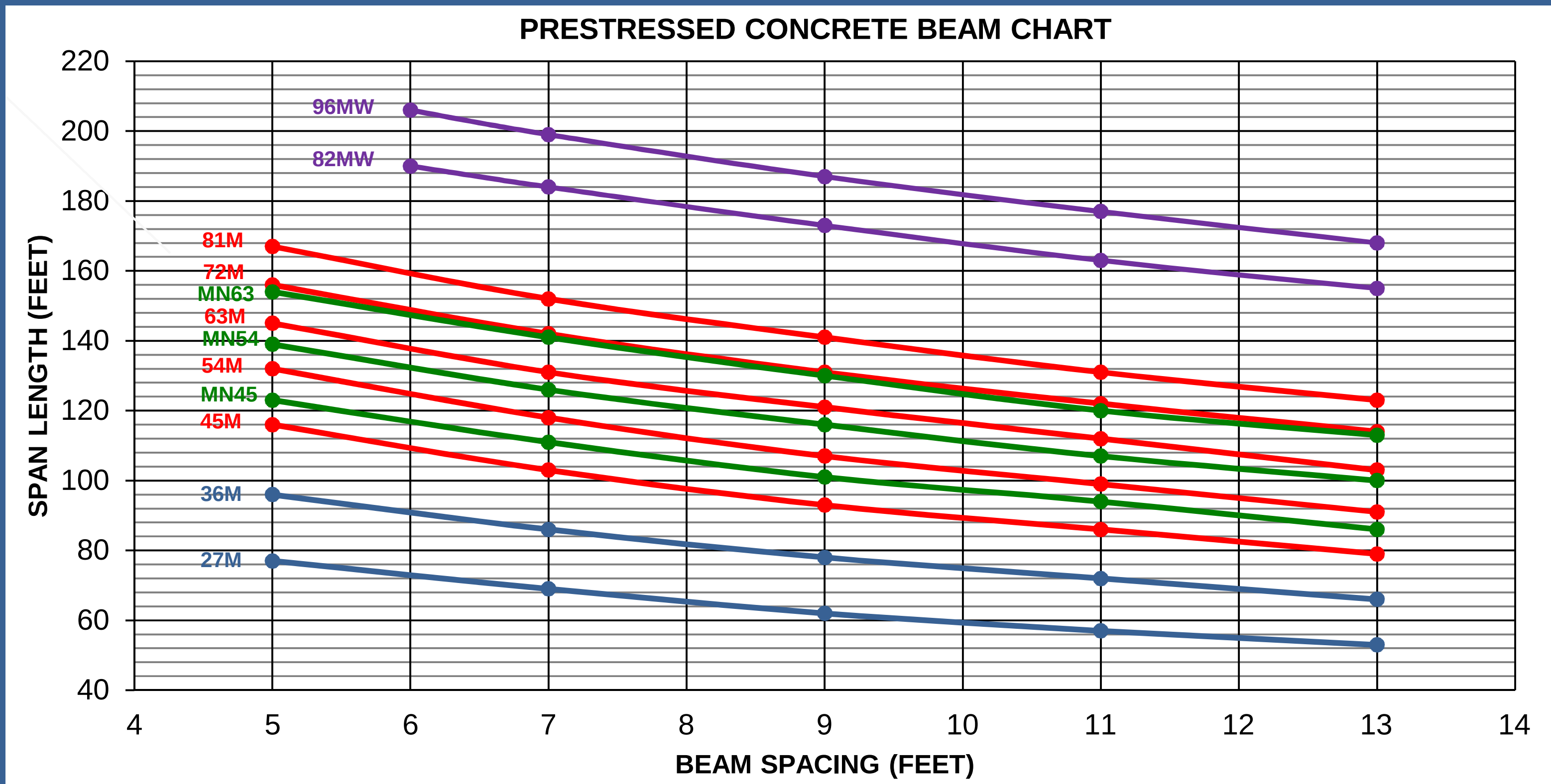


MW Shapes – Standard Plans and B-Details Developed/Modified

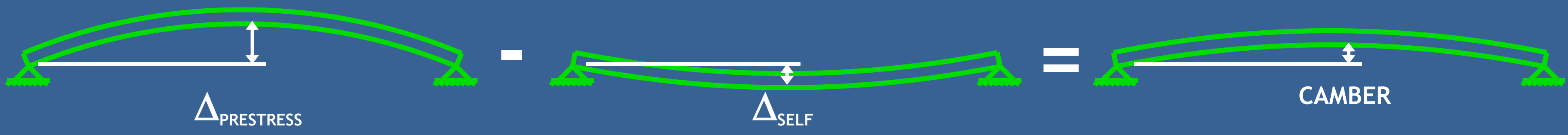
- Standard Plans
  - 5-397.531 82MW Prestressed Concrete Beam
  - 5-397.532 96MW Prestressed Concrete Beam
- B-Details
  - B303 Sole Plate
  - B310 Curved Plate Bearing Assembly - Fixed
  - B311 Curved Plate Bearing Assembly - Expansion
  - B412 Steel Intermediate Bolted Diaphragm (All MW Prestressed Beams)
  - B814 Concrete End Diaphragm - Parapet Abutment

Archiving M Shapes

- Archiving 45M through 81M beams
- Similar depth MN and MW shapes more efficient
- 27M and 36M still available



Camber Study - Background



- Estimation of camber at erection:
  - PCI: 1.85 for self-weight, 1.80 for prestress
    - Girders arriving at bridge site with cambers much lower than predicted
  - MnDOT: 1.50 for self-weight and prestress based on limited internal study
- Study by University of Minnesota to investigate MnDOT's factors

Camber Study – Methodology

- Historical camber data
  - Fabricator records for 1,067 girders from 2006-2010
  - Erection records for 768 of 1,067 girders
- Instrumentation/monitoring of 14 girders
- Measurement of compressive strength/elastic modulus of samples from two precasting plants
- Parametric study to investigate time-dependent effects using PBEAM

Camber Study – Girder Fabrication Recommendations

- Pouring Schedule/Management
- Strand Tensioning and Temperature Corrections
- Bunking/Storage Conditions

Camber Study – Release Camber Prediction Considerations

- Increase f'_{ci} by multiplying by a specified factor for camber calculations
- Use a different equation to calculate concrete modulus of elasticity
- Reduce the stress in the strands at release for camber calculations

Camber Study – Long-Term (Erection) Camber Prediction Suggested Changes

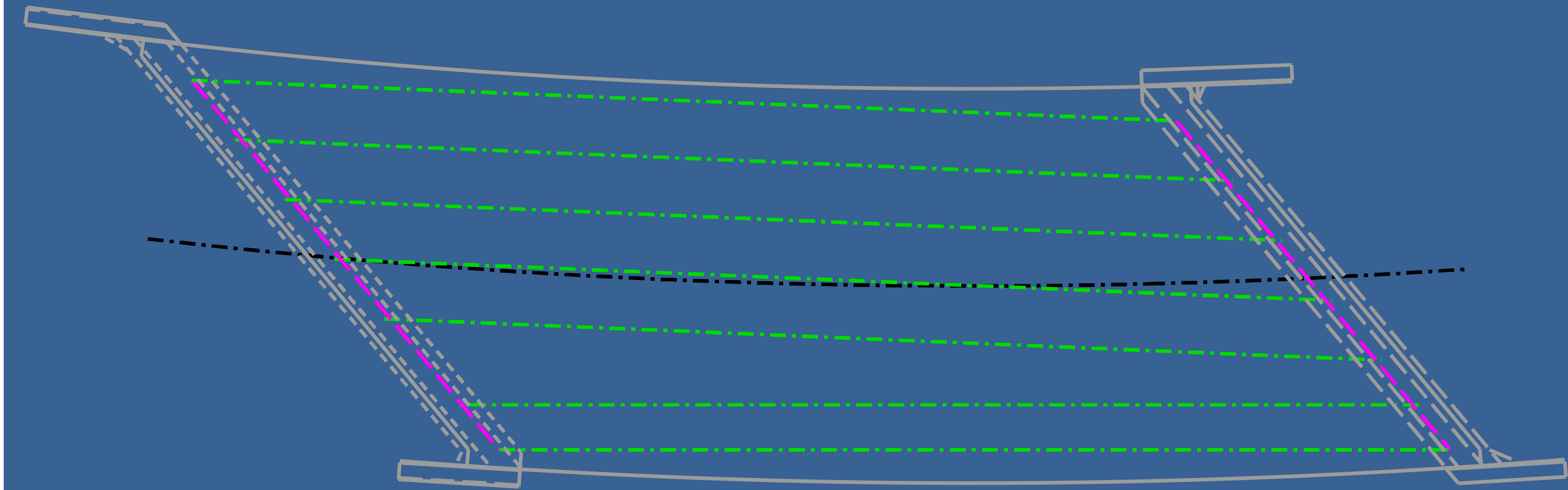
	NO CHANGE TO RELEASE CAMBER ESTIMATION	CHANGE RELEASE CAMBER ESTIMATION
Girder Age at Erection	MnDOT Time-Dependent Multipliers	Improved Time-Dependent Multipliers
0-2 months	1.25	1.65
2-6 months	1.40	1.85
6-12 months	1.50	2.00
12+ months	1.55	2.05

MnDOT Single-Value Multiplier: 1.35 ← NO OTHER CHANGES

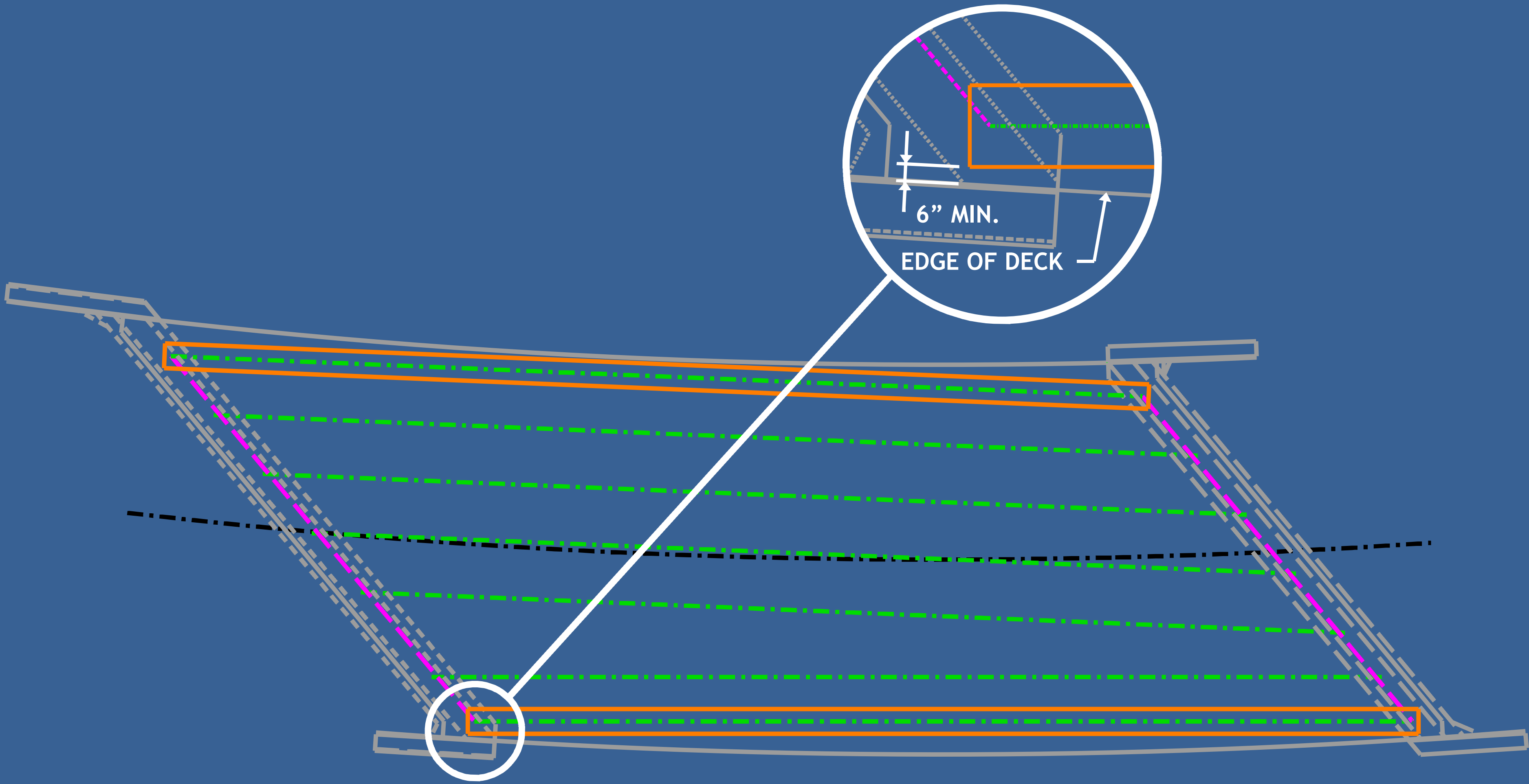
Improved Single-Value Multiplier: 1.80

- MnDOT is currently in the process of deciding which multipliers will be used

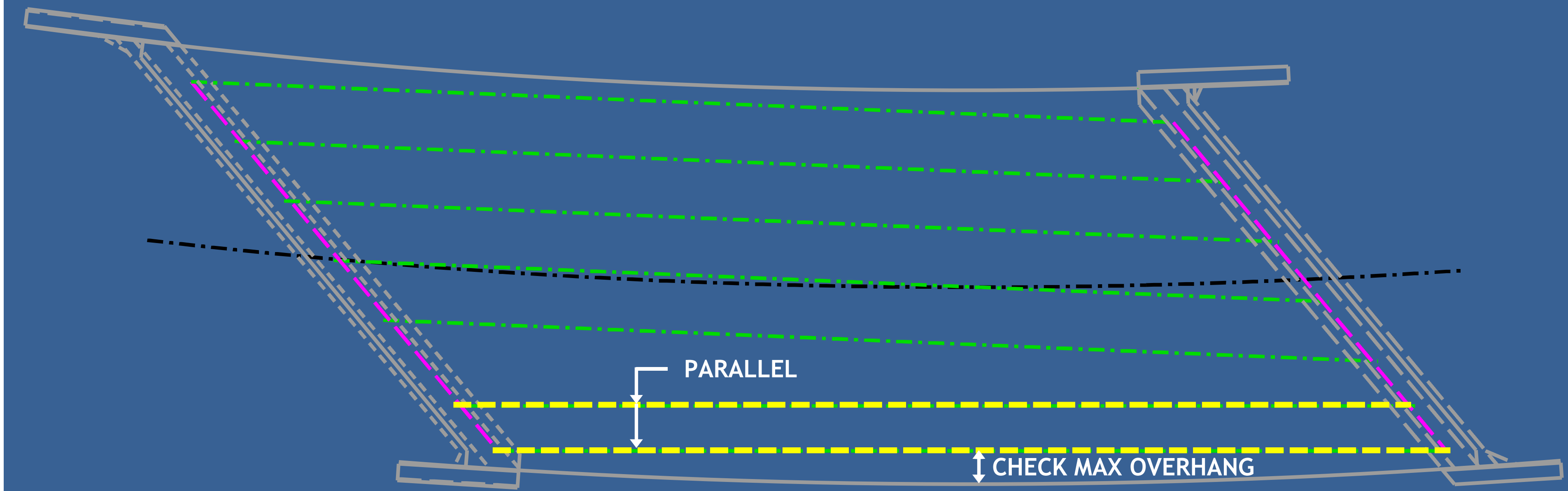
Curved Bridge Design



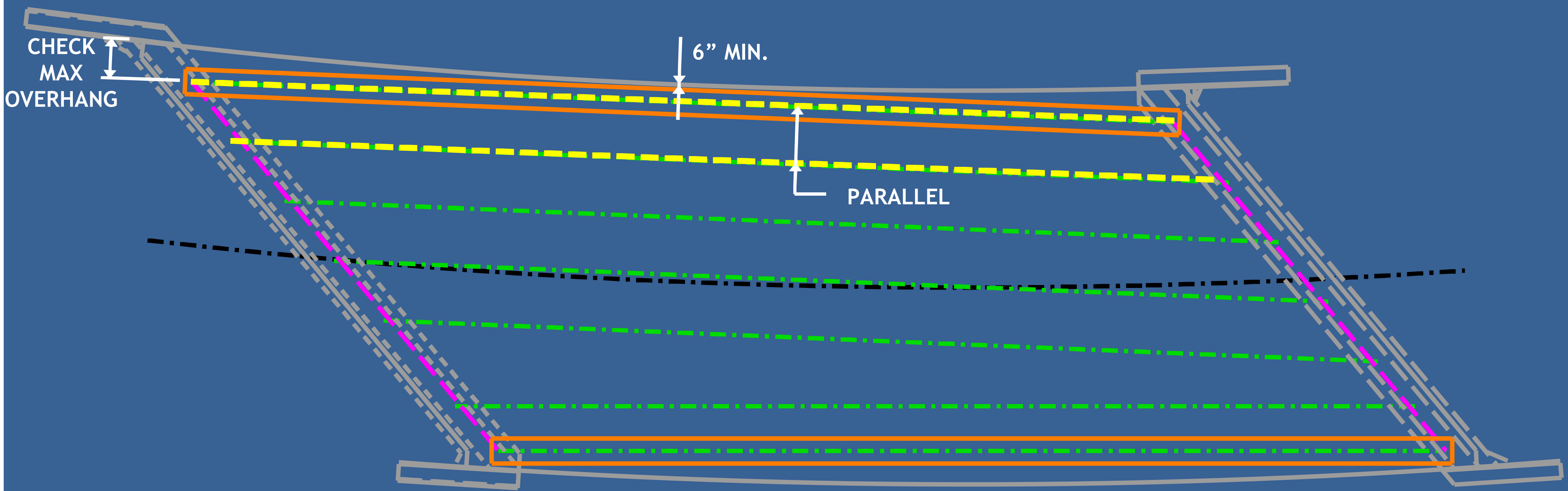
Curved Bridge Design – Layout Considerations



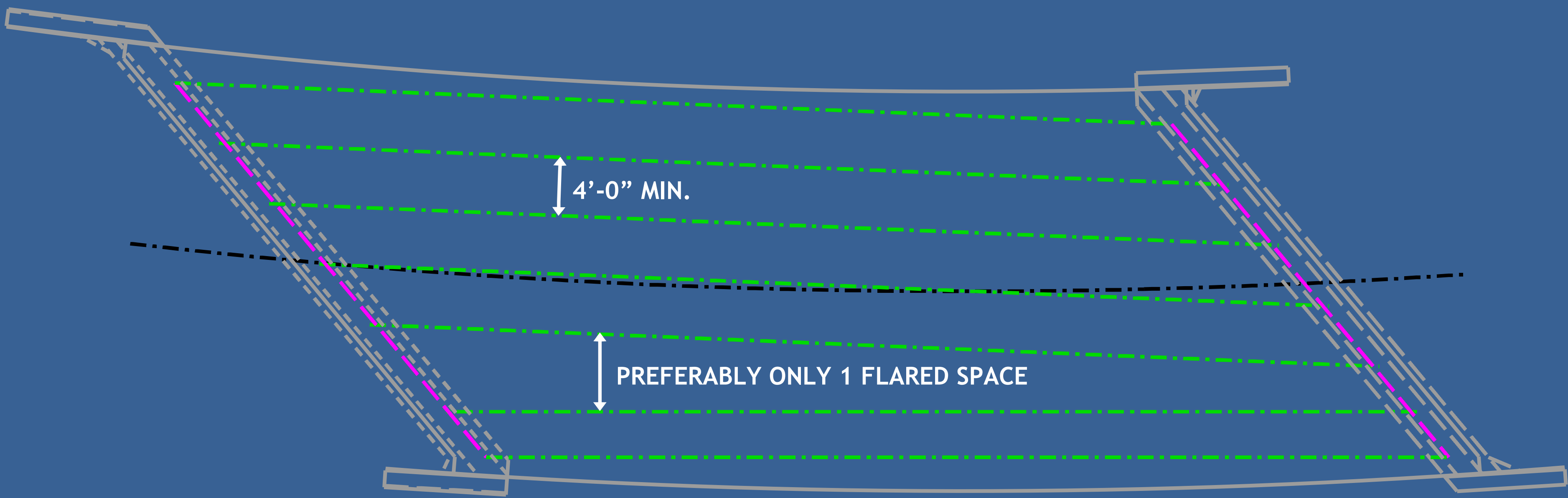
Curved Bridge Design – Layout Considerations



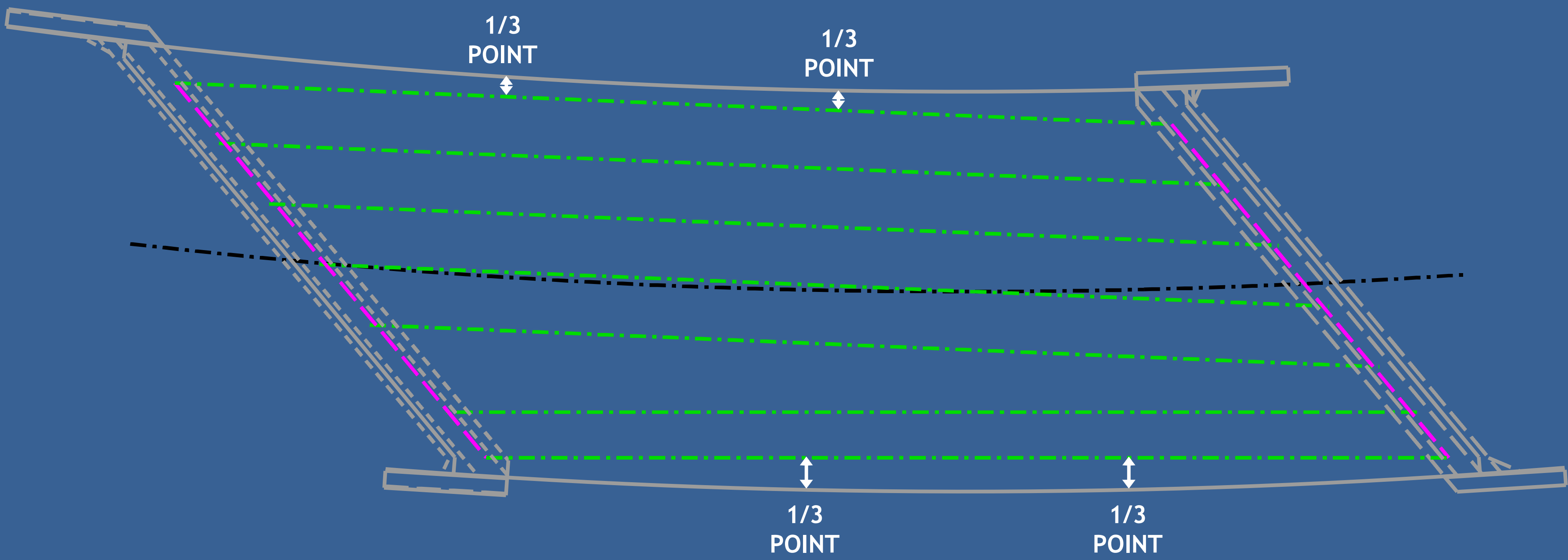
Curved Bridge Design – Layout Considerations



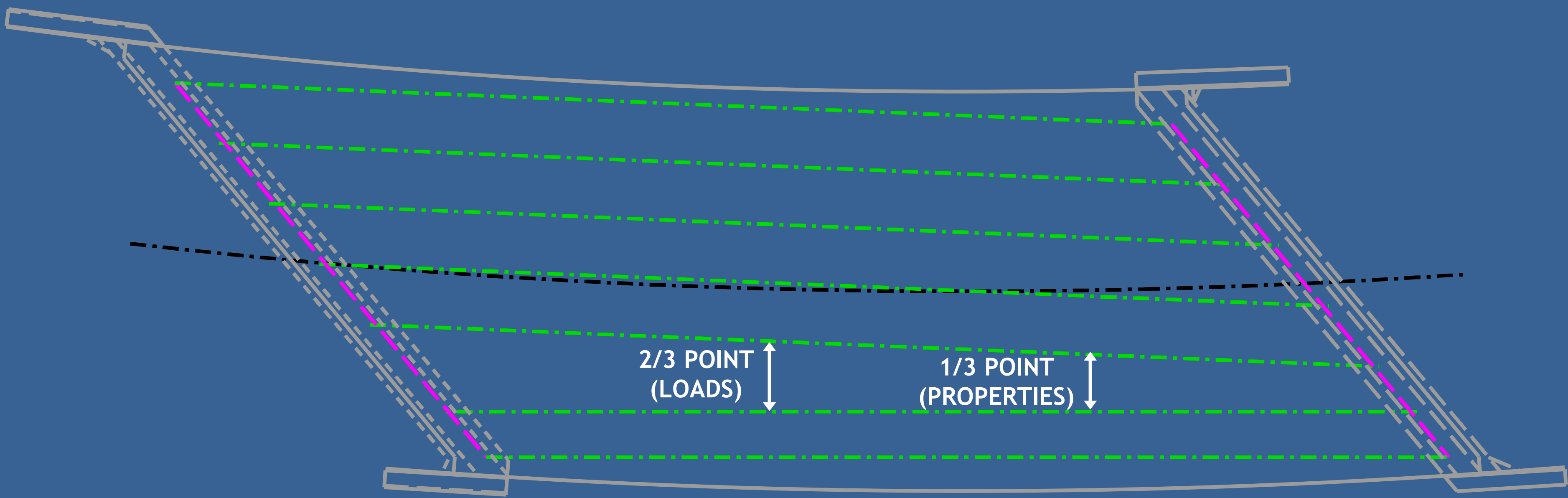
Curved Bridge Design – Layout Considerations



Curved Bridge Design – Design Considerations



Curved Bridge Design – Design Considerations



Curved Bridge Fascia Design – Design Considerations

- Stool
  - Should take into account horizontal curve
  - For straight bridges, typically use stool thickness of 2.5” for initial load calculations and 1.5” for properties.
  - For curved bridges, consider using stool thickness of something larger than 2.5” for initial load calculations to account for horizontal curve and increased stool heights. Use 1.5” for properties.

Summary

- Inverted Tees
- MW-Shapes
- Archiving M-Shapes
- Camber Study
- Curved Bridges

Questions and Discussion

Inverted Tees

MW-Shapes

M-Shapes

Camber Study

Curved Bridges

ABC: Accelerated Bridge Construction

Todd Stevens
Final Design Unit Leader

Presentation Outline

- **ABC – What it is/What it involves**
- **ABC – Reasons to consider ABC**
- **ABC – MN Applications**
- **ABC - Analysis**
- **ABC – MN Implementation**
- **ABC – MnDOT Contact Info**

Definition of ABC

- **Not just building bridges faster – <u>Building bridges while minimizing traffic disruption</u>**
  - **Contracting/Procurement Methods**
  - **Construction Means/Methods**
- **Affects Design, Cost, Risk, etc. (vs. Conventional Methods)**

Contracting/Procurement Methods

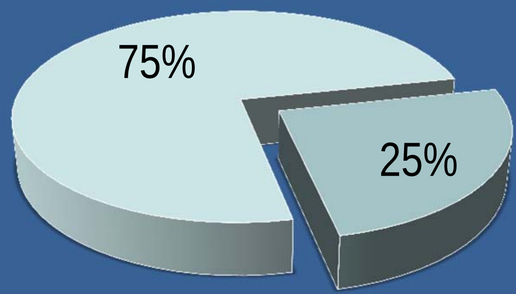
- **Design-Bid-Build**
  - **"A + B" Bidding**
  - **Incentives (& Disincentives)**
  - **Off-peak Scheduling**
  - **Lane Rental**
- **Design-Build**
- **CMGC (new MN option; 2012 Leg.)**

Construction Means/Methods

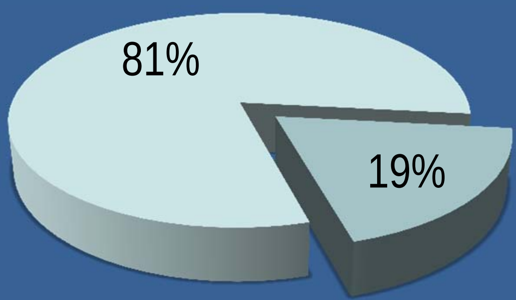
- **Materials**
  - **Concrete & Steel Strengths**
- **Equipment**
  - **SPMT, Cranes**
- **Procedures**
  - **Post-tensioning, Precasting, Temp. Works**
- **Maintenance of Traffic**

Why Consider ABC?

U.S. Bridge Deficiency

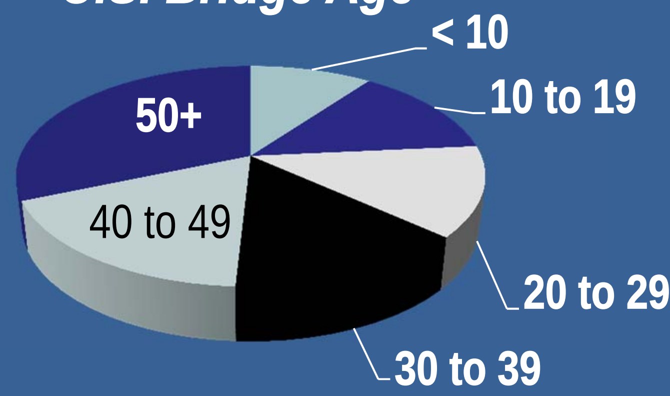


MN Bridge Deficiency

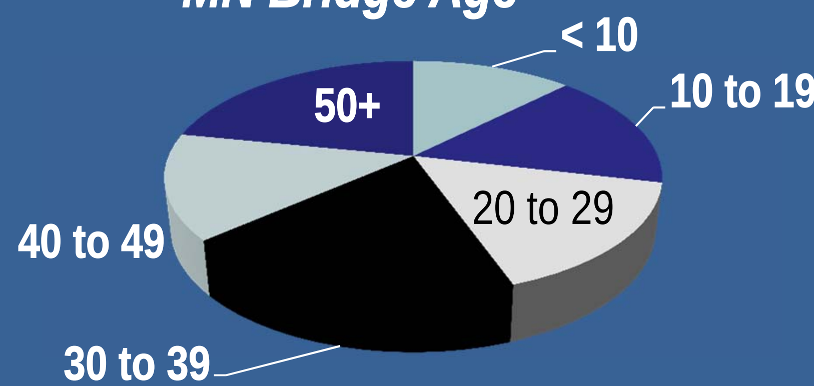


(non-culvert, all roadways)

U.S. Bridge Age



MN Bridge Age



Why Consider ABC?

Deficiencies → Construction

Construction → Traffic Disruption

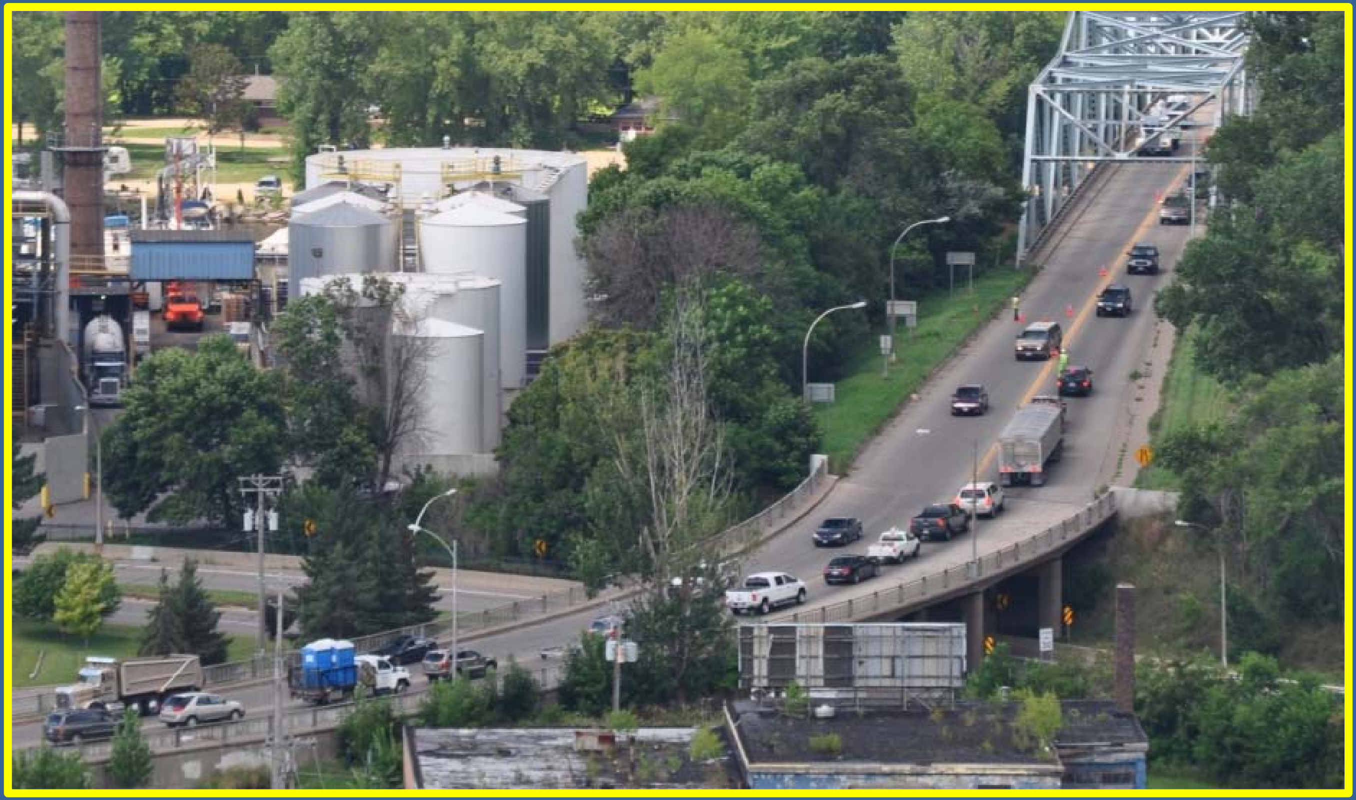


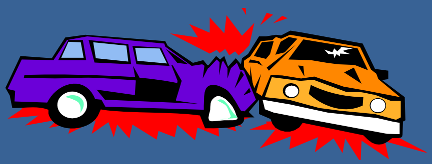
Photo courtesy of Atkins

Why Consider ABC?

- **Societal Expectations**
  - **Context: NOW!**

- **Roadway User Costs (RUCs)**
  - **Time is Money**

- **Safety**
  - **Motorists & Workers**



Why Consider ABC?

- **Environment**
  - **Smaller/Cleaner Constr. Sites**

- **Minnesota Weather**
  - **Short Constr. Season/Cold Weather**

- **Higher Quality**
  - **Precast vs. C.I.P.**

- **Because We Can!**
  - **Equipment, Materials**

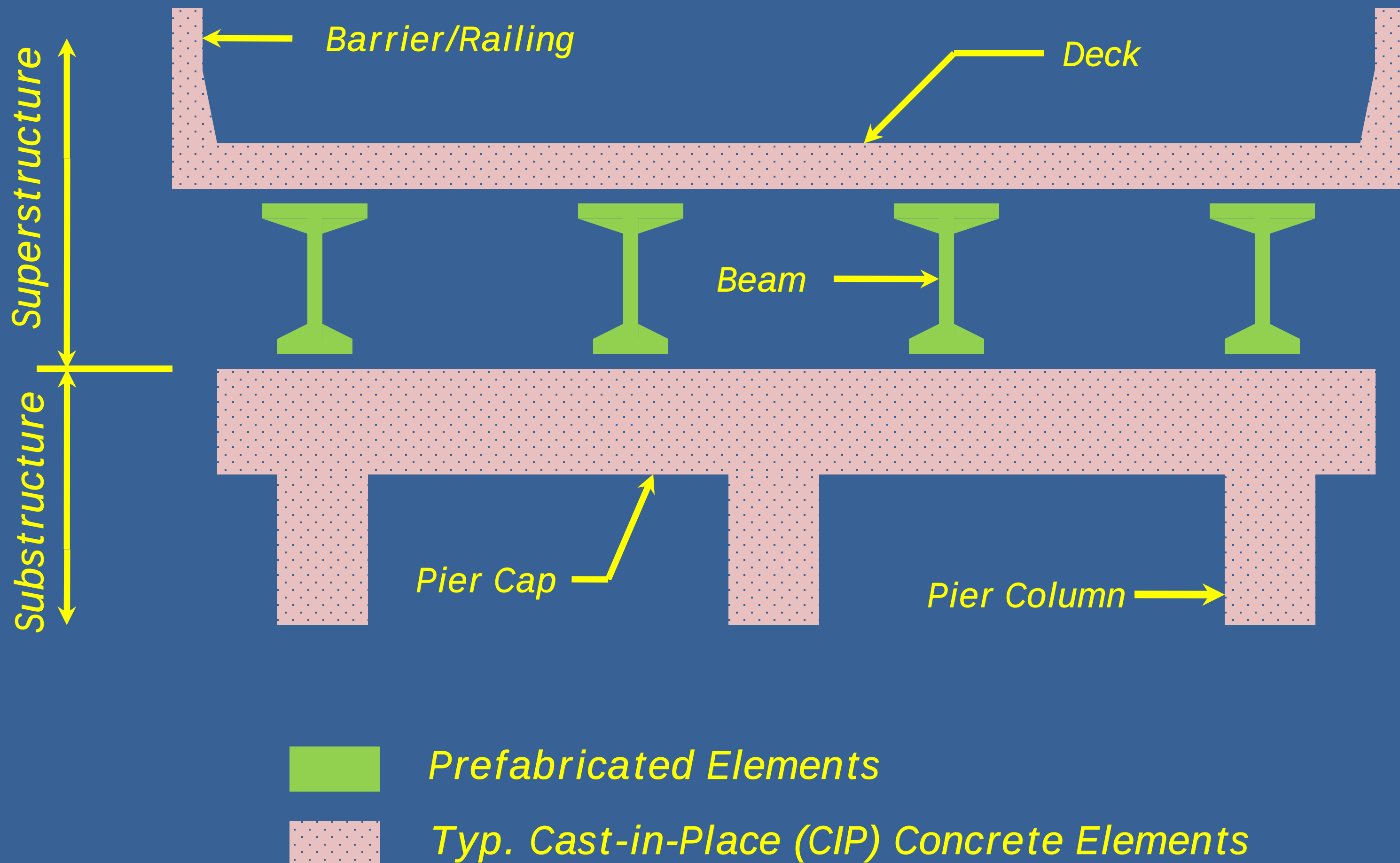
Why Consider ABC?

- **Many Beneficiaries**
  - **Travelling Public (time, $$, safety)**
  - **MnDOT (public perception)**
  - **Business & Industry (access, delivery)**
  - **Contractors (safety, more tools in toolbox)**
  - **Environment**

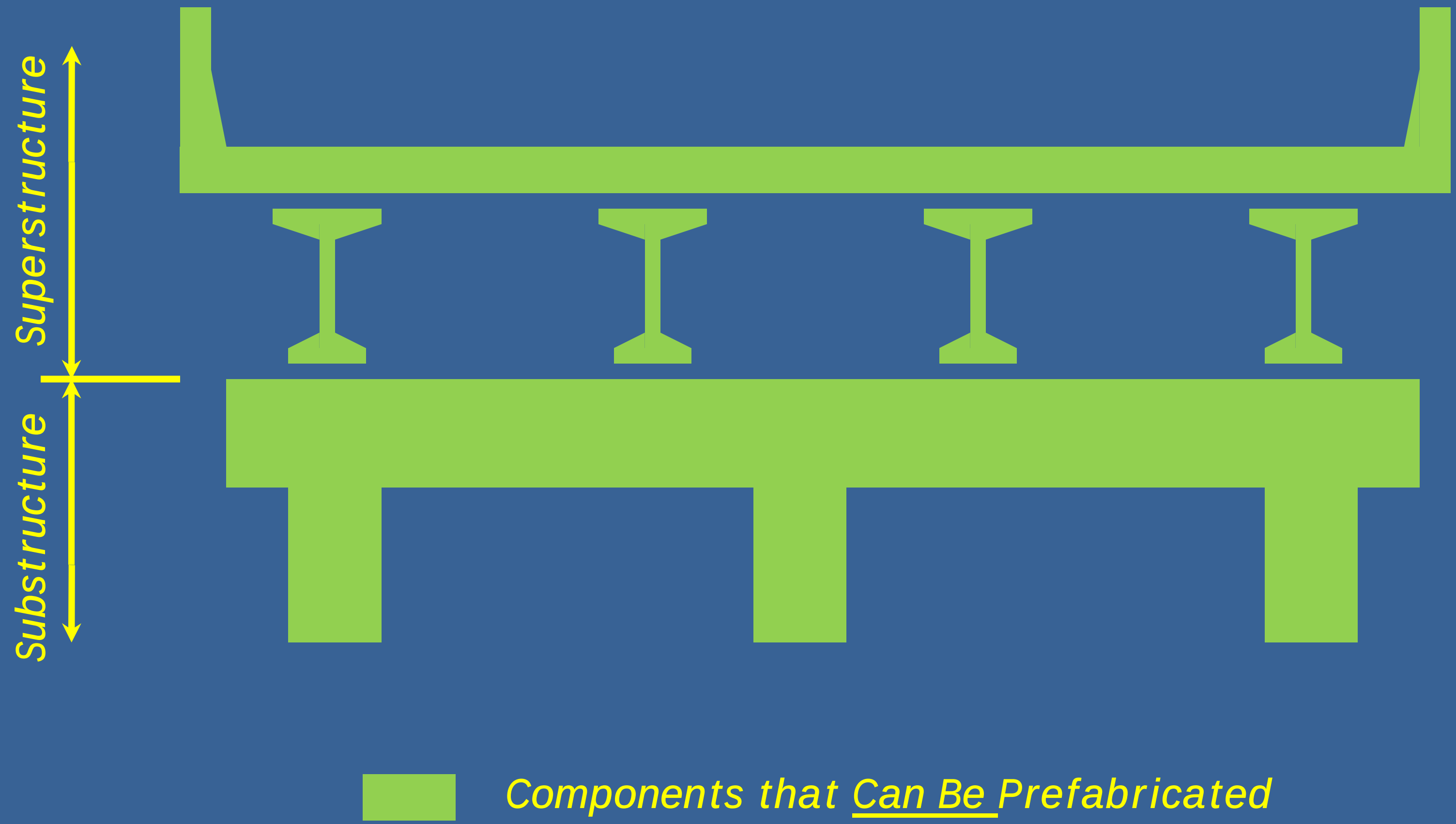
How to Achieve ABC?

- **Main Theme: Prefabrication**
  - **Precast Superstructure Elements**
  - **Precast Substructure Elements**
  - **Bridge Moves (Precast Entire Structure)**

Conventional Bridge Construction



Accelerated Bridge Construction



ABC – MN Applications

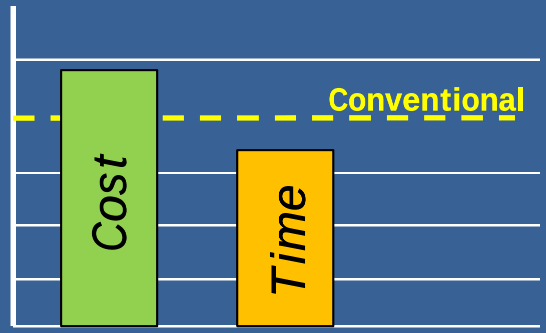
- **ABC Techniques for Minnesota**
  - **Contracting/Procurement Methods**
  - **Full-depth Precast Conc. Deck Panels**
  - **Inverted-tee Beams**
  - **Precast Conc. Segmental Box Girders**
  - **Precast Substructures**
  - **Slide-in Construction**
  - **Self-Propelled Modular Transporters (SPMT)**

Full-Depth Precast Conc. Deck Panels

Photo courtesy of CME Associates

Full-Depth Precast Conc. Deck Panels

- **Pros:**
  - Any Size Bridge (New or Rehab)
  - Quality/Durability
  - Faster Construction
- **Cons:**
  - Requires Post-tensioning
  - Roadway Crown Logistics
  - Grouting (Shear Pockets, Haunches)
  - Skewed Supports
  - Existing Shear Connectors On Rehabs



Full-Depth Precast Conc. Deck Panels

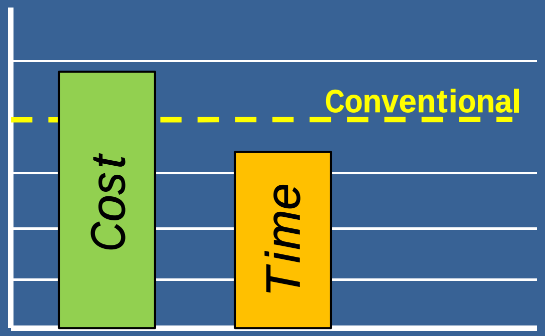
- **Nationwide Implementation:**
  - **Tried by About Half the States**
  - **Use Dates Back to 1970's**
  - **Detail & Spec Resources Available**
- **MnDOT Implementation:**
  - **Br. 69071, SB T.H. 53 over Paleface River**
  - **Let Jan. 2011**
  - **Panel Fabrication in Progress**
  - **Delayed by Bidding Issues**

Inverted-Tee Beams

Photo courtesy of MnDOT

Inverted-Tee Beams

- **Pros:**
  - Slab Span Alternative
  - Higher Quality Precast Elements
  - Faster Construction
  - No Falsework, Improved Safety
- **Cons:**
  - Still Requires Some CIP Conc.
  - Cracking Issues in Topping



Inverted-Tee Beams

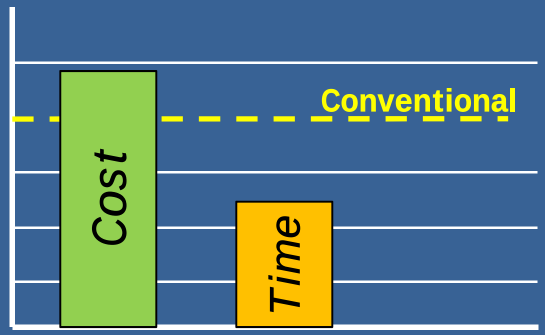
- **History/Development:**
  - **Based on French System**
  - **Developed in U.S. by MnDOT**
  - **Design Still Evolving (Stds. being developed)**
- **MnDOT Implementation:**
  - **First Bridges Let in 2005**
  - **11 Bridges Let to Date**
  - **Research at Univ. of Minnesota**
  - **Price Has Come Down**

Precast Conc. Segmental Box Girder

Photo courtesy of MnDOT

Precast Conc. Segmental Box Girder

- **Pros:**
  - **Long Spans/Geometric Constraints**
  - **Higher Quality Precast Elements**
  - **Speed of Construction**
- **Cons:**
  - **Requires PT and Grouting**
  - **Deck Replacement Not Feasible**
  - **Specialized Equipment/Skills**



Precast Conc. Segmental Box Girder

- **Nationwide Implementation:**
  - **First Used in U.S. in early 1970's**
  - **Hundreds of Bridges Nationwide**
  - **Used In All Regions**
- **MnDOT Implementation:**
  - **35W/62 Crosstown (4 Bridges)**
  - **Center Span of New 35W Bridge**
  - **Potential Use on St. Croix**

Precast Substructures

Abutments

Photo courtesy of MnDOT

Piers

Photo courtesy of Texas DOT

Precast Substructures

- **Pros:**
  - **Higher Quality Precast Elements**
  - **Potential for Faster Construction**
  - **Advantage With Repeatable Elements**
- **Cons:**
  - **Connection Issues**
  - **Contractor Enthusiasm (tend to like C.I.P)**
  - **Early Strength Not Req'd (Exc. Pier Caps)**

Precast Substructures

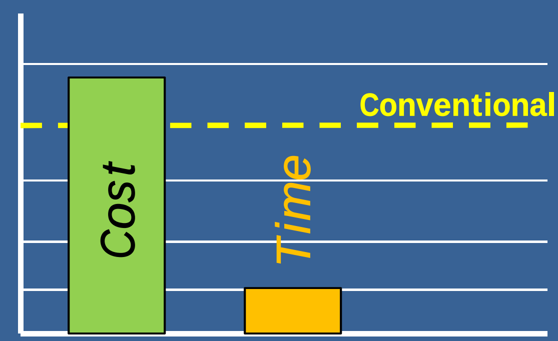
- **Nationwide Implementation:**
  - Tried By Many States
  - Texas Leader (research, implementation)
  - Attempts to Standardize
- **MnDOT Implementation:**
  - Br. No. 13004, T.H. 8, Chisago Co., 2005
  - Br. No. 25024, T.H. 61, Goodhue Co., 2011
  - Unweave the Weave (PT Column Alt.)

Slide-In Construction

Photos courtesy of Nevada DOT

Slide-In Construction

- **Pros:**
  - **Very Minimal Traffic Disruption**
  - **Work Separated From Traffic**
  - **Higher Quality (not on Critical Path)**
- **Cons:**
  - **Need Right Site Conditions**
  - **New Foundations Under Inplace Bridge**
  - **Non-standard/Dynamic Loads**



Slide-In Construction

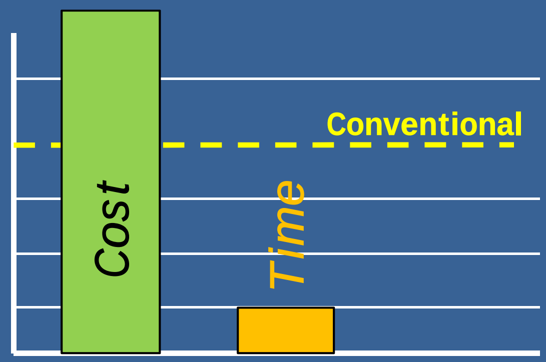
- **National Implementation:**
  - **Not As Common as SPMT**
  - **Showcase/Demonstration Projects**
  - **More Variability (Contractor Methods)**
- **MnDOT Implementation:**
  - **3 Staged Removals/Temp. Crossings**
  - **Br. 25028, T.H. 61 Red Wing, Jan. '13 Let**
  - **Potential Site in District 3**
  - **Other Potential Sites Being Considered**

Self-Propelled Modular Transporter

Photo courtesy of Utah DOT

Self-Propelled Modular Transporter

- **Pros:**
  - **Very Minimal Traffic Disruption**
  - **No Work Over Traffic**
  - **Higher Quality (not on Critical Path)**
- **Cons:**
  - **Need Right Site Conditions**
  - **New Foundations Under Inplace Bridge**
  - **High Mobilization Costs**
  - **Non-standard/Dynamic Loads**



Self-Propelled Modular Transporter

- **National Implementation:**
  - **Tried by at Least Dozen States (25+ in Utah)**
  - **Detail and Spec Resources Available**
  - **More Options for Heavy Lifter**
- **MnDOT Implementation:**
  - **Br. No. 62626 (Maryland over 35E)**
  - **Design-Build, Move Scheduled Summer '12**
  - **Hastings Design-Build (Arch Installation)**

MINNESOTA DEPARTMENT OF TRANSPORTATION

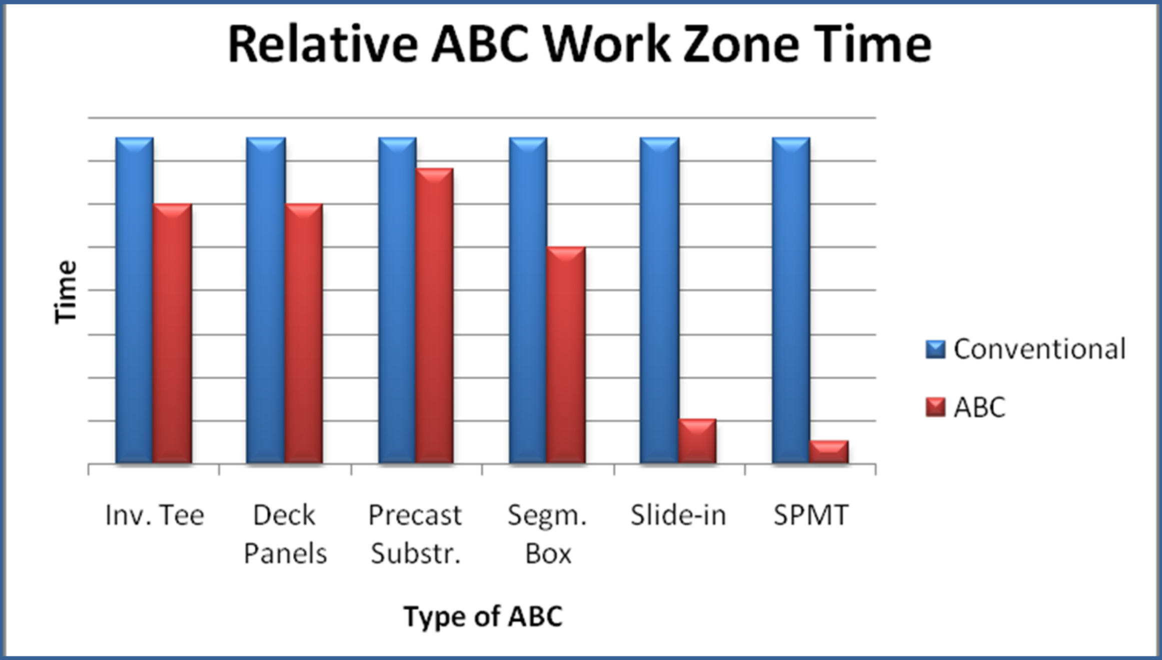
ABC: SPMT

Time-Lapse SPMT Move

Video courtesy of Utah DOT

ABC Analysis – The Good News

- **Reduction in Work Zone Time**



- **Real Savings for Roadway Users (RUCs)**

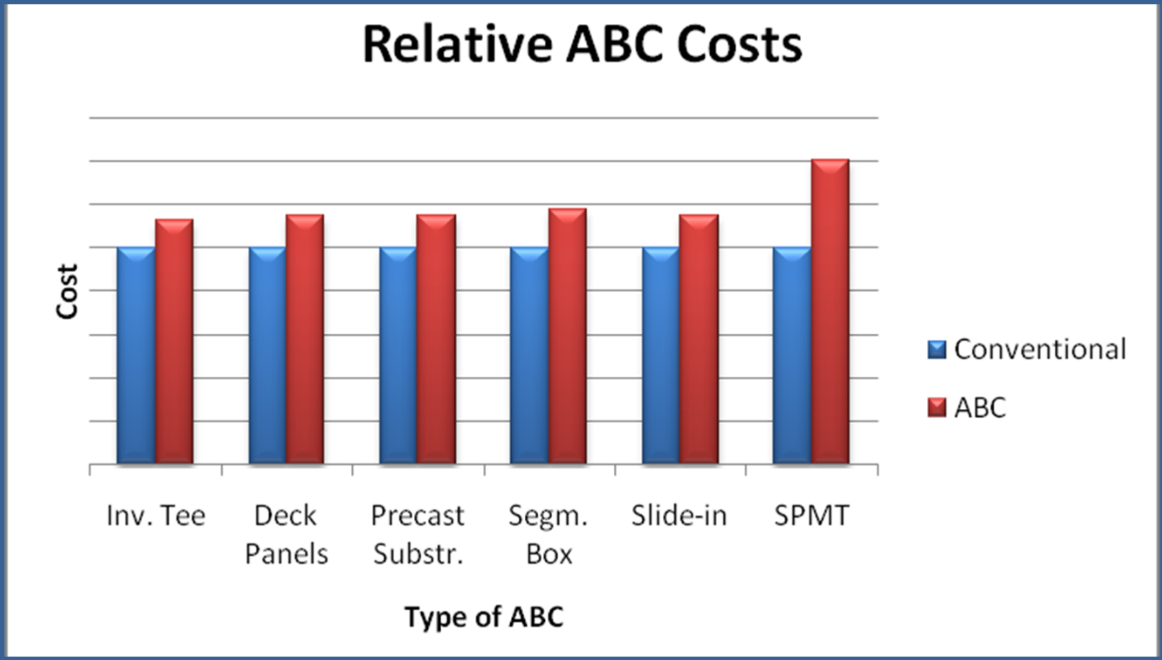
ABC Analysis – The Good News

- **Perfect Match for MnDOT Strategic Vision**
  - *Safety*: **reduce workzone accidents**
  - *Mobility*: **reduce congestion; improve flow**
  - *Innovation*: **new equipment & procedures**
  - *Leadership*: **new standards, use by local agencies**
  - *Transparency*: **public discussion of cost/benefit**

MINNESOTA DEPARTMENT OF TRANSPORTATION

ABC Analysis – The Bad News

- **Increased Construction Costs**



- **RUCs Don't Come Back to MnDOT**

MnDOT Implementation of ABC

- **ABC When Appropriate**
  - **Trial Projects, Shorten Durations in Future**
- **Internal ABC Committee**
  - **Constr., Prelim & Final Design, C.O. (STIP)**
- **Implementation on Selected Projects**
  - **Precast Substr., Inv Tee, Deck Panels, SPMT**
- **Actively Seeking Supplemental Funding**
  - **Highways for LIFE, Destination Innovation**
- **Develop Decision Criteria/Standards/Policy**
  - **Decision Criteria: Spreadsheets, Specialty Software**
  - **Standards/Policy: Based on Successful Projects**

MN ABC – Consultant Involvement

- Design-Build
  - Designer for Contractor
  - Design Oversight
- Design-Bid-Build
  - Consultant Contracts with MnDOT
  - Designs for Local Agencies

MN ABC – Contact Info

- Paul Rowekamp (Standards)
  - (651) 366-4484
  - paul.rowekamp@state.mn.us
- Keith Molnau (Preliminary Design)
  - (651) 366-4456
  - keith.molnau@state.mn.us
- Todd Stevens (Final Design)
  - (651) 366-4488
  - todd.stevens@state.mn.us

Thank You

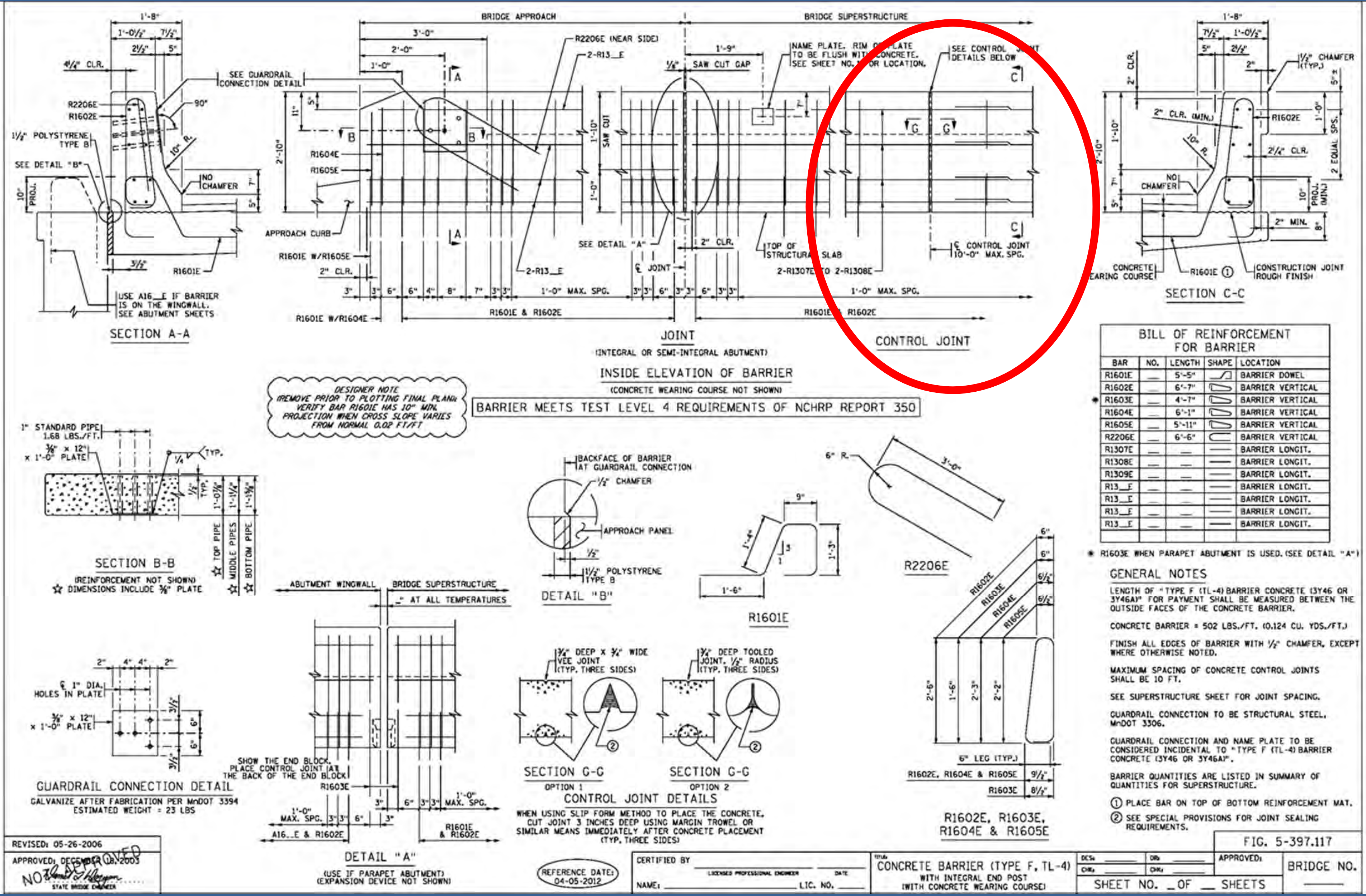
Questions?

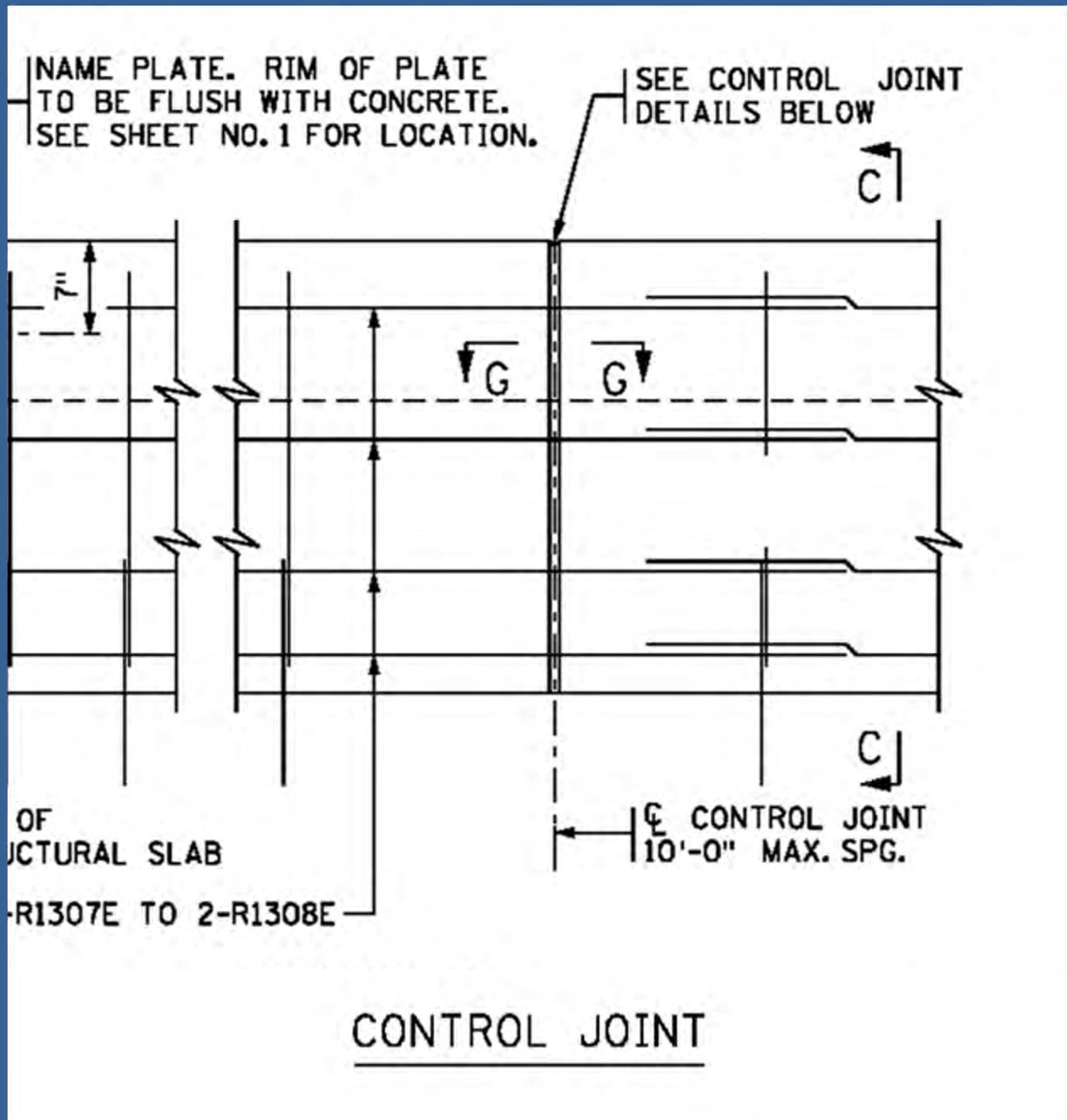
Bridge Standards Update

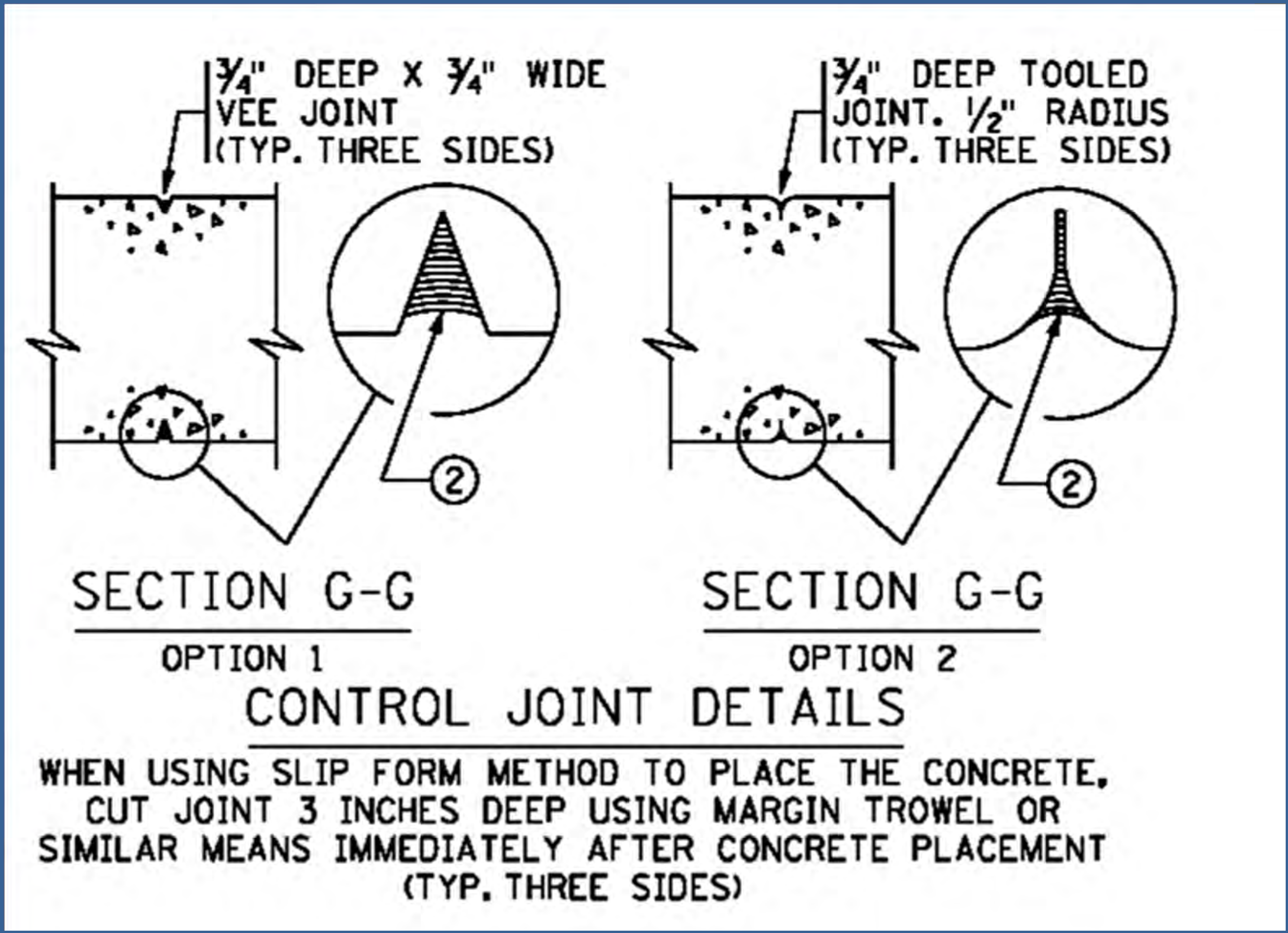
Paul Rowekamp
Bridge Standards Engineer

Overview

- Barriers
- Parapets
- Ornamental Railings
- Approach Panels
- Expansion Devices
- Precast Box Culverts
- MW Prestressed Beams
- Rip Rap Slope Protection
- Tapered Plate Bearing Assembly
- Miscellaneous Issues


SECTION A-A
JOINT
(INTEGRAL OR SEMI-INTEGRAL ABUTMENT)
CONTROL JOINT
INSIDE ELEVATION OF BARRIER
(CONCRETE WEARING COURSE NOT SHOWN)
SECTION C-C
BARRIER MEETS TEST LEVEL 4 REQUIREMENTS OF NCHRP REPORT 350
BILL OF REINFORCEMENT FOR BARRIER
SECTION B-B
DETAIL "B"
R1601E
R2206E
GUARDRAIL CONNECTION DETAIL
DETAIL "A"
SECTION G-G
CONTROL JOINT DETAILS
R1602E, R1603E, R1604E & R1605E
GENERAL NOTES
FIG. 5-397.117
CONCRETE BARRIER (TYPE F, TL-4)
WITH INTEGRAL END POST
(WITH CONCRETE WEARING COURSE)
BRIDGE NO.

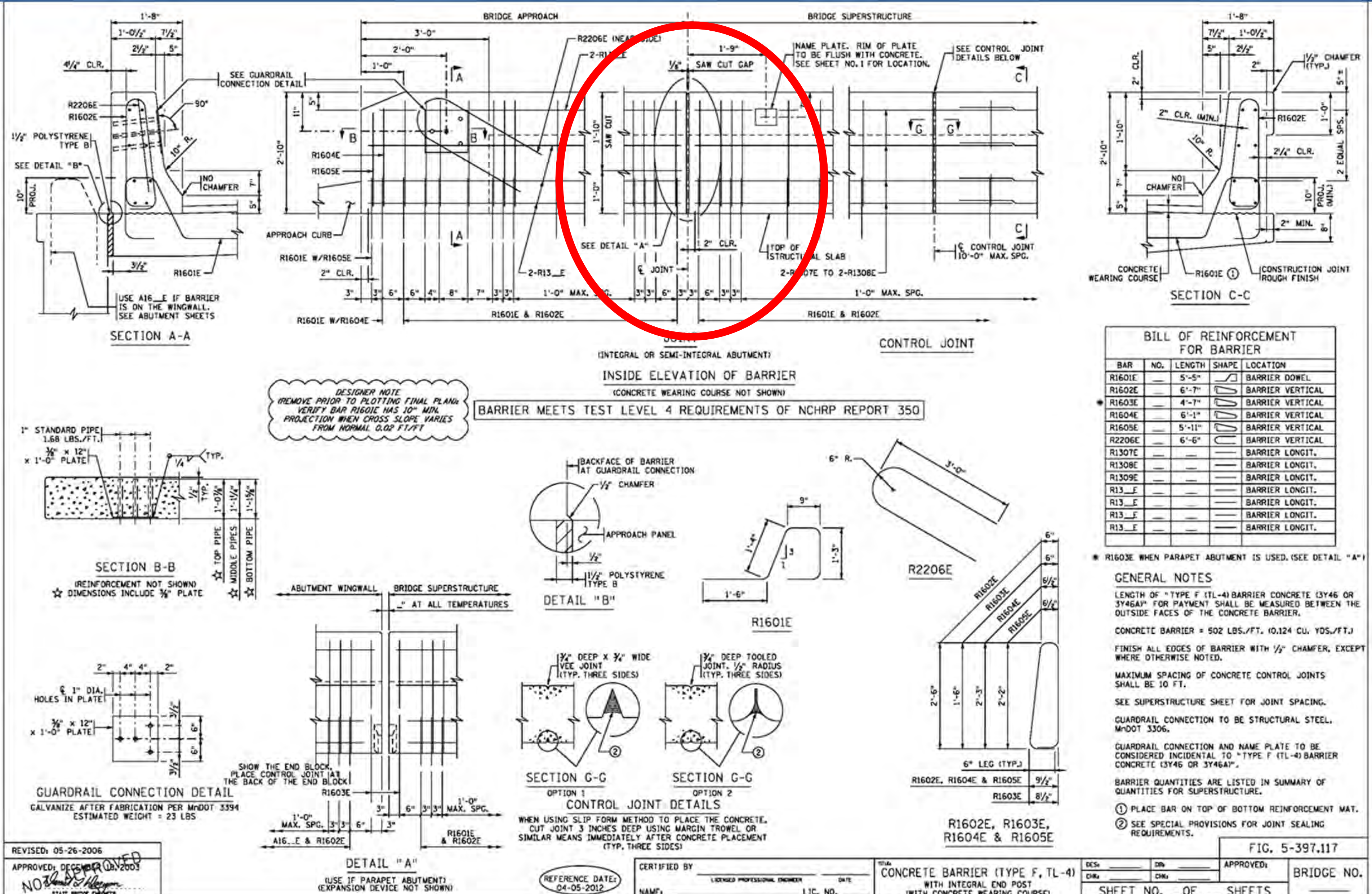

NAME PLATE. RIM OF PLATE TO BE FLUSH WITH CONCRETE. SEE SHEET NO. 1 FOR LOCATION.
SEE CONTROL JOINT DETAILS BELOW
C
7"
G
G
C
OF
UCTURAL SLAB
-R1307E TO 2-R1308E
℄ CONTROL JOINT 10'-0" MAX. SPG.
CONTROL JOINT



3/4" DEEP X 3/4" WIDE
VEE JOINT
(TYP. THREE SIDES)
3/4" DEEP TOOLED
JOINT. 1/2" RADIUS
(TYP. THREE SIDES)
2
2
SECTION G-G
OPTION 1
SECTION G-G
OPTION 2
CONTROL JOINT DETAILS
WHEN USING SLIP FORM METHOD TO PLACE THE CONCRETE,
CUT JOINT 3 INCHES DEEP USING MARGIN TROWEL OR
SIMILAR MEANS IMMEDIATELY AFTER CONCRETE PLACEMENT
(TYP. THREE SIDES)

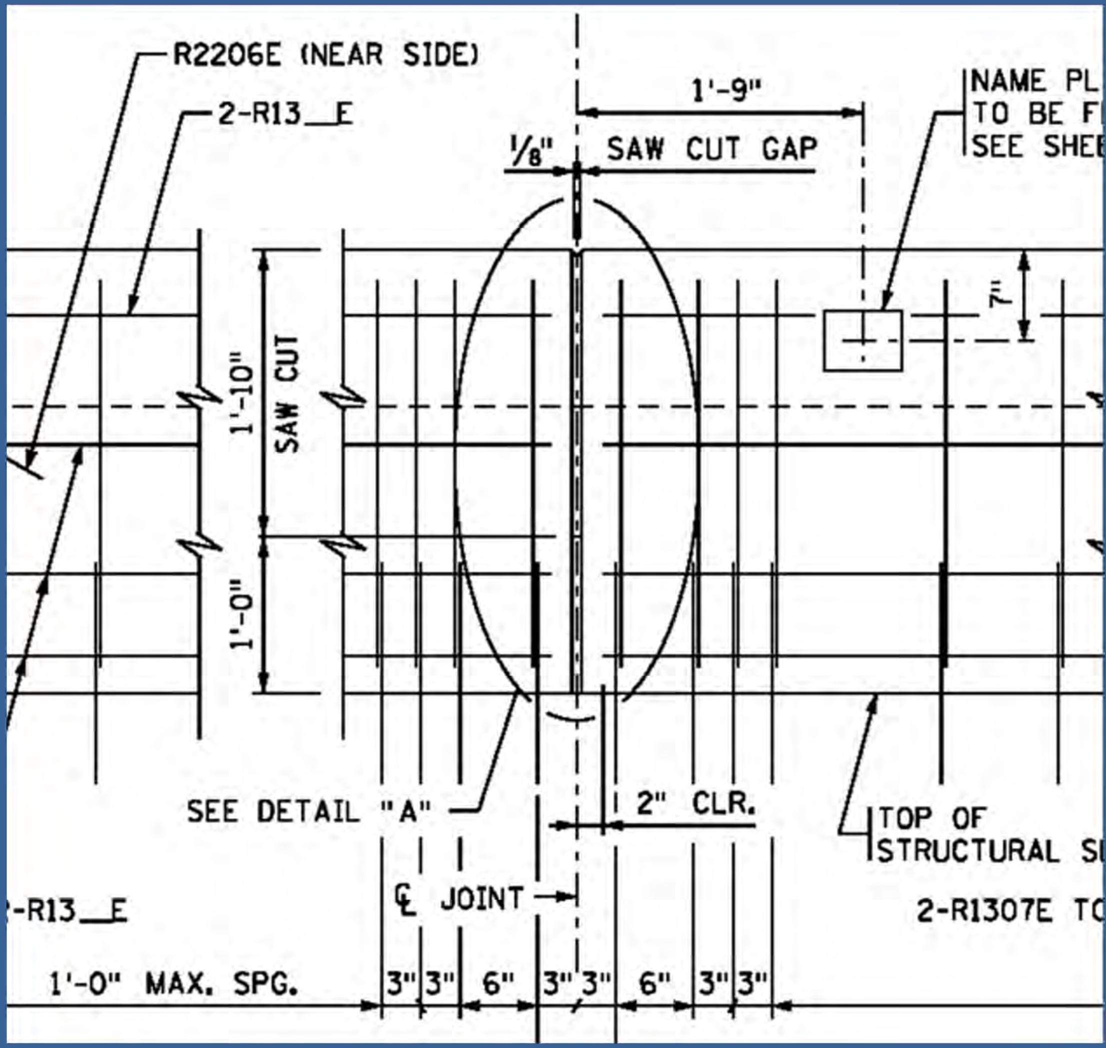

EAST
Grand Rapids
SOUTH
Park Rapids
PCi
5
430
25-259
PCi

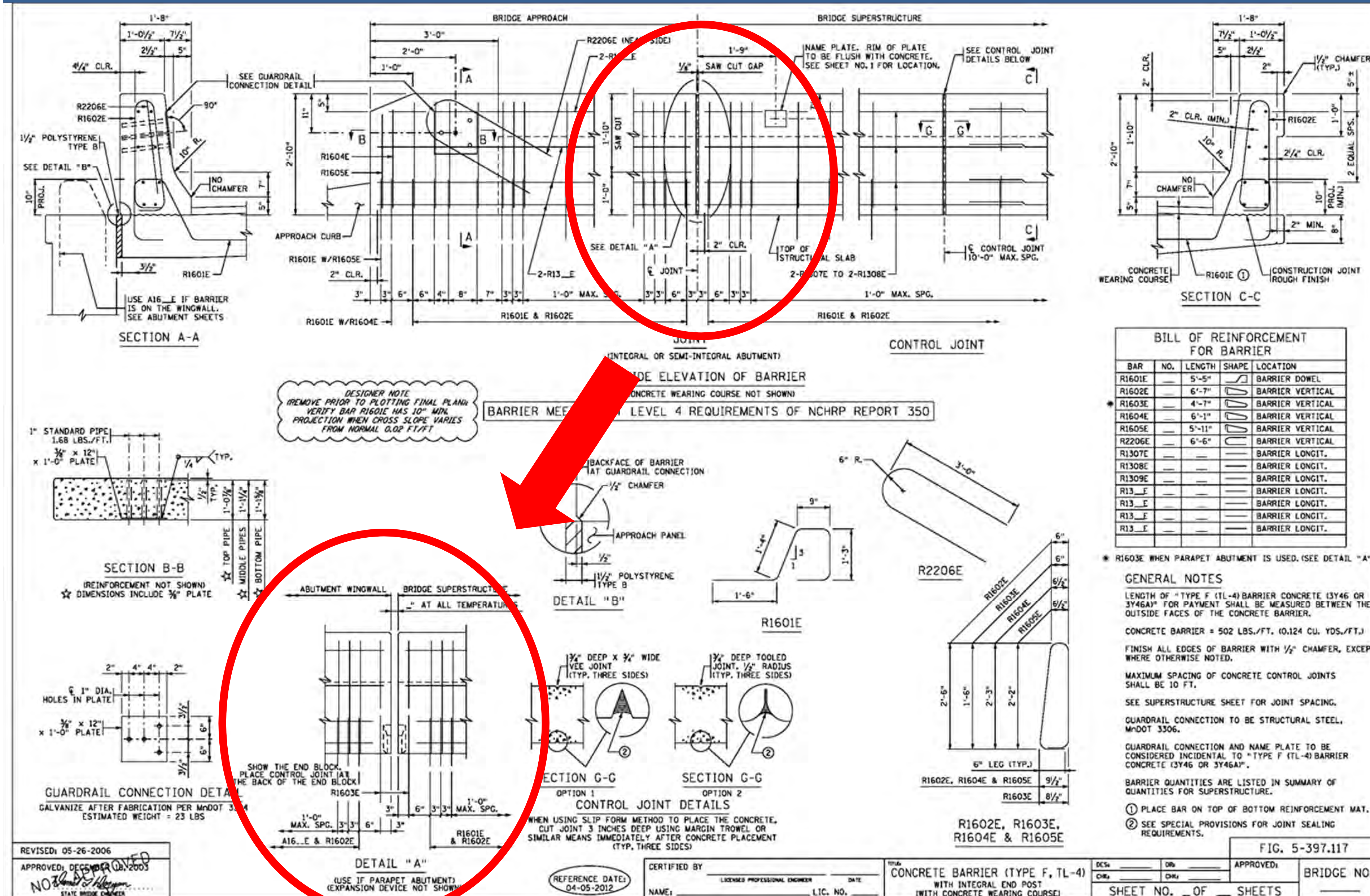

01/18/2012 10:38



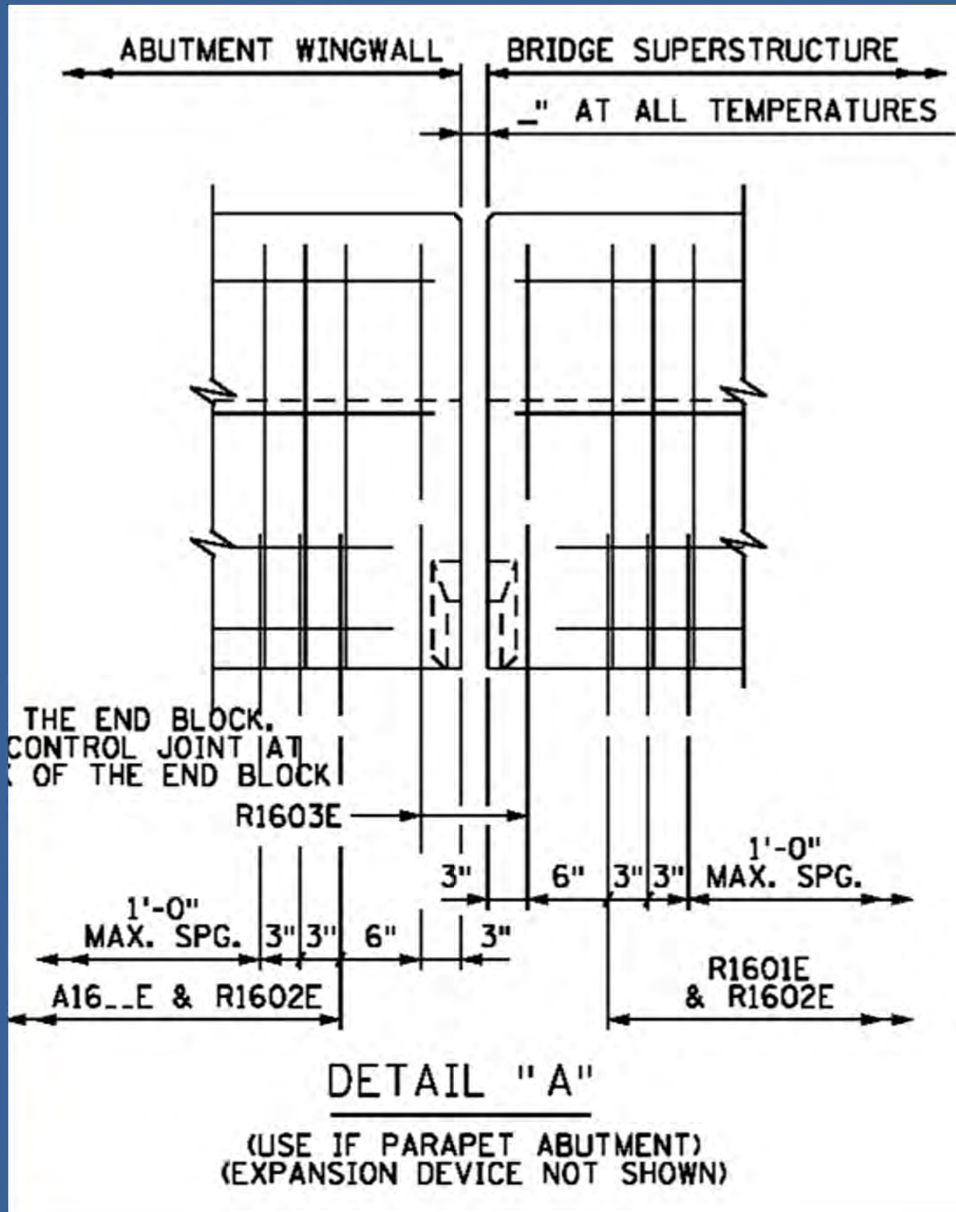
BILL OF REINFORCEMENT FOR BARRIER

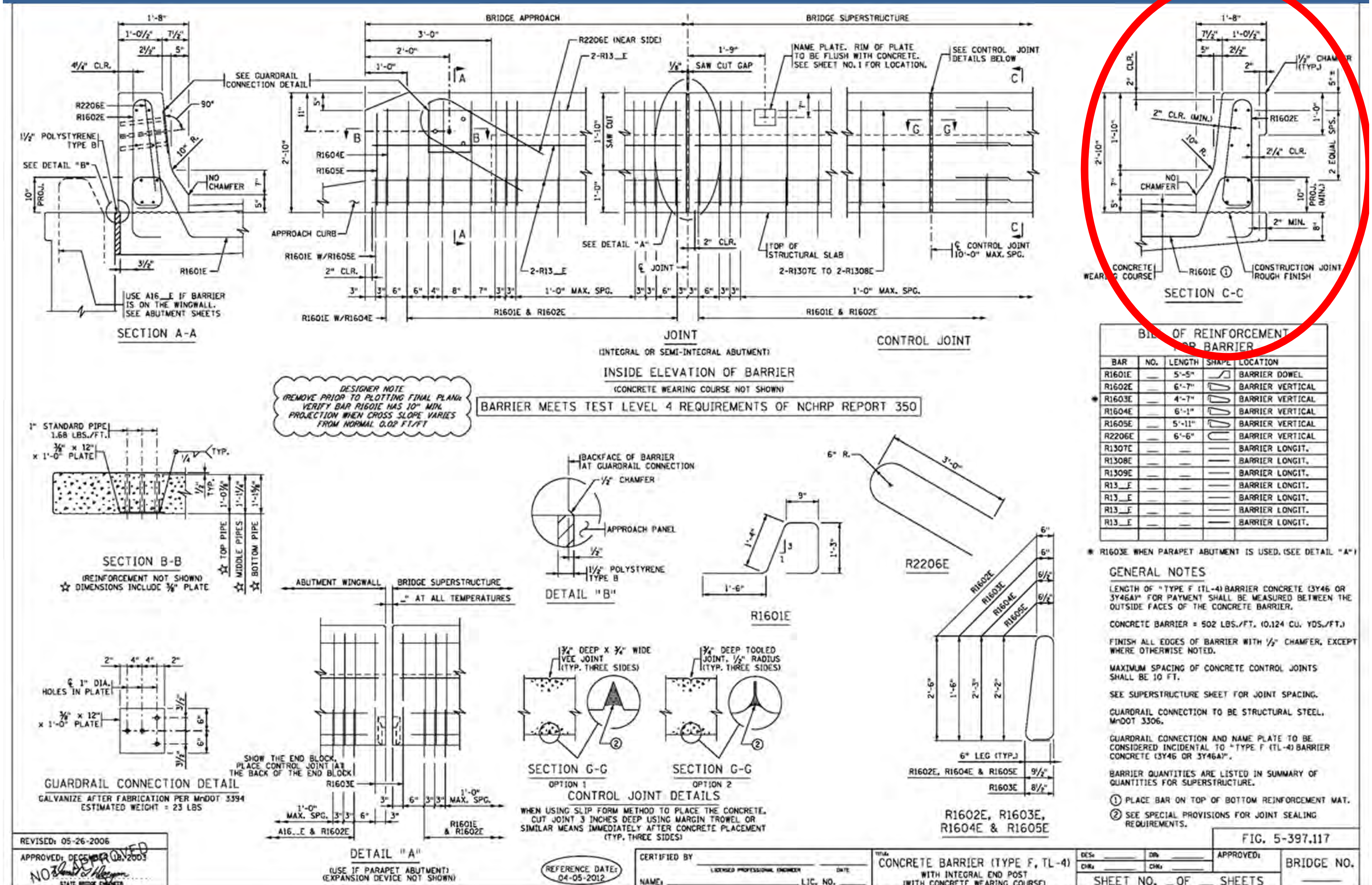
BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	__	5'-5"		BARRIER DOWEL
R1602E	__	6'-7"		BARRIER VERTICAL
* R1603E	__	4'-7"		BARRIER VERTICAL
R1604E	__	6'-1"		BARRIER VERTICAL
R1605E	__	5'-11"		BARRIER VERTICAL
R2206E	__	6'-6"		BARRIER VERTICAL
R1307E	__	__		BARRIER LONGIT.
R1308E	__	__		BARRIER LONGIT.
R1309E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.


R2206E (NEAR SIDE)
2-R13__E
1'-9"
1/8"
SAW CUT GAP
NAME PL
TO BE F
SEE SHEE
7"
1'-10"
SAW CUT
1'-0"
SEE DETAIL "A"
2" CLR.
TOP OF
STRUCTURAL S
℄ JOINT
-R13__E
2-R1307E TC
1'-0" MAX. SPG.
3" 3" 6" 3" 3" 6" 3" 3"



BRIDGE APPROACH
BRIDGE SUPERSTRUCTURE
SECTION A-A
SECTION B-B
(REINFORCEMENT NOT SHOWN)
☆ DIMENSIONS INCLUDE 3/8" PLATE
SECTION C-C
JOINT
(INTEGRAL OR SEMI-INTEGRAL ABUTMENT)
CONTROL JOINT
INSIDE ELEVATION OF BARRIER
(CONCRETE WEARING COURSE NOT SHOWN)
BARRIER MEETS TEST LEVEL 4 REQUIREMENTS OF NCHRP REPORT 350
DESIGNER NOTE
(REMOVE PRIOR TO PLOTTING FINAL PLAN)
VERIFY BAR R1601E HAS 10" MIN. PROJECTION WHEN CROSS SLOPE VARIES FROM NORMAL 0.02 FT/FT
DETAIL "B"
R1601E
R2206E
BILL OF REINFORCEMENT FOR BARRIER
BAR | NO. | LENGTH | SHAPE | LOCATION
R1601E | 5'-5" | BARRIER DOWEL
R1602E | 6'-7" | BARRIER VERTICAL
R1603E | 4'-7" | BARRIER VERTICAL
R1604E | 6'-1" | BARRIER VERTICAL
R1605E | 5'-11" | BARRIER VERTICAL
R2206E | 6'-6" | BARRIER VERTICAL
R1307E | BARRIER LONGIT.
R1308E | BARRIER LONGIT.
R1309E | BARRIER LONGIT.
R13_E | BARRIER LONGIT.
* R1603E WHEN PARAPET ABUTMENT IS USED. (SEE DETAIL "A")
GENERAL NOTES
LENGTH OF "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)" FOR PAYMENT SHALL BE MEASURED BETWEEN THE OUTSIDE FACES OF THE CONCRETE BARRIER.
CONCRETE BARRIER = 502 LBS./FT. (0.124 CU. YDS./FT.)
FINISH ALL EDGES OF BARRIER WITH 1/2" CHAMFER, EXCEPT WHERE OTHERWISE NOTED.
MAXIMUM SPACING OF CONCRETE CONTROL JOINTS SHALL BE 10 FT.
SEE SUPERSTRUCTURE SHEET FOR JOINT SPACING.
GUARDRAIL CONNECTION TO BE STRUCTURAL STEEL, MnDOT 3306.
GUARDRAIL CONNECTION AND NAME PLATE TO BE CONSIDERED INCIDENTAL TO "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)".
BARRIER QUANTITIES ARE LISTED IN SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE.
① PLACE BAR ON TOP OF BOTTOM REINFORCEMENT MAT.
② SEE SPECIAL PROVISIONS FOR JOINT SEALING REQUIREMENTS.
DETAIL "A"
(USE IF PARAPET ABUTMENT)
(EXPANSION DEVICE NOT SHOWN)
GUARDRAIL CONNECTION DETAIL
GALVANIZE AFTER FABRICATION PER MnDOT 3394
ESTIMATED WEIGHT = 23 LBS
SECTION G-G
OPTION 1
SECTION G-G
OPTION 2
CONTROL JOINT DETAILS
WHEN USING SLIP FORM METHOD TO PLACE THE CONCRETE, CUT JOINT 3 INCHES DEEP USING MARGIN TROWEL OR SIMILAR MEANS IMMEDIATELY AFTER CONCRETE PLACEMENT (TYP. THREE SIDES)
R1602E, R1603E, R1604E & R1605E
REVISED: 05-26-2006
APPROVED: DECEMBER 18, 2003
NOT APPROVED
STATE BRIDGE ENGINEER
REFERENCE DATE: 04-05-2012
CERTIFIED BY
CONCRETE BARRIER (TYPE F, TL-4)
WITH INTEGRAL END POST
(WITH CONCRETE WEARING COURSE)
FIG. 5-397.117
BRIDGE NO.
SHEET NO. _ OF _ SHEETS


ABUTMENT WINGWALL
BRIDGE SUPERSTRUCTURE
_" AT ALL TEMPERATURES
THE END BLOCK.
CONTROL JOINT AT
OF THE END BLOCK
R1603E
3"
6"
3" 3"
1'-0" MAX. SPG.
1'-0" MAX. SPG.
3" 3"
6"
3"
A16__E & R1602E
R1601E & R1602E
DETAIL "A"
(USE IF PARAPET ABUTMENT)
(EXPANSION DEVICE NOT SHOWN)



BILL OF REINFORCEMENT FOR BARRIER

BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	__	5'-5"		BARRIER DOWEL
R1602E	__	6'-7"		BARRIER VERTICAL
* R1603E	__	4'-7"		BARRIER VERTICAL
R1604E	__	6'-1"		BARRIER VERTICAL
R1605E	__	5'-11"		BARRIER VERTICAL
R2206E	__	6'-6"		BARRIER VERTICAL
R1307E	__	__		BARRIER LONGIT.
R1308E	__	__		BARRIER LONGIT.
R1309E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.

* R1603E WHEN PARAPET ABUTMENT IS USED. (SEE DETAIL "A")

GENERAL NOTES

LENGTH OF "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)" FOR PAYMENT SHALL BE MEASURED BETWEEN THE OUTSIDE FACES OF THE CONCRETE BARRIER.

CONCRETE BARRIER = 502 LBS./FT. (0.124 CU. YDS./FT.)

FINISH ALL EDGES OF BARRIER WITH ½" CHAMFER, EXCEPT WHERE OTHERWISE NOTED.

MAXIMUM SPACING OF CONCRETE CONTROL JOINTS SHALL BE 10 FT.

SEE SUPERSTRUCTURE SHEET FOR JOINT SPACING.

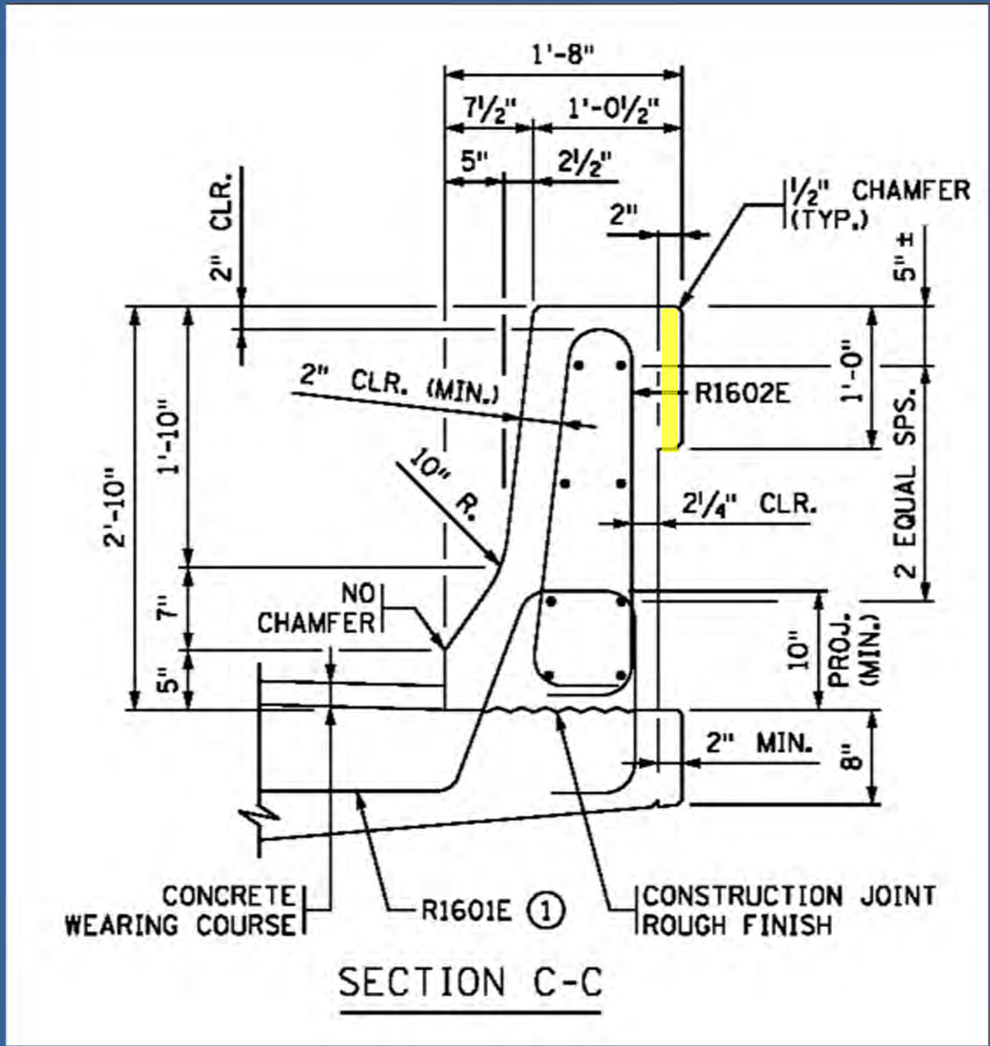
GUARDRAIL CONNECTION TO BE STRUCTURAL STEEL, MnDOT 3306.

GUARDRAIL CONNECTION AND NAME PLATE TO BE CONSIDERED INCIDENTAL TO "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)".

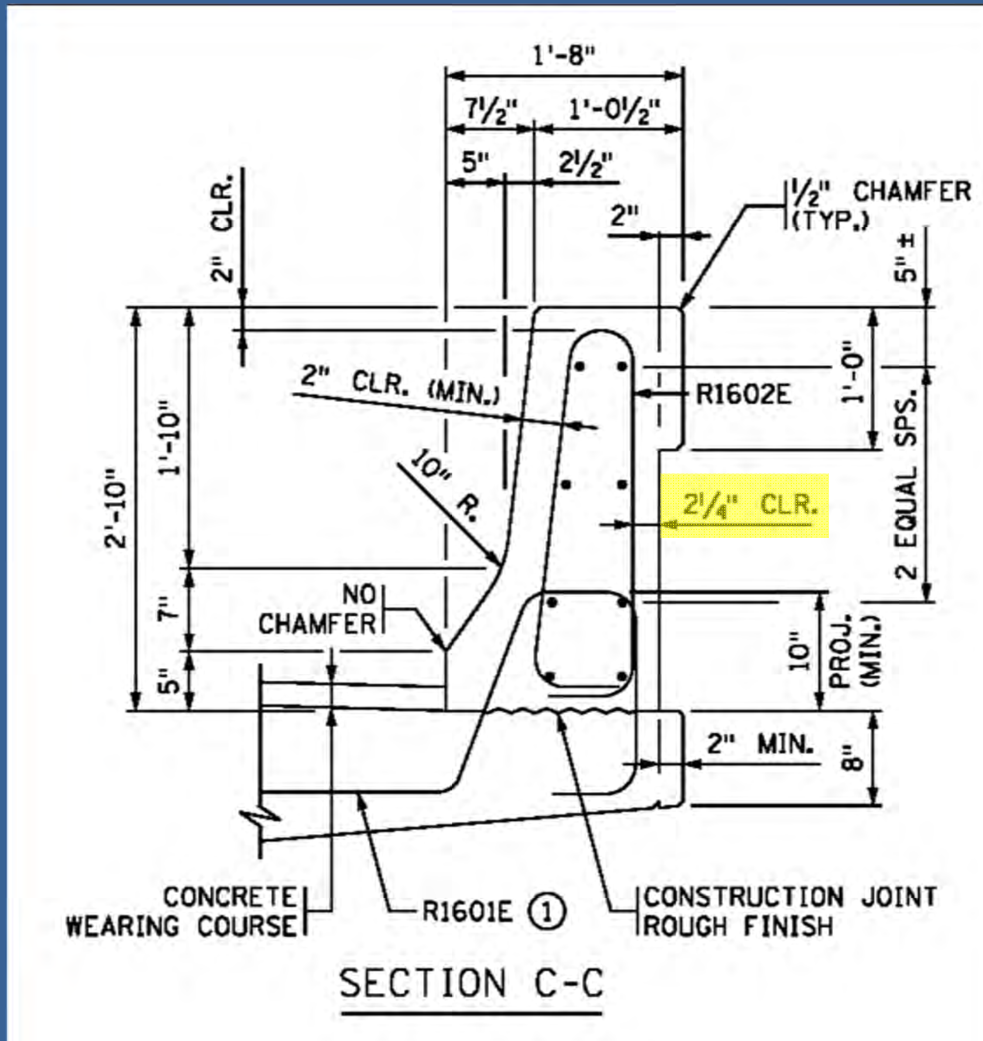
BARRIER QUANTITIES ARE LISTED IN SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE.

(1) PLACE BAR ON TOP OF BOTTOM REINFORCEMENT MAT.

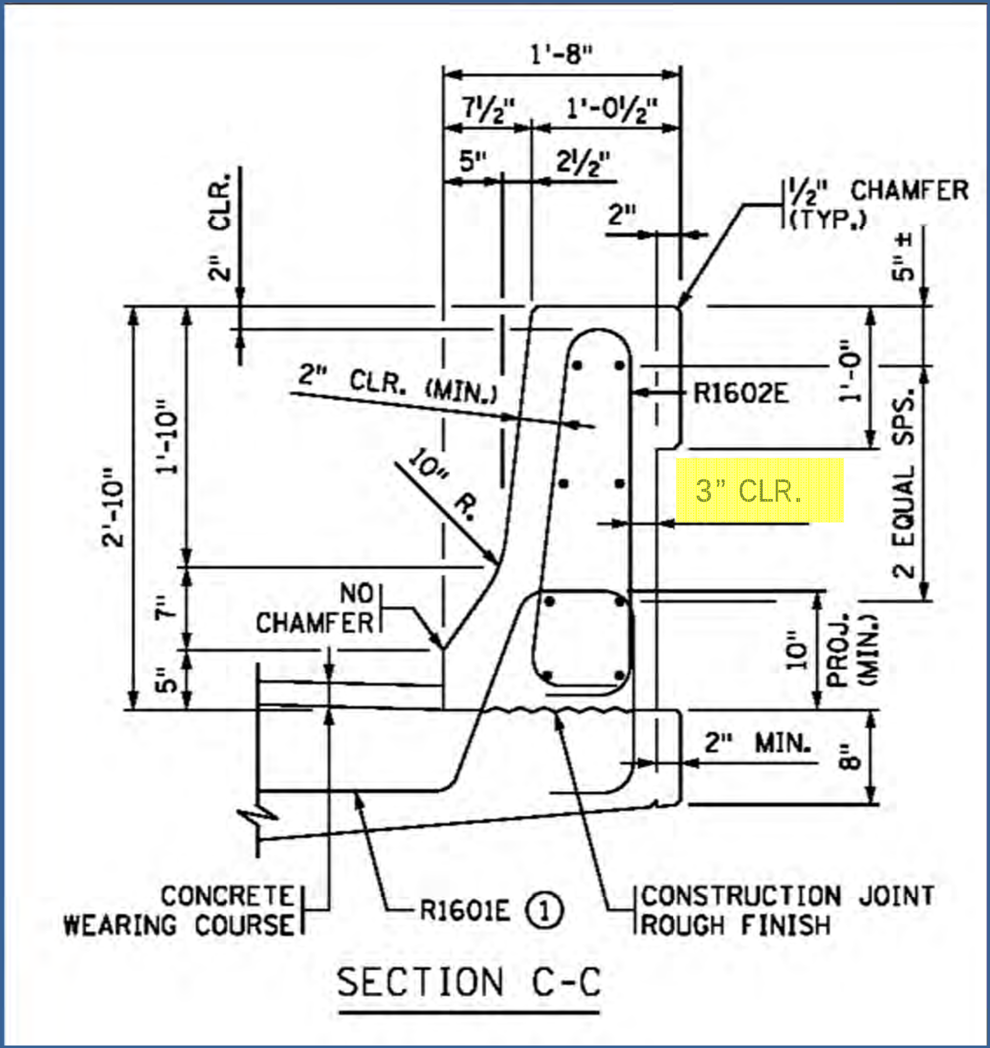
(2) SEE SPECIAL PROVISIONS FOR JOINT SEALING REQUIREMENTS.

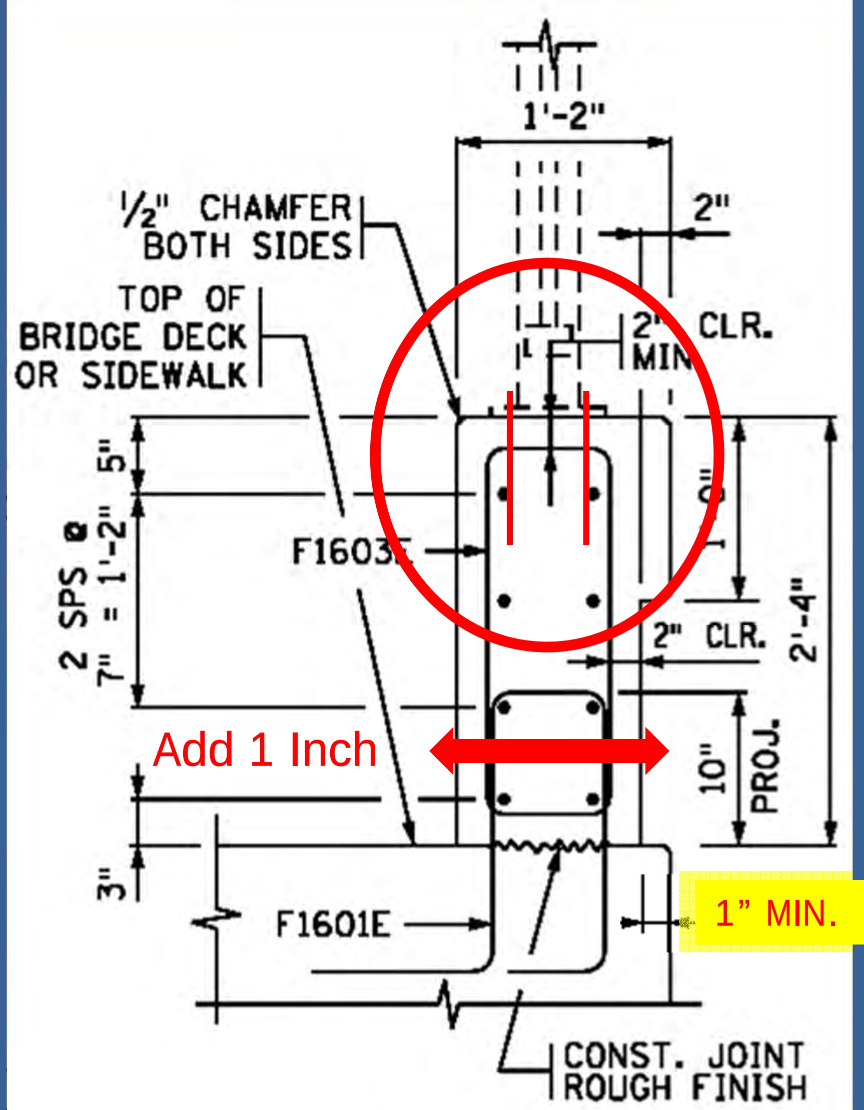

1'-8"
7½"
1'-0½"
5"
2½"
½" CHAMFER
(TYP.)
2"
2" CLR.
5" ±
2" CLR. (MIN.)
R1602E
1'-0"
2 EQUAL SPS.
10" R.
2¼" CLR.
2'-10"
1'-10"
7"
5"
NO
CHAMFER
10"
PROJ.
(MIN.)
2" MIN.
8"
CONCRETE
WEARING COURSE
R1601E ①
CONSTRUCTION JOINT
ROUGH FINISH
SECTION C-C


GOMACO
PCi
ST. MICHAEL, MN


1'-8"
7½"
1'-0½"
5"
2½"
2" CLR.
½" CHAMFER
(TYP.)
2"
5" ±
2'-10"
1'-10"
2" CLR. (MIN.)
R1602E
1'-0"
2 EQUAL SPS.
10" R.
2¼" CLR.
NO
CHAMFER
7"
5"
10"
PROJ.
(MIN.)
2" MIN.
8"
CONCRETE
WEARING COURSE
R1601E ①
CONSTRUCTION JOINT
ROUGH FINISH
SECTION C-C

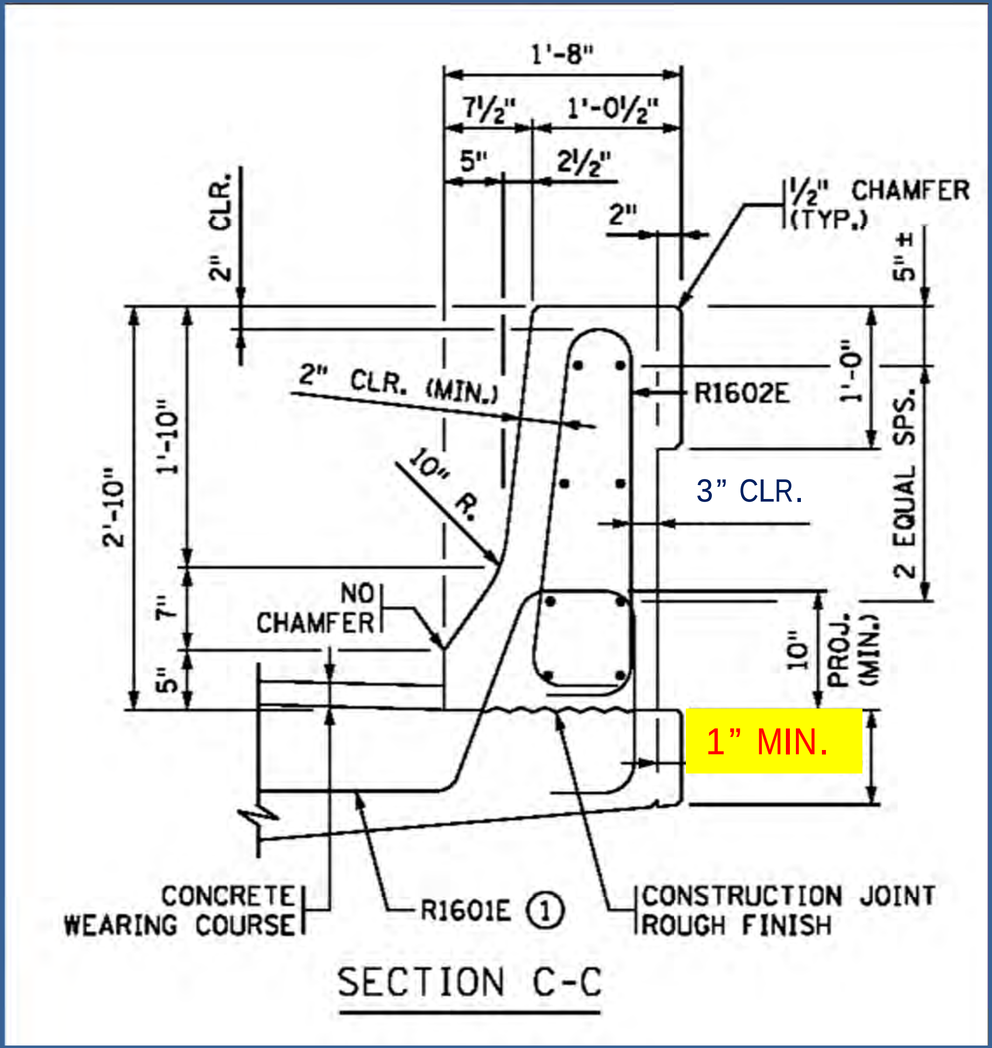

LEFT LANE
MUST
TURN LEFT
01/18/2012 10:28

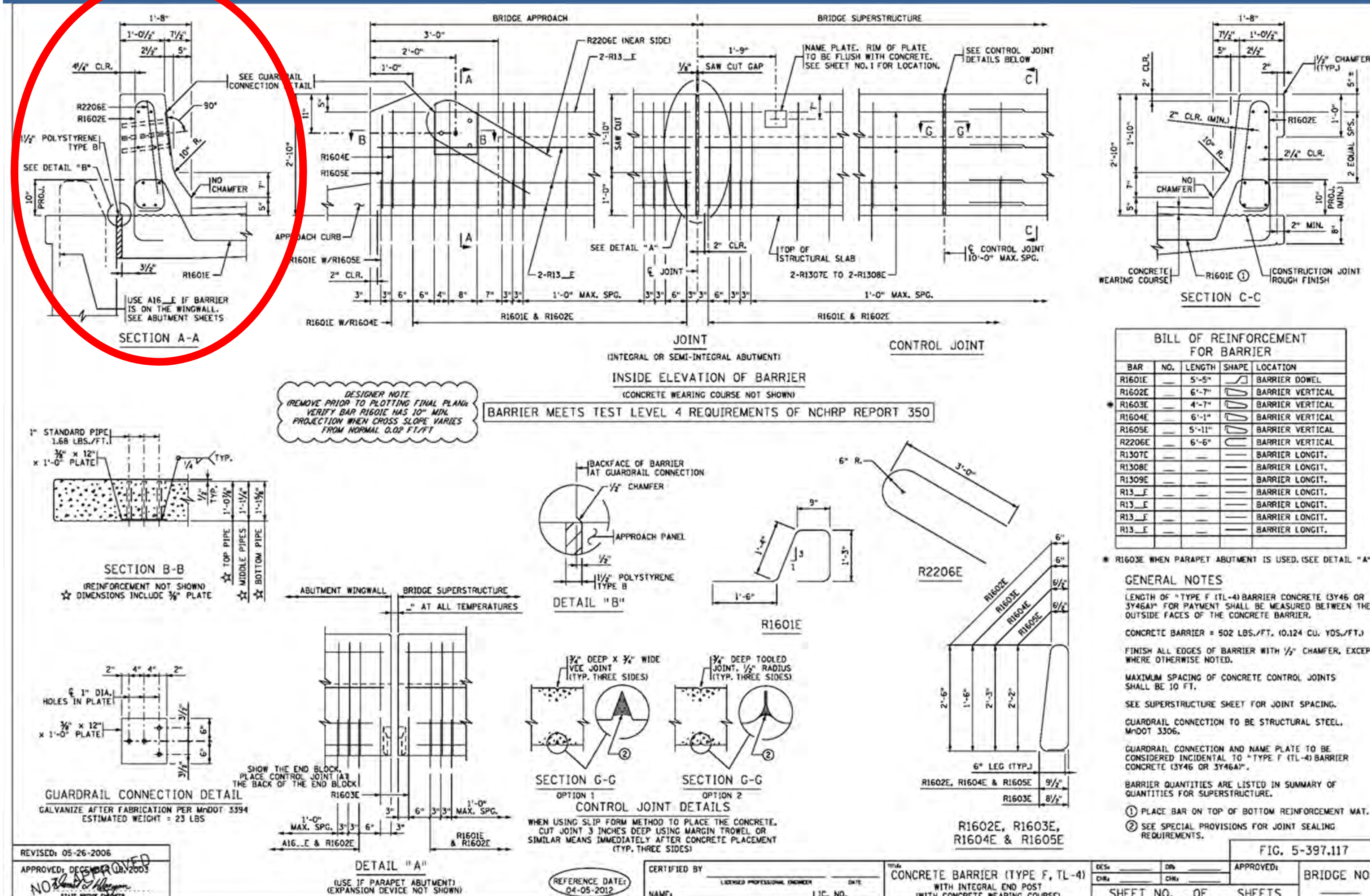

1'-8"
7½"
1'-0½"
5"
2½"
2"
½" CHAMFER
(TYP.)
2" CLR.
5" ±
2" CLR. (MIN.)
R1602E
1'-0"
2 EQUAL SPS.
10" R.
3" CLR.
2'-10"
1'-10"
7"
5"
NO
CHAMFER
10"
PROJ.
(MIN.)
2" MIN.
8"
CONCRETE
WEARING COURSE
R1601E ①
CONSTRUCTION JOINT
ROUGH FINISH
SECTION C-C



1'-2"
2"
½" CHAMFER BOTH SIDES
TOP OF BRIDGE DECK OR SIDEWALK
2" CLR.
2" MIN
5"
2 SPS @ 7" = 1'-2"
F1603E
2" CLR.
2'-4"
Add 1 Inch
10" PROJ.
3"
F1601E
1" MIN.
CONST. JOINT ROUGH FINISH

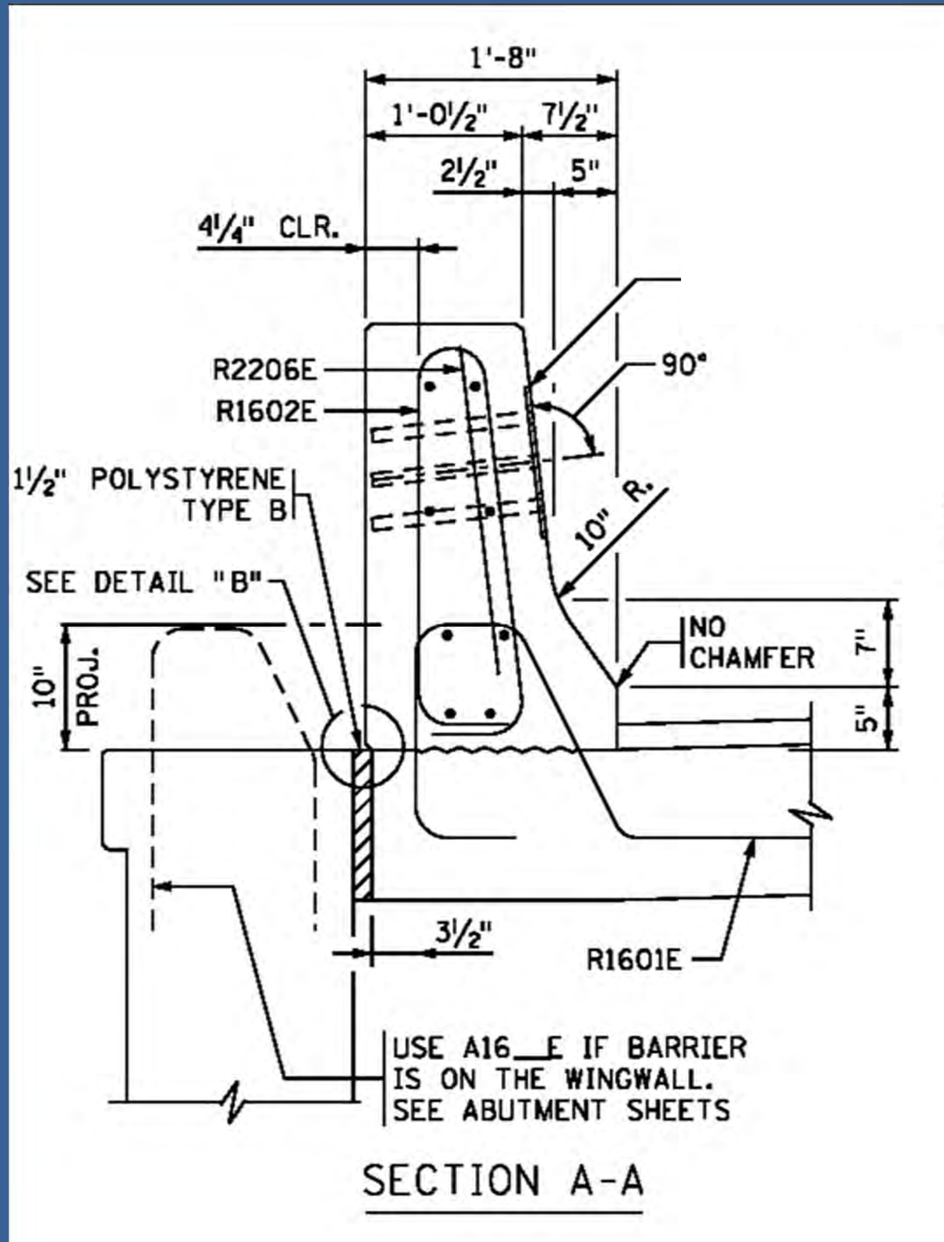
SECTION B-B

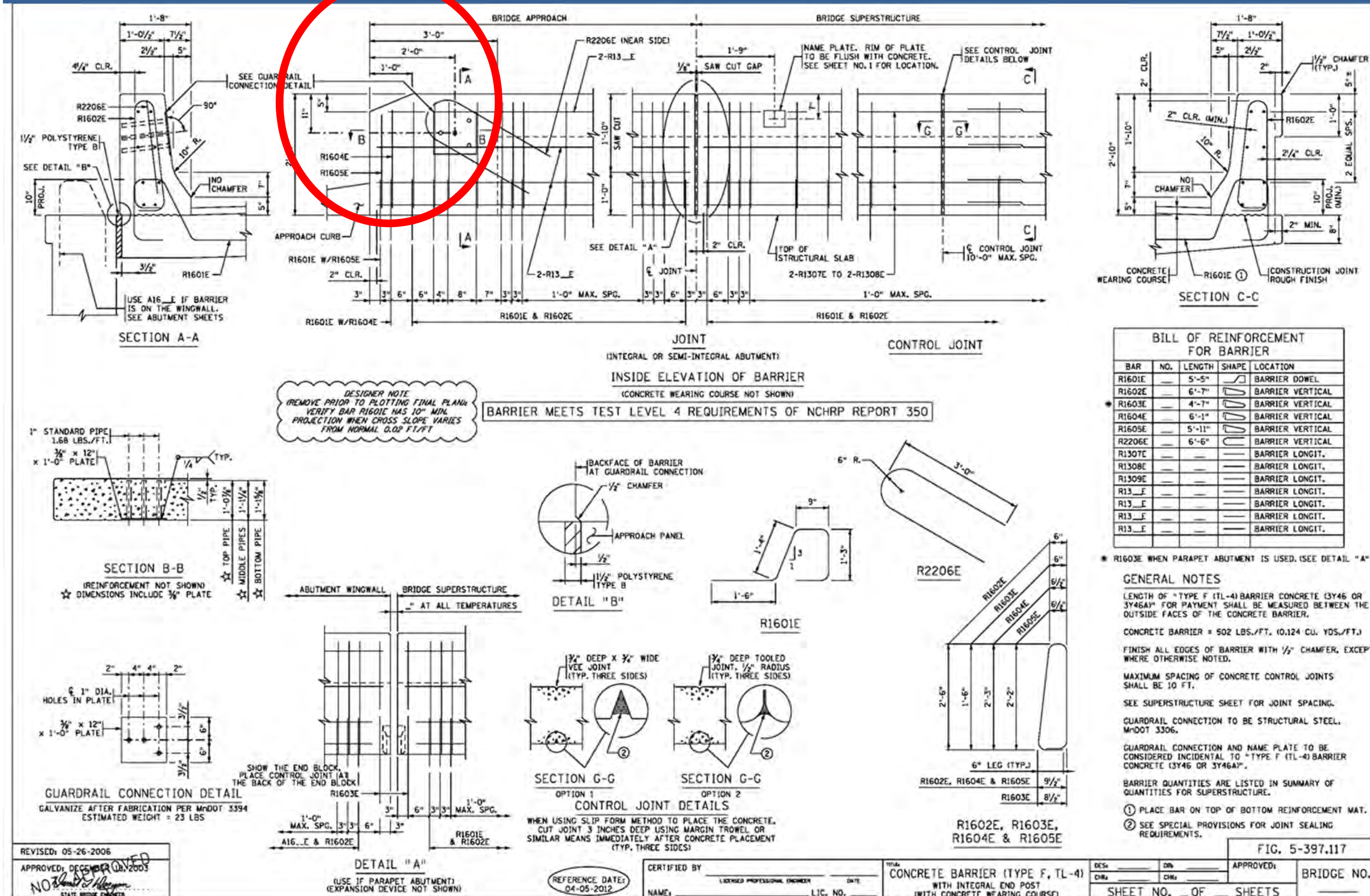

1'-8"
7½"
1'-0½"
5"
2½"
2"
½" CHAMFER (TYP.)
2" CLR.
5"±
2" CLR. (MIN.)
R1602E
1'-0"
2 EQUAL SPS.
10" R.
3" CLR.
2'-10"
1'-10"
7"
5"
NO CHAMFER
10" PROJ. (MIN.)
1" MIN.
CONCRETE WEARING COURSE
R1601E ①
CONSTRUCTION JOINT ROUGH FINISH
SECTION C-C



BILL OF REINFORCEMENT FOR BARRIER

BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	__	5'-5"		BARRIER DOWEL
R1602E	__	6'-7"		BARRIER VERTICAL
* R1603E	__	4'-7"		BARRIER VERTICAL
R1604E	__	6'-1"		BARRIER VERTICAL
R1605E	__	5'-11"		BARRIER VERTICAL
R2206E	__	6'-6"		BARRIER VERTICAL
R1307E	__	__		BARRIER LONGIT.
R1308E	__	__		BARRIER LONGIT.
R1309E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.
R13__E	__	__		BARRIER LONGIT.


1'-8"
1'-0½"
7½"
2½"
5"
4¼" CLR.
R2206E
R1602E
90°
1½" POLYSTYRENE TYPE B
10" R.
SEE DETAIL "B"
NO CHAMFER
7"
5"
10" PROJ.
3½"
R1601E
USE A16__E IF BARRIER IS ON THE WINGWALL. SEE ABUTMENT SHEETS
SECTION A-A



BILL OF REINFORCEMENT FOR BARRIER

BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	—	5'-5"		BARRIER DOWEL
R1602E	—	6'-7"		BARRIER VERTICAL
* R1603E	—	4'-7"		BARRIER VERTICAL
R1604E	—	6'-1"		BARRIER VERTICAL
R1605E	—	5'-11"		BARRIER VERTICAL
R2206E	—	6'-6"		BARRIER VERTICAL
R1307E	—	—		BARRIER LONGIT.
R1308E	—	—		BARRIER LONGIT.
R1309E	—	—		BARRIER LONGIT.
R13__E	—	—		BARRIER LONGIT.
R13__E	—	—		BARRIER LONGIT.
R13__E	—	—		BARRIER LONGIT.
R13__E	—	—		BARRIER LONGIT.

* R1603E WHEN PARAPET ABUTMENT IS USED. (SEE DETAIL "A")

GENERAL NOTES

LENGTH OF "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)" FOR PAYMENT SHALL BE MEASURED BETWEEN THE OUTSIDE FACES OF THE CONCRETE BARRIER.

CONCRETE BARRIER = 502 LBS./FT. (0.124 CU. YDS./FT.)

FINISH ALL EDGES OF BARRIER WITH 1/2" CHAMFER, EXCEPT WHERE OTHERWISE NOTED.

MAXIMUM SPACING OF CONCRETE CONTROL JOINTS SHALL BE 10 FT.

SEE SUPERSTRUCTURE SHEET FOR JOINT SPACING.

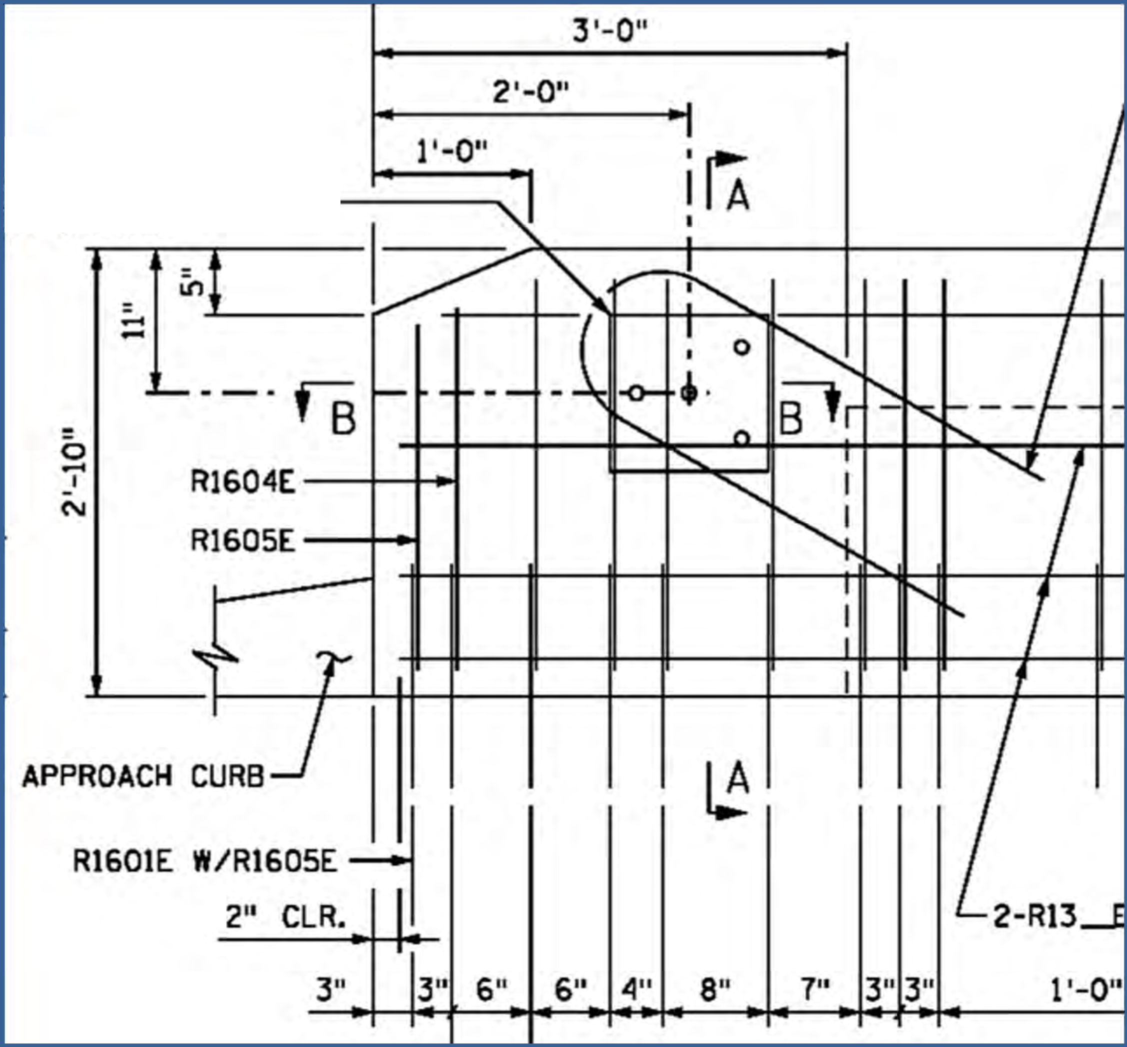
GUARDRAIL CONNECTION TO BE STRUCTURAL STEEL, MnDOT 3306.

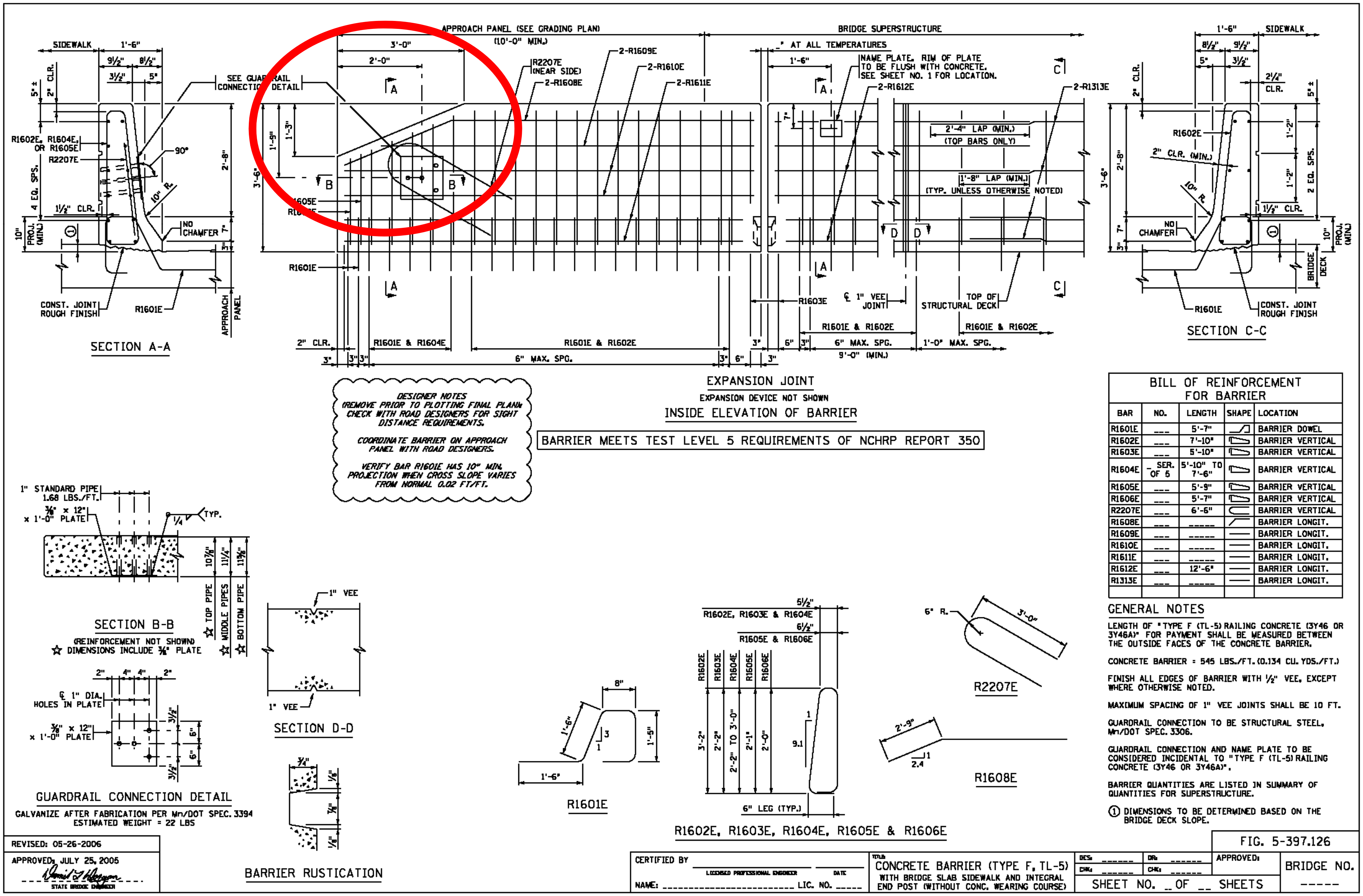
GUARDRAIL CONNECTION AND NAME PLATE TO BE CONSIDERED INCIDENTAL TO "TYPE F (TL-4) BARRIER CONCRETE (3Y46 OR 3Y46A)".

BARRIER QUANTITIES ARE LISTED IN SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE.

① PLACE BAR ON TOP OF BOTTOM REINFORCEMENT MAT.

② SEE SPECIAL PROVISIONS FOR JOINT SEALING REQUIREMENTS.


3'-0"
2'-0"
1'-0"
A
5"
11"
2'-10"
B
B
R1604E
R1605E
APPROACH CURB
A
R1601E W/R1605E
2" CLR.
2-R13
3"
3"
6"
6"
4"
8"
7"
3"
3"
1'-0"



BILL OF REINFORCEMENT FOR BARRIER

BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	___	5'-7"		BARRIER DOWEL
R1602E	___	7'-10"		BARRIER VERTICAL
R1603E	___	5'-10"		BARRIER VERTICAL
R1604E	_ SER. OF 5	5'-10" TO 7'-6"		BARRIER VERTICAL
R1605E	___	5'-9"		BARRIER VERTICAL
R1606E	___	5'-7"		BARRIER VERTICAL
R2207E	___	6'-6"		BARRIER VERTICAL
R1608E	___	_____		BARRIER LONGIT.
R1609E	___	_____		BARRIER LONGIT.
R1610E	___	_____		BARRIER LONGIT.
R1611E	___	_____		BARRIER LONGIT.
R1612E	___	12'-6"		BARRIER LONGIT.
R1313E	___	_____		BARRIER LONGIT.

GENERAL NOTES

LENGTH OF "TYPE F (TL-5) RAILING CONCRETE (3Y46 OR 3Y46A)" FOR PAYMENT SHALL BE MEASURED BETWEEN THE OUTSIDE FACES OF THE CONCRETE BARRIER.

CONCRETE BARRIER = 545 LBS./FT. (0.134 CU. YDS./FT.)

FINISH ALL EDGES OF BARRIER WITH 1/2" VEE, EXCEPT WHERE OTHERWISE NOTED.

MAXIMUM SPACING OF 1" VEE JOINTS SHALL BE 10 FT.

GUARDRAIL CONNECTION TO BE STRUCTURAL STEEL, Mn/DOT SPEC. 3306.

GUARDRAIL CONNECTION AND NAME PLATE TO BE CONSIDERED INCIDENTAL TO "TYPE F (TL-5) RAILING CONCRETE (3Y46 OR 3Y46A)".

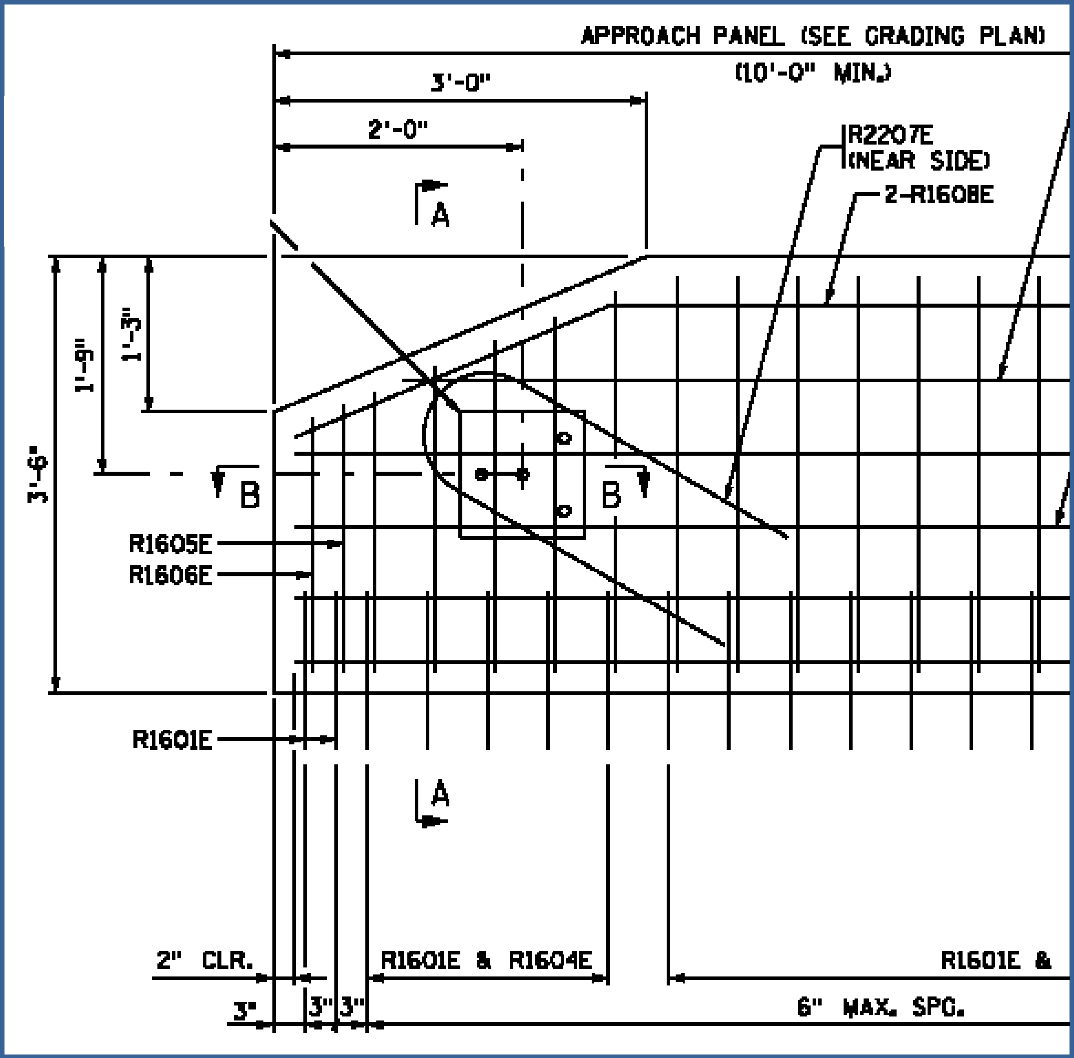
BARRIER QUANTITIES ARE LISTED IN SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE.

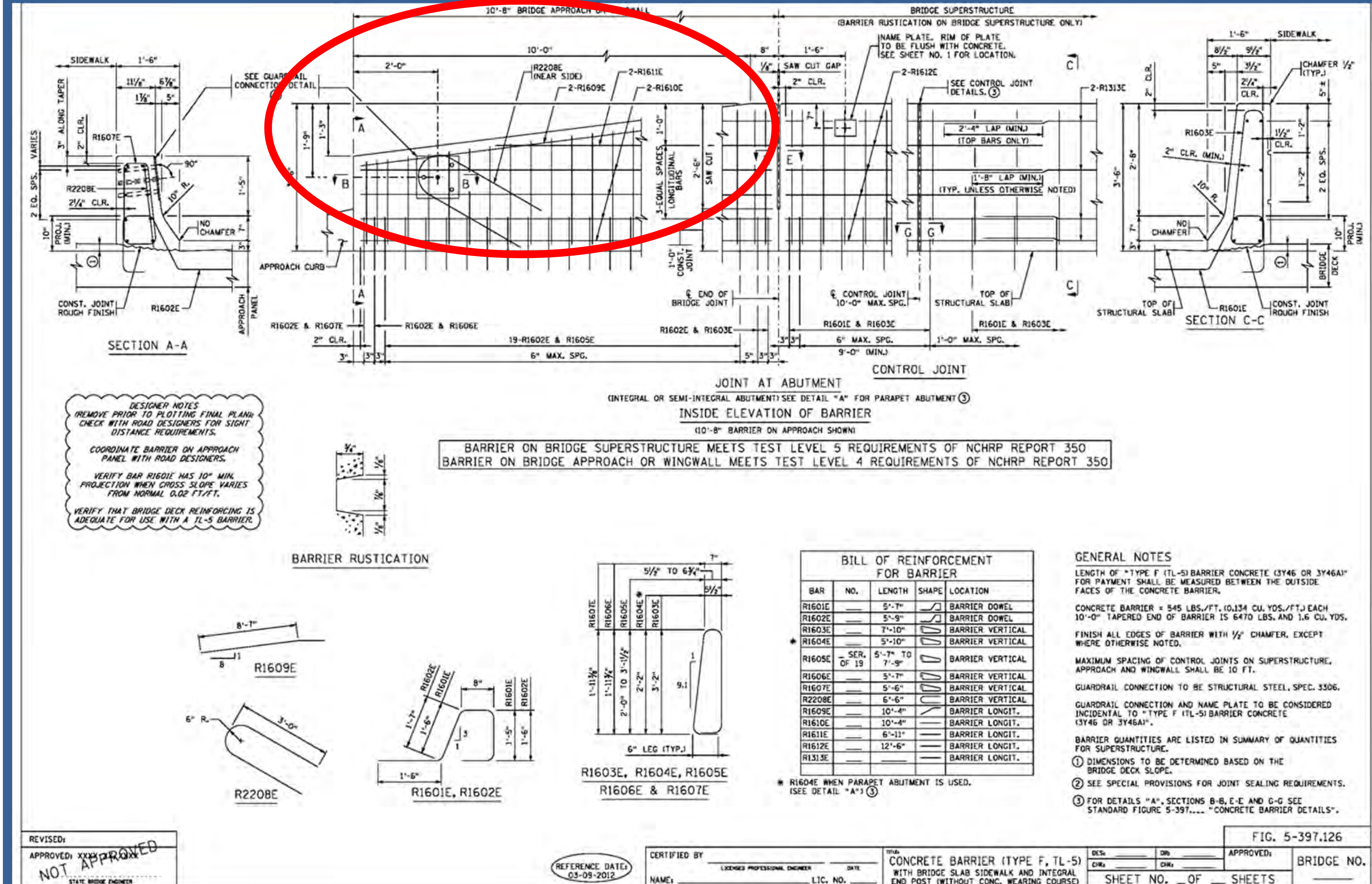
① DIMENSIONS TO BE DETERMINED BASED ON THE BRIDGE DECK SLOPE.

FIG. 5-397.126

DES: ______ DR: ______ CHK: ______ CHK: ______ APPROVED: BRIDGE NO. -----

SHEET NO. __ OF __ SHEETS

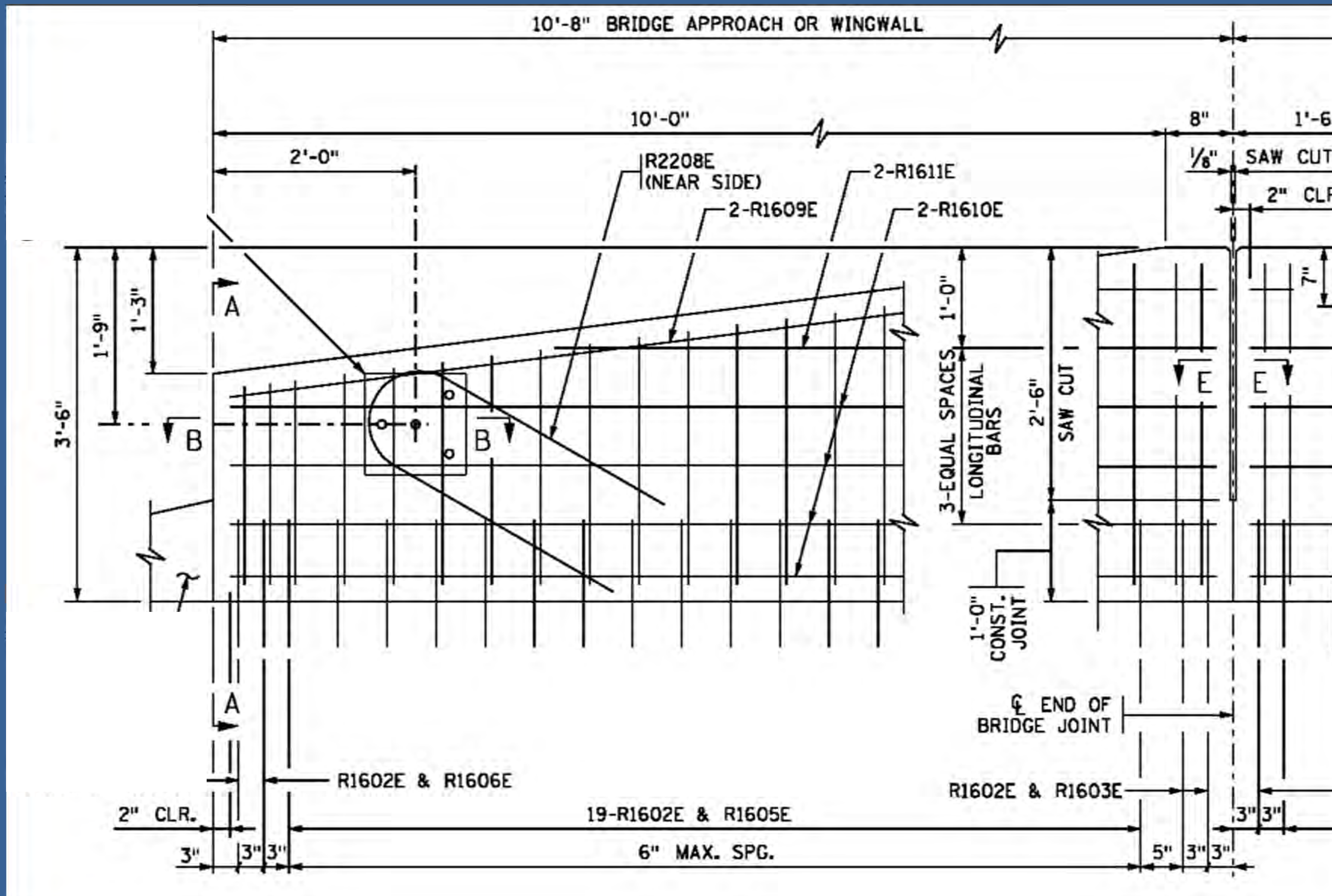

APPROACH PANEL (SEE GRADING PLAN)
(10'-0" MIN.)
3'-0"
2'-0"
R2207E
(NEAR SIDE)
2-R1608E
A
A
B
B
1'-3"
1'-9"
3'-6"
R1605E
R1606E
R1601E
2" CLR.
R1601E & R1604E
R1601E &
3"
3"
3"
6" MAX. SPG.

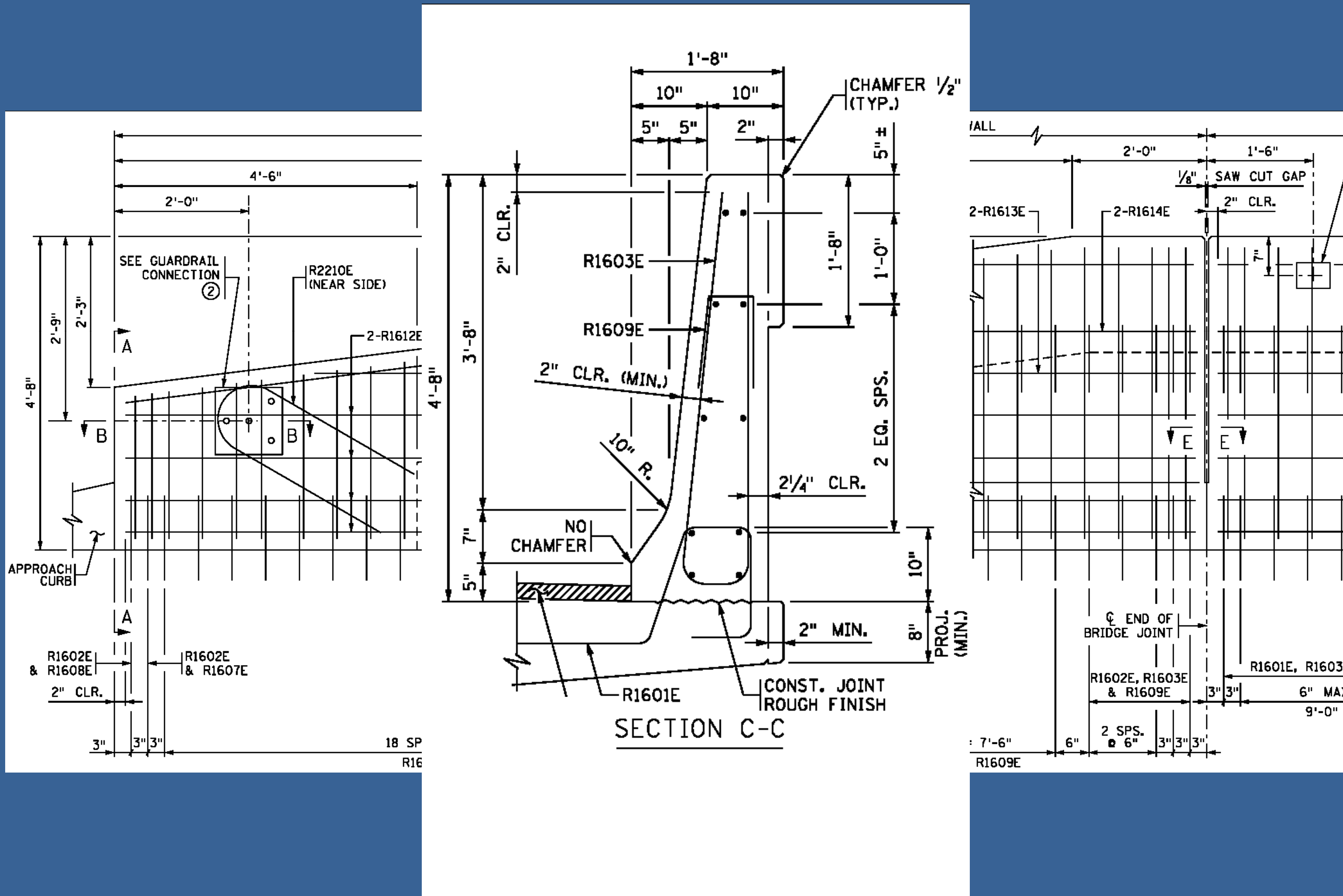


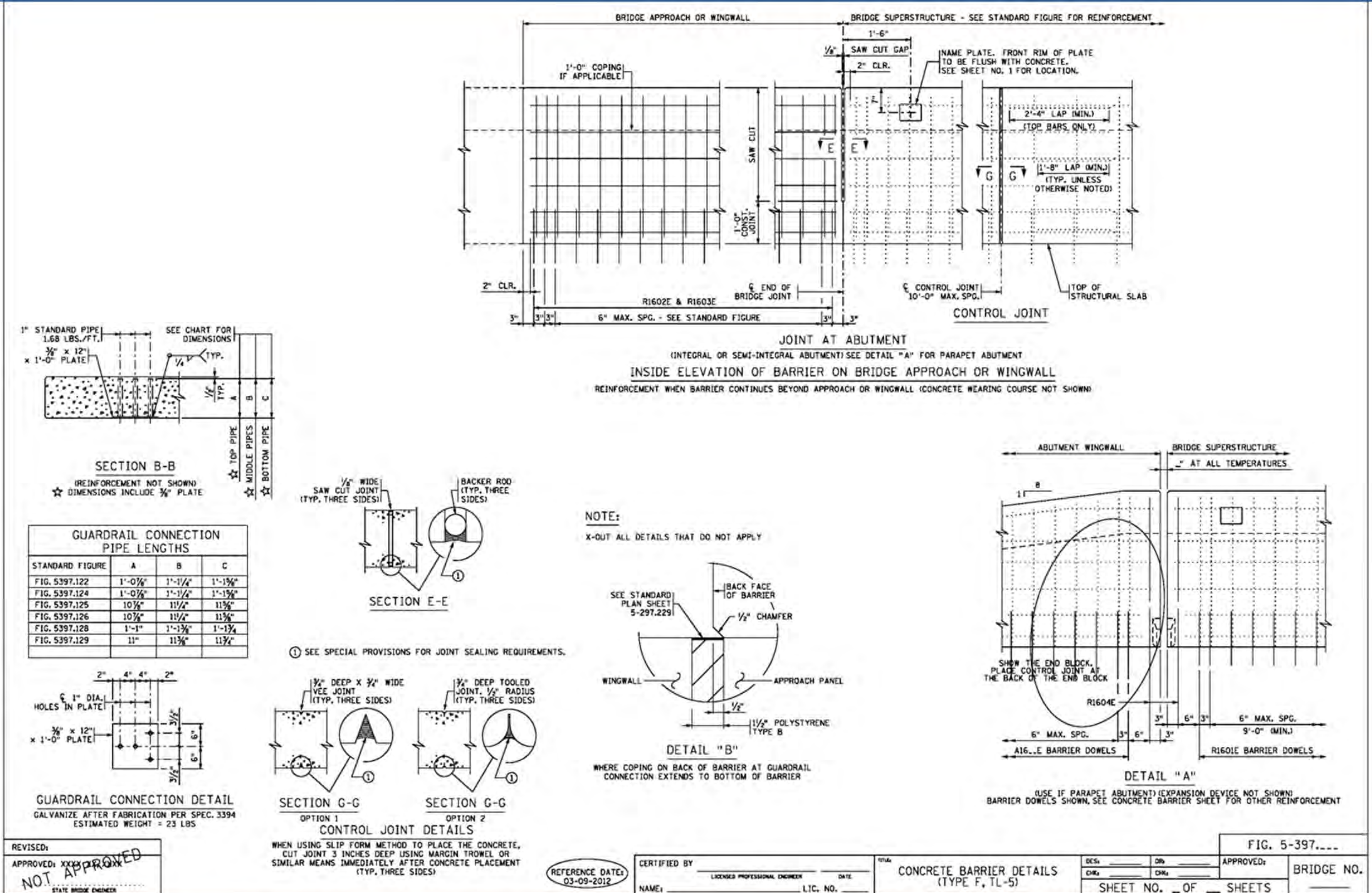
BILL OF REINFORCEMENT FOR BARRIER

BAR	NO.	LENGTH	SHAPE	LOCATION
R1601E	___	5'-7"		BARRIER DOWEL
R1602E	___	5'-9"		BARRIER DOWEL
R1603E	___	7'-10"		BARRIER VERTICAL
* R1604E	___	5'-10"		BARRIER VERTICAL
R1605E	_ SER. OF 19	5'-7" TO 7'-9"		BARRIER VERTICAL
R1606E	___	5'-7"		BARRIER VERTICAL
R1607E	___	5'-6"		BARRIER VERTICAL
R2208E	___	6'-6"		BARRIER VERTICAL
R1609E	___	10'-4"		BARRIER LONGIT.
R1610E	___	10'-4"		BARRIER LONGIT.
R1611E	___	6'-11"		BARRIER LONGIT.
R1612E	___	12'-6"		BARRIER LONGIT.
R1313E	___	___		BARRIER LONGIT.

* R1604E WHEN PARAPET ABUTMENT IS USED. (SEE DETAIL "A") ③

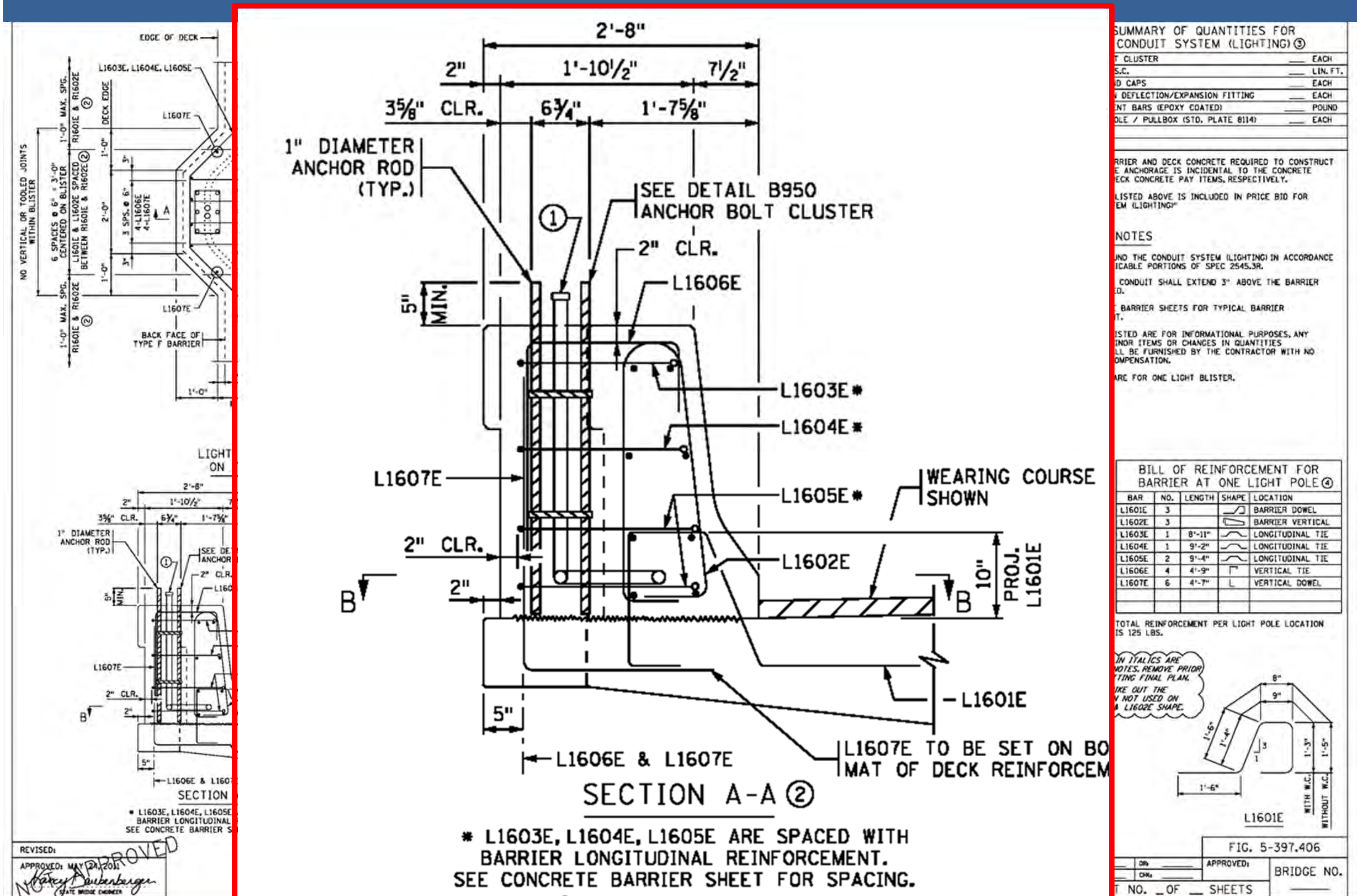

10'-8" BRIDGE APPROACH OR WINGWALL
10'-0"
8"
1'-6"
2'-0"
R2208E
(NEAR SIDE)
2-R1611E
2-R1609E
2-R1610E
1/8"
SAW CUT
2" CLR.
7"
3'-6"
1'-9"
1'-3"
A
B
B
1'-0"
3-EQUAL SPACES, LONGITUDINAL BARS
2'-6"
SAW CUT
E
E
1'-0" CONST. JOINT
℄ END OF BRIDGE JOINT
R1602E & R1606E
R1602E & R1603E
2" CLR.
19-R1602E & R1605E
6" MAX. SPG.
3"
3"
3"
5"
3"
3"
3"
3"

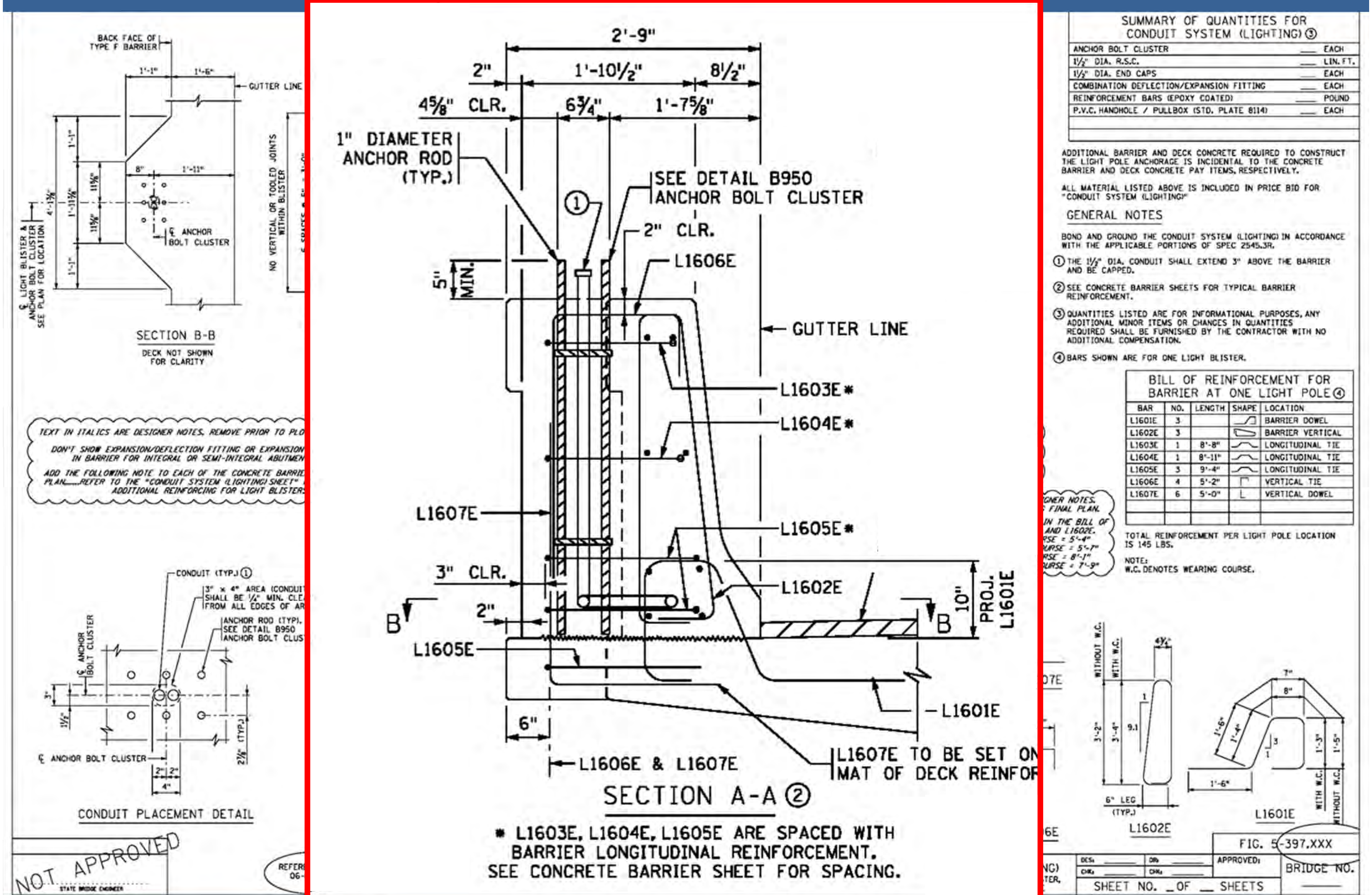

1'-8"
10"
10"
5"
5"
2"
CHAMFER ½" (TYP.)
5" ±
2" CLR.
R1603E
R1609E
1'-8"
1'-0"
3'-8"
4'-8"
2" CLR. (MIN.)
10" R.
2 EQ. SPS.
2¼" CLR.
NO CHAMFER
7"
5"
10"
2" MIN.
8"
PROJ. (MIN.)
R1601E
CONST. JOINT ROUGH FINISH
SECTION C-C
4'-6"
2'-0"
2'-9"
2'-3"
SEE GUARDRAIL CONNECTION ②
R2210E (NEAR SIDE)
2-R1612E
APPROACH CURB
R1602E & R1608E
R1602E & R1607E
2" CLR.
3"
3"
3"
18 SP
2'-0"
1'-6"
⅛"
SAW CUT GAP
2" CLR.
2-R1613E
2-R1614E
7"
℄ END OF BRIDGE JOINT
R1602E, R1603E & R1609E
R1601E, R1603E
6" MAX.
9'-0"
2 SPS. @ 6"
7'-6"
6"
R1609E

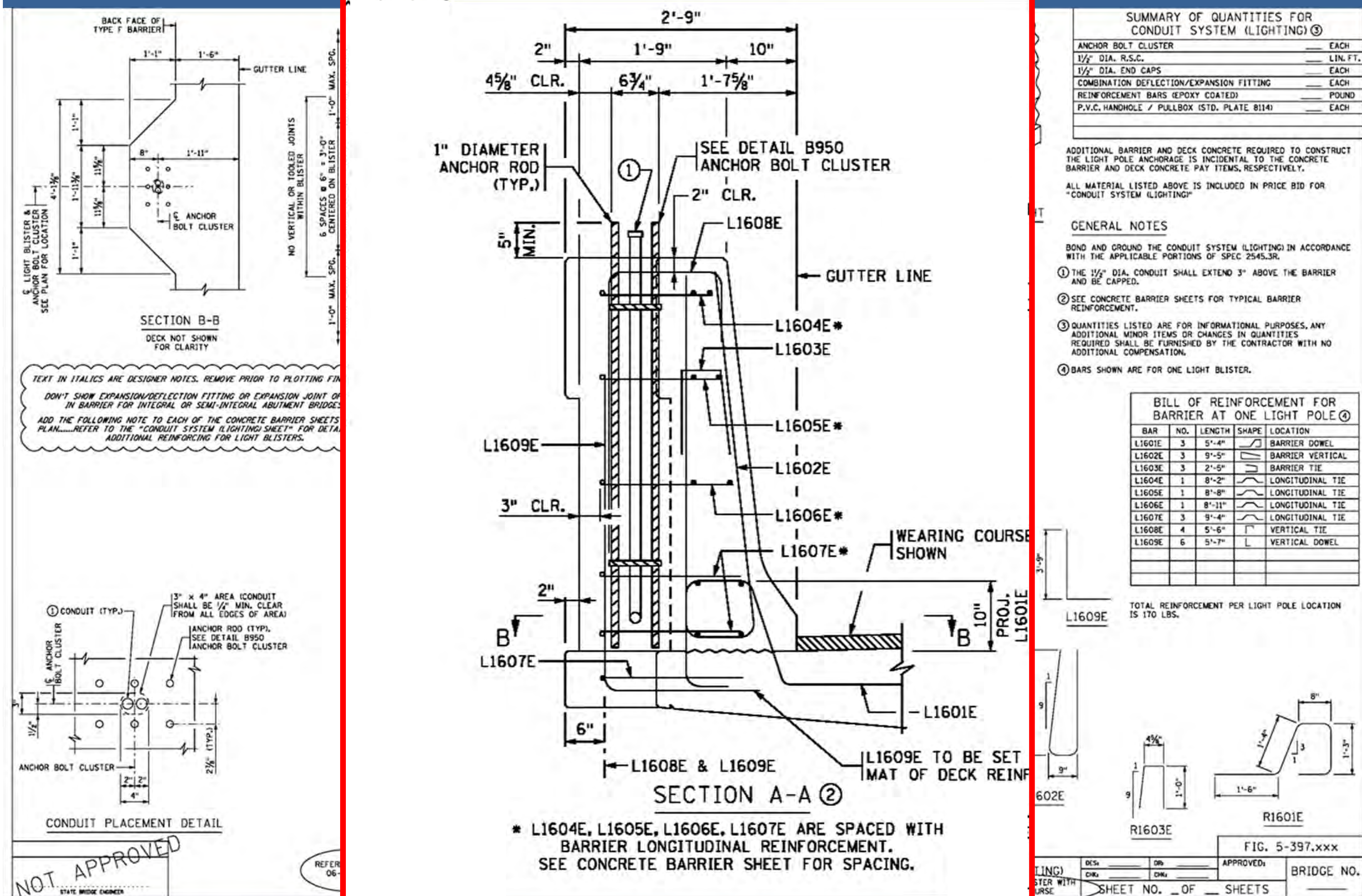


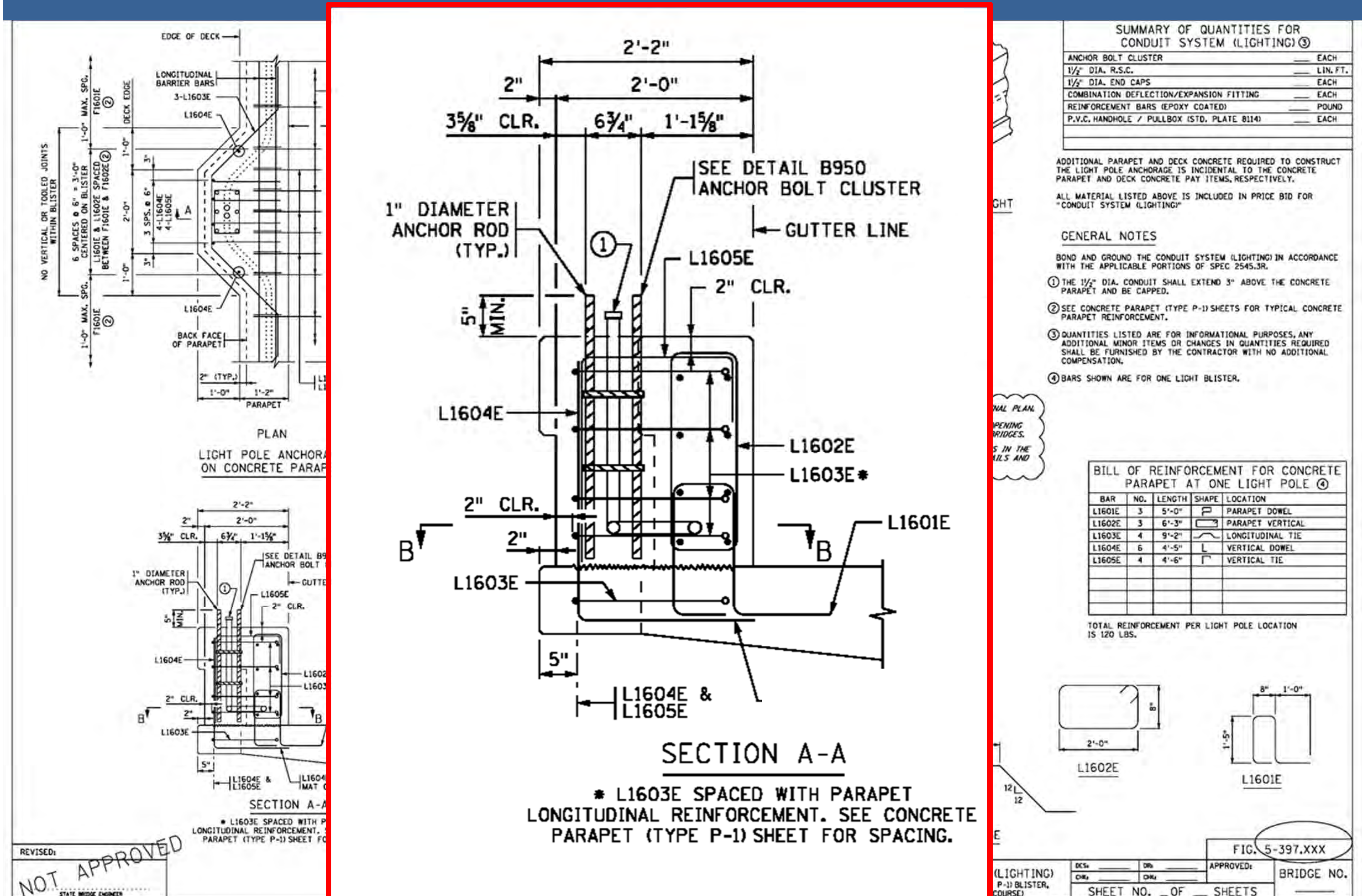
GUARDRAIL CONNECTION PIPE LENGTHS

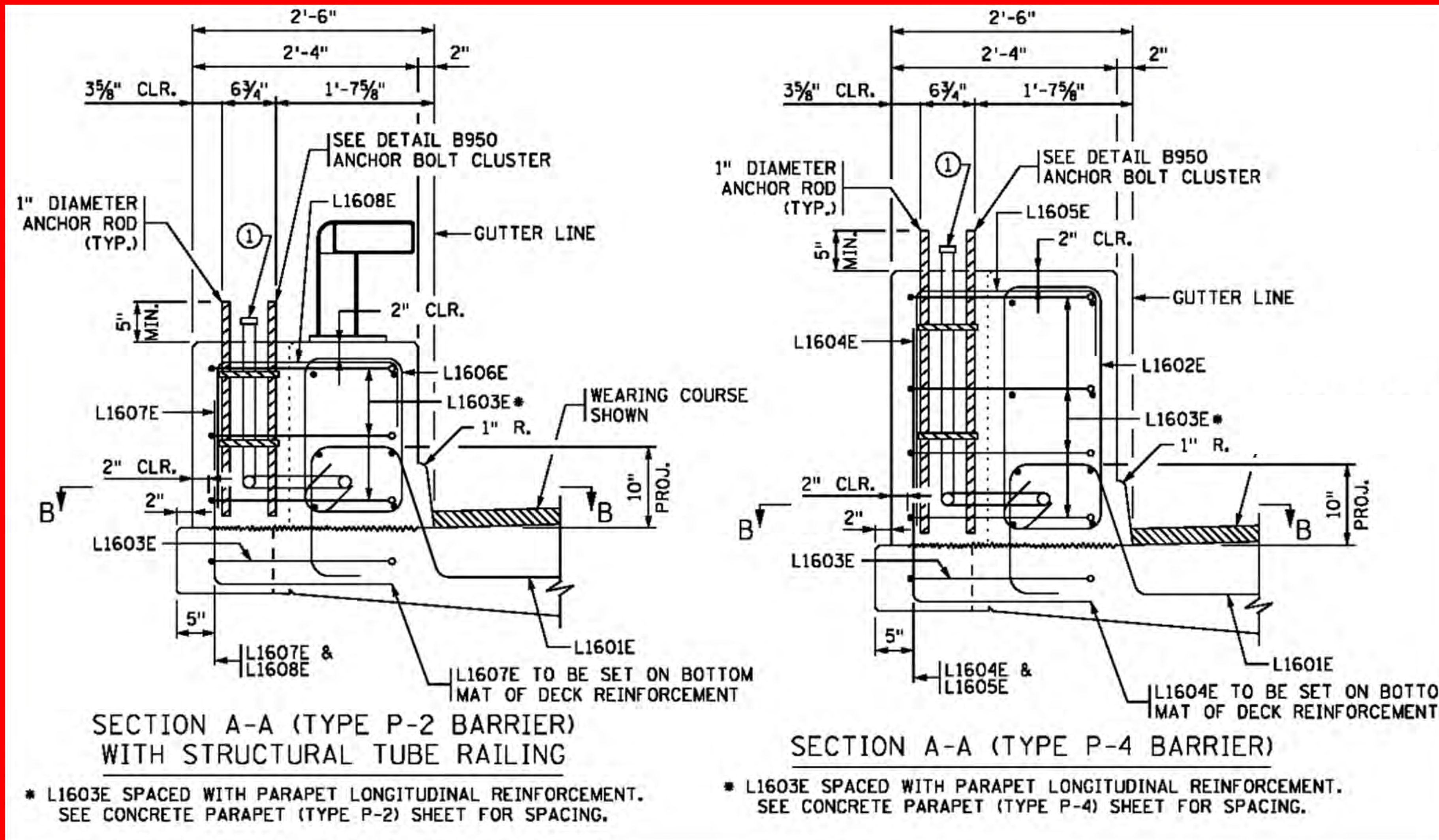
STANDARD FIGURE	A	B	C
FIG. 5397.122	1'-0⅞"	1'-1¼"	1'-1⅝"
FIG. 5397.124	1'-0⅞"	1'-1¼"	1'-1⅝"
FIG. 5397.125	10⅞"	11¼"	11⅝"
FIG. 5397.126	10⅞"	11¼"	11⅝"
FIG. 5397.128	1'-1"	1'-1⅜"	1'-1¾
FIG. 5397.129	11"	11⅜"	11¾"

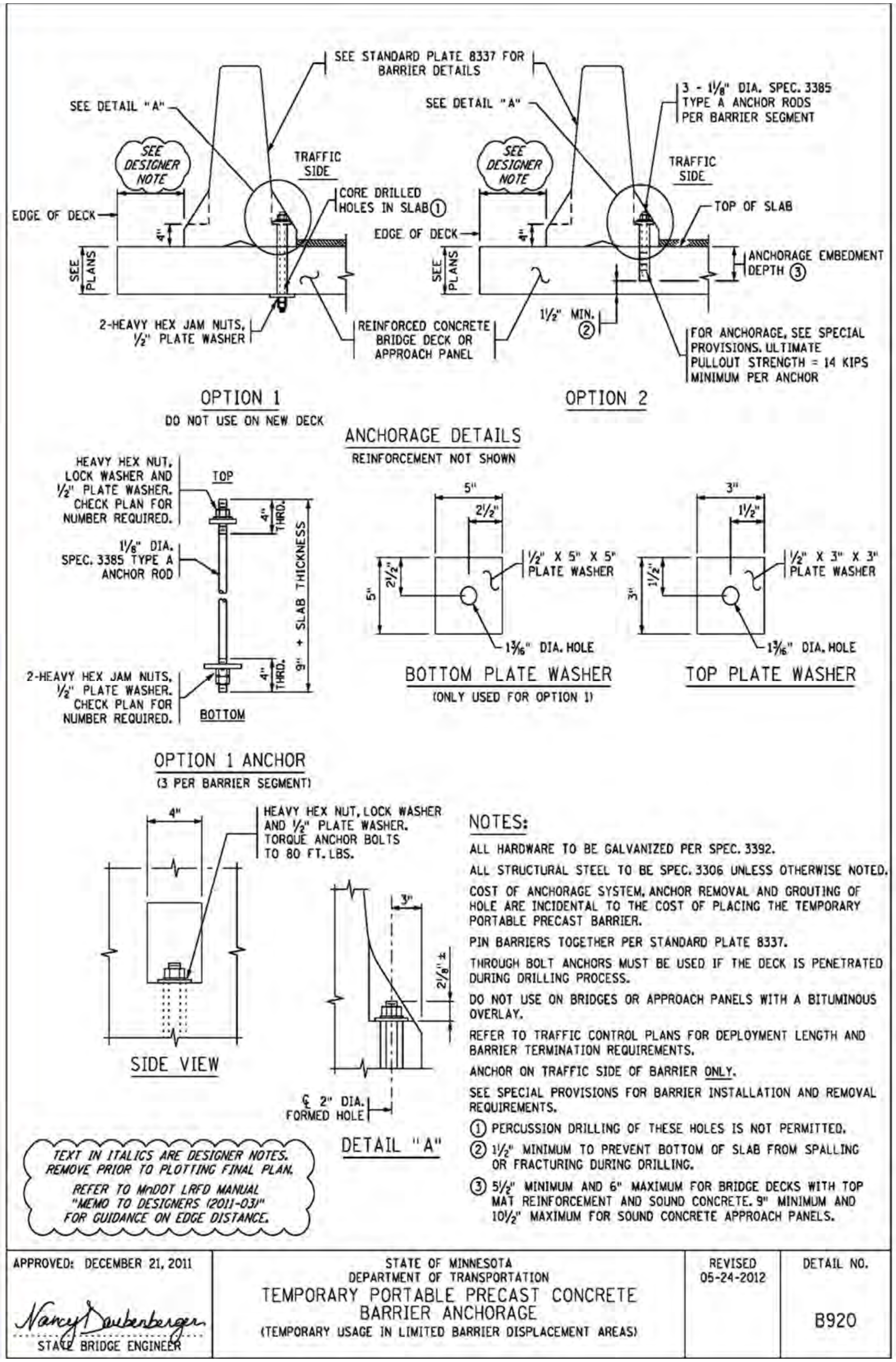

2'-8"
2"
1'-10½"
7½"
3⅝" CLR.
6¾"
1'-7⅝"
1" DIAMETER ANCHOR ROD (TYP.)
SEE DETAIL B950 ANCHOR BOLT CLUSTER
2" CLR.
L1606E
5" MIN.
L1603E*
L1604E*
L1607E
L1605E*
WEARING COURSE SHOWN
2" CLR.
L1602E
B
B
10" PROJ. L1601E
L1601E
5"
L1606E & L1607E
L1607E TO BE SET ON BO
MAT OF DECK REINFORCEM
SECTION A-A ②
* L1603E, L1604E, L1605E ARE SPACED WITH BARRIER LONGITUDINAL REINFORCEMENT. SEE CONCRETE BARRIER SHEET FOR SPACING.
SUMMARY OF QUANTITIES FOR CONDUIT SYSTEM (LIGHTING) ③
NOTES
BILL OF REINFORCEMENT FOR BARRIER AT ONE LIGHT POLE ④
TOTAL REINFORCEMENT PER LIGHT POLE LOCATION IS 125 LBS.
FIG. 5-397.406
BRIDGE NO.
NOT APPROVED


SECTION A-A ②
2'-9"
2"
1'-10½"
8½"
4⅝" CLR.
6¾"
1'-7⅝"
1" DIAMETER ANCHOR ROD (TYP.)
SEE DETAIL B950 ANCHOR BOLT CLUSTER
2" CLR.
L1606E
5" MIN.
GUTTER LINE
L1603E*
L1604E*
L1607E
L1605E*
3" CLR.
L1602E
10" PROJ. L1601E
L1605E
L1601E
6"
L1606E & L1607E
L1607E TO BE SET ON MAT OF DECK REINFOR
* L1603E, L1604E, L1605E ARE SPACED WITH BARRIER LONGITUDINAL REINFORCEMENT. SEE CONCRETE BARRIER SHEET FOR SPACING.
SECTION B-B
DECK NOT SHOWN FOR CLARITY
CONDUIT PLACEMENT DETAIL
SUMMARY OF QUANTITIES FOR CONDUIT SYSTEM (LIGHTING) ③
GENERAL NOTES
BILL OF REINFORCEMENT FOR BARRIER AT ONE LIGHT POLE ④
L1602E
L1601E
NOT APPROVED
FIG. 5-397.XXX
BRIDGE NO.
SHEET NO. _ OF _ SHEETS


2'-9"
2"
1'-9"
10"
4⅝" CLR.
6¾"
1'-7⅝"
1" DIAMETER ANCHOR ROD (TYP.)
SEE DETAIL B950 ANCHOR BOLT CLUSTER
2" CLR.
L1608E
GUTTER LINE
L1604E*
L1603E
L1605E*
L1609E
L1602E
3" CLR.
L1606E*
WEARING COURSE SHOWN
L1607E*
2"
10"
PROJ. L1601E
B
L1607E
L1601E
6"
L1608E & L1609E
L1609E TO BE SET MAT OF DECK REINF
SECTION A-A ②
* L1604E, L1605E, L1606E, L1607E ARE SPACED WITH BARRIER LONGITUDINAL REINFORCEMENT. SEE CONCRETE BARRIER SHEET FOR SPACING.
SECTION B-B
DECK NOT SHOWN FOR CLARITY
CONDUIT PLACEMENT DETAIL
NOT APPROVED
SUMMARY OF QUANTITIES FOR CONDUIT SYSTEM (LIGHTING) ③
GENERAL NOTES
BILL OF REINFORCEMENT FOR BARRIER AT ONE LIGHT POLE ④
TOTAL REINFORCEMENT PER LIGHT POLE LOCATION IS 170 LBS.
FIG. 5-397.xxx
BRIDGE NO.


2'-2"
2"
2'-0"
3⅝" CLR.
6¾"
1'-1⅝"
SEE DETAIL B950
ANCHOR BOLT CLUSTER
1" DIAMETER
ANCHOR ROD
(TYP.)
GUTTER LINE
L1605E
2" CLR.
5" MIN.
L1604E
L1602E
L1603E*
2" CLR.
2"
L1601E
B
B
L1603E
5"
L1604E &
L1605E
SECTION A-A
* L1603E SPACED WITH PARAPET
LONGITUDINAL REINFORCEMENT. SEE CONCRETE
PARAPET (TYPE P-1) SHEET FOR SPACING.
SUMMARY OF QUANTITIES FOR
CONDUIT SYSTEM (LIGHTING) ③
ANCHOR BOLT CLUSTER — EACH
1½" DIA. R.S.C. — LIN. FT.
1½" DIA. END CAPS — EACH
COMBINATION DEFLECTION/EXPANSION FITTING — EACH
REINFORCEMENT BARS (EPOXY COATED) — POUND
P.V.C. HANDHOLE / PULLBOX (STD. PLATE 8114) — EACH
ADDITIONAL PARAPET AND DECK CONCRETE REQUIRED TO CONSTRUCT THE LIGHT POLE ANCHORAGE IS INCIDENTAL TO THE CONCRETE PARAPET AND DECK CONCRETE PAY ITEMS, RESPECTIVELY.
ALL MATERIAL LISTED ABOVE IS INCLUDED IN PRICE BID FOR "CONDUIT SYSTEM (LIGHTING)"
GENERAL NOTES
BOND AND GROUND THE CONDUIT SYSTEM (LIGHTING) IN ACCORDANCE WITH THE APPLICABLE PORTIONS OF SPEC 2545.3R.
① THE 1½" DIA. CONDUIT SHALL EXTEND 3" ABOVE THE CONCRETE PARAPET AND BE CAPPED.
② SEE CONCRETE PARAPET (TYPE P-1) SHEETS FOR TYPICAL CONCRETE PARAPET REINFORCEMENT.
③ QUANTITIES LISTED ARE FOR INFORMATIONAL PURPOSES. ANY ADDITIONAL MINOR ITEMS OR CHANGES IN QUANTITIES REQUIRED SHALL BE FURNISHED BY THE CONTRACTOR WITH NO ADDITIONAL COMPENSATION.
④ BARS SHOWN ARE FOR ONE LIGHT BLISTER.
BILL OF REINFORCEMENT FOR CONCRETE
PARAPET AT ONE LIGHT POLE ④
BAR | NO. | LENGTH | SHAPE | LOCATION
L1601E | 3 | 5'-0" | PARAPET DOWEL
L1602E | 3 | 6'-3" | PARAPET VERTICAL
L1603E | 4 | 9'-2" | LONGITUDINAL TIE
L1604E | 6 | 4'-5" | VERTICAL DOWEL
L1605E | 4 | 4'-6" | VERTICAL TIE
TOTAL REINFORCEMENT PER LIGHT POLE LOCATION IS 120 LBS.
L1602E
L1601E
PLAN
LIGHT POLE ANCHORA
ON CONCRETE PARAP
EDGE OF DECK
LONGITUDINAL BARRIER BARS
3-L1603E
L1604E
BACK FACE OF PARAPET
NO VERTICAL OR TOOLED JOINTS WITHIN BLISTER
REVISED:
NOT APPROVED
STATE BRIDGE ENGINEER
FIG. 5-397.XXX
APPROVED:
BRIDGE NO.
SHEET NO. _ OF _ SHEETS


2'-6"
2'-4"
2"
3⅝" CLR.
6¾"
1'-7⅝"
SEE DETAIL B950 ANCHOR BOLT CLUSTER
L1608E
1" DIAMETER ANCHOR ROD (TYP.)
GUTTER LINE
5" MIN.
2" CLR.
L1606E
L1603E*
1" R.
WEARING COURSE SHOWN
L1607E
2" CLR.
2"
B
10" PROJ.
L1603E
5"
L1607E & L1608E
L1601E
L1607E TO BE SET ON BOTTOM MAT OF DECK REINFORCEMENT
SECTION A-A (TYPE P-2 BARRIER) WITH STRUCTURAL TUBE RAILING
* L1603E SPACED WITH PARAPET LONGITUDINAL REINFORCEMENT. SEE CONCRETE PARAPET (TYPE P-2) SHEET FOR SPACING.
L1605E
L1604E
L1602E
L1604E & L1605E
L1604E TO BE SET ON BOTTOM MAT OF DECK REINFORCEMENT
SECTION A-A (TYPE P-4 BARRIER)
* L1603E SPACED WITH PARAPET LONGITUDINAL REINFORCEMENT. SEE CONCRETE PARAPET (TYPE P-4) SHEET FOR SPACING.


SEE STANDARD PLATE 8337 FOR BARRIER DETAILS
SEE DETAIL "A"
SEE DESIGNER NOTE
TRAFFIC SIDE
CORE DRILLED HOLES IN SLAB ①
EDGE OF DECK
SEE PLANS
2-HEAVY HEX JAM NUTS, ½" PLATE WASHER
REINFORCED CONCRETE BRIDGE DECK OR APPROACH PANEL
3 - 1⅛" DIA. SPEC. 3385 TYPE A ANCHOR RODS PER BARRIER SEGMENT
TOP OF SLAB
ANCHORAGE EMBEDMENT DEPTH ③
1½" MIN. ②
FOR ANCHORAGE, SEE SPECIAL PROVISIONS. ULTIMATE PULLOUT STRENGTH = 14 KIPS MINIMUM PER ANCHOR
OPTION 1
DO NOT USE ON NEW DECK
OPTION 2
ANCHORAGE DETAILS
REINFORCEMENT NOT SHOWN
HEAVY HEX NUT, LOCK WASHER AND ½" PLATE WASHER. CHECK PLAN FOR NUMBER REQUIRED.
1⅛" DIA. SPEC. 3385 TYPE A ANCHOR ROD
2-HEAVY HEX JAM NUTS, ½" PLATE WASHER. CHECK PLAN FOR NUMBER REQUIRED.
TOP
BOTTOM
4" THRD.
9" + SLAB THICKNESS
OPTION 1 ANCHOR
(3 PER BARRIER SEGMENT)
½" X 5" X 5" PLATE WASHER
1⅜" DIA. HOLE
BOTTOM PLATE WASHER
(ONLY USED FOR OPTION 1)
½" X 3" X 3" PLATE WASHER
TOP PLATE WASHER
HEAVY HEX NUT, LOCK WASHER AND ½" PLATE WASHER. TORQUE ANCHOR BOLTS TO 80 FT. LBS.
SIDE VIEW
℄ 2" DIA. FORMED HOLE
DETAIL "A"
TEXT IN ITALICS ARE DESIGNER NOTES. REMOVE PRIOR TO PLOTTING FINAL PLAN. REFER TO MnDOT LRFD MANUAL "MEMO TO DESIGNERS (2011-03)" FOR GUIDANCE ON EDGE DISTANCE.
NOTES:
ALL HARDWARE TO BE GALVANIZED PER SPEC. 3392.
ALL STRUCTURAL STEEL TO BE SPEC. 3306 UNLESS OTHERWISE NOTED.
COST OF ANCHORAGE SYSTEM, ANCHOR REMOVAL AND GROUTING OF HOLE ARE INCIDENTAL TO THE COST OF PLACING THE TEMPORARY PORTABLE PRECAST BARRIER.
PIN BARRIERS TOGETHER PER STANDARD PLATE 8337.
THROUGH BOLT ANCHORS MUST BE USED IF THE DECK IS PENETRATED DURING DRILLING PROCESS.
DO NOT USE ON BRIDGES OR APPROACH PANELS WITH A BITUMINOUS OVERLAY.
REFER TO TRAFFIC CONTROL PLANS FOR DEPLOYMENT LENGTH AND BARRIER TERMINATION REQUIREMENTS.
ANCHOR ON TRAFFIC SIDE OF BARRIER ONLY.
SEE SPECIAL PROVISIONS FOR BARRIER INSTALLATION AND REMOVAL REQUIREMENTS.
① PERCUSSION DRILLING OF THESE HOLES IS NOT PERMITTED.
② 1½" MINIMUM TO PREVENT BOTTOM OF SLAB FROM SPALLING OR FRACTURING DURING DRILLING.
③ 5½" MINIMUM AND 6" MAXIMUM FOR BRIDGE DECKS WITH TOP MAT REINFORCEMENT AND SOUND CONCRETE. 9" MINIMUM AND 10½" MAXIMUM FOR SOUND CONCRETE APPROACH PANELS.
APPROVED: DECEMBER 21, 2011
STATE BRIDGE ENGINEER
STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION
TEMPORARY PORTABLE PRECAST CONCRETE BARRIER ANCHORAGE
(TEMPORARY USAGE IN LIMITED BARRIER DISPLACEMENT AREAS)
REVISED 05-24-2012
DETAIL NO.
B920

Minimum Distance from Edge of Deck to Back (Non-Traffic) Side of Barrier on Bridges and Approach Panels			
Construction Posted Speed Limit	50 mph or greater or with significant geometric elements*	40-45 mph	35 mph or less
Anchored	4'-0"	2'-0"	6"
Unanchored	N/A	6'-0"	3'-0"

*Significant geometric elements include installation on all interstate highways and curved alignments.

Designers may also choose to use a more restrictive setback distance for bridges where travel speeds may significantly exceed the posted speed limit, with heavy truck traffic, or where other situations may warrant increasing the dimensions in the chart above.

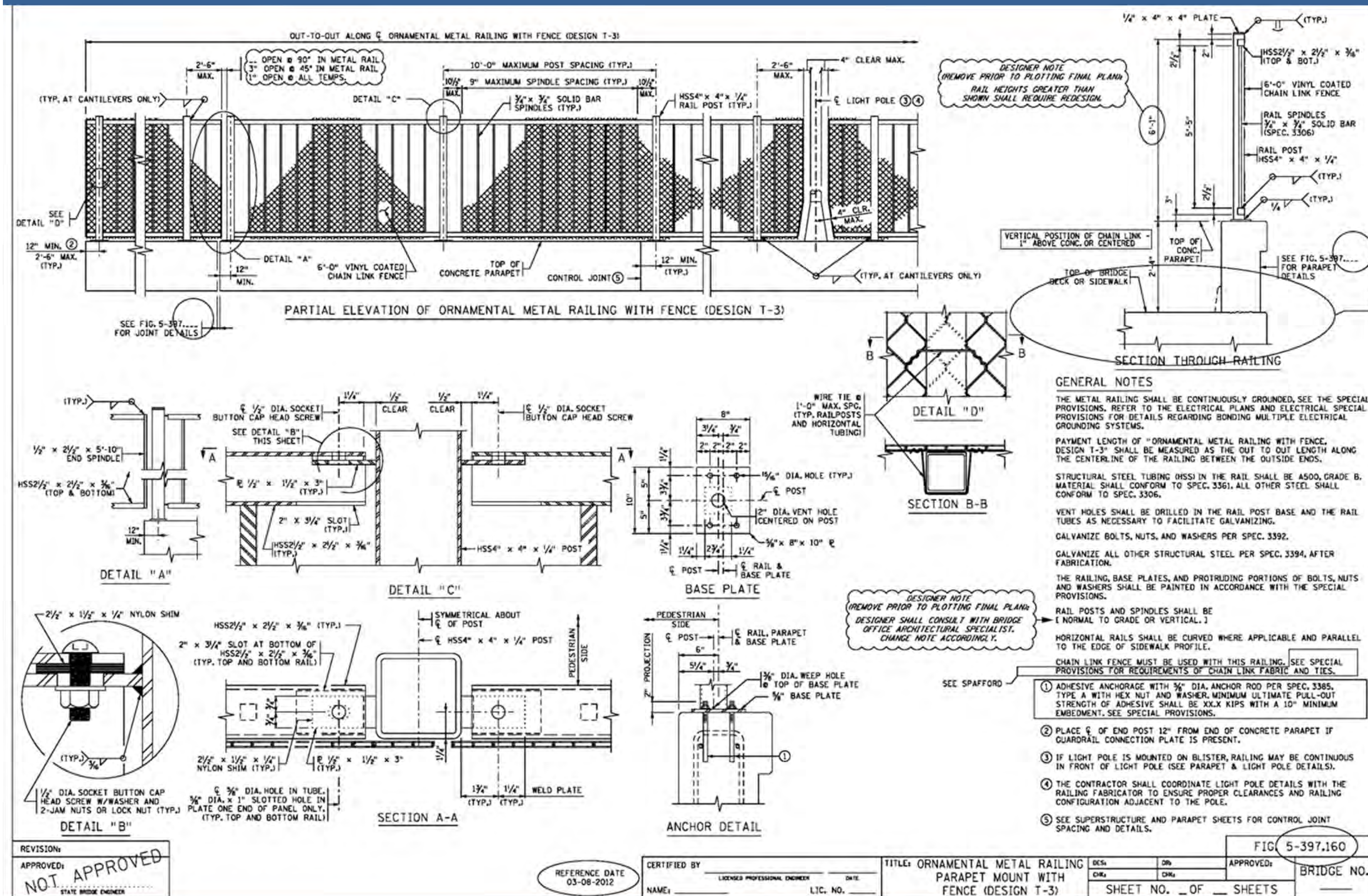
The following anchor requirements must be met if utilizing an anchored alternative:

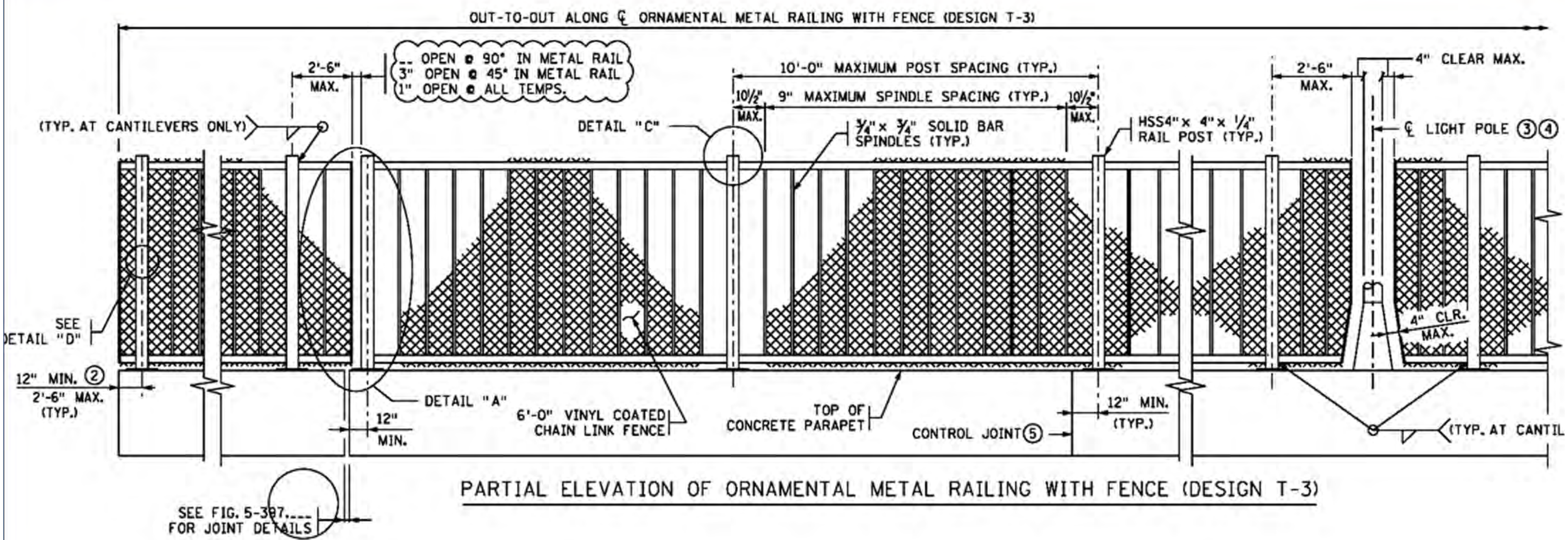
- For each barrier segment, install three, 1⅛" diameter anchor rods (MnDOT Spec. 3385 Type A) on traffic side only.
- For bridge decks in good condition, chemical anchors shall have 5½" minimum embedment and 6" maximum embedment. Maximum depth of the hole shall be 1½ inches less than the slab depth to help ensure that the bottom of the slab doesn't spall or fracture during hole drilling.
- For approach panels with top and bottom mats of reinforcement, chemical anchors shall have 5½" minimum embedment.
- For approach panels with no reinforcement or only a bottom mat of reinforcement, chemical anchors shall have 9" minimum embedment.
- Chemical anchors may only be used where concrete is in good condition. Regional Bridge Engineer will confirm adequacy for installations on in-place bridges.
- Through-deck anchoring may be utilized on existing bridge decks in poor condition.
- For the minimum length noted above, the anchor manufacturer's minimum bond stress shall provide an ultimate (nominal) strength of 14 kips and will be proof tested to 7 kips. See the Special Provision for additional testing requirements.

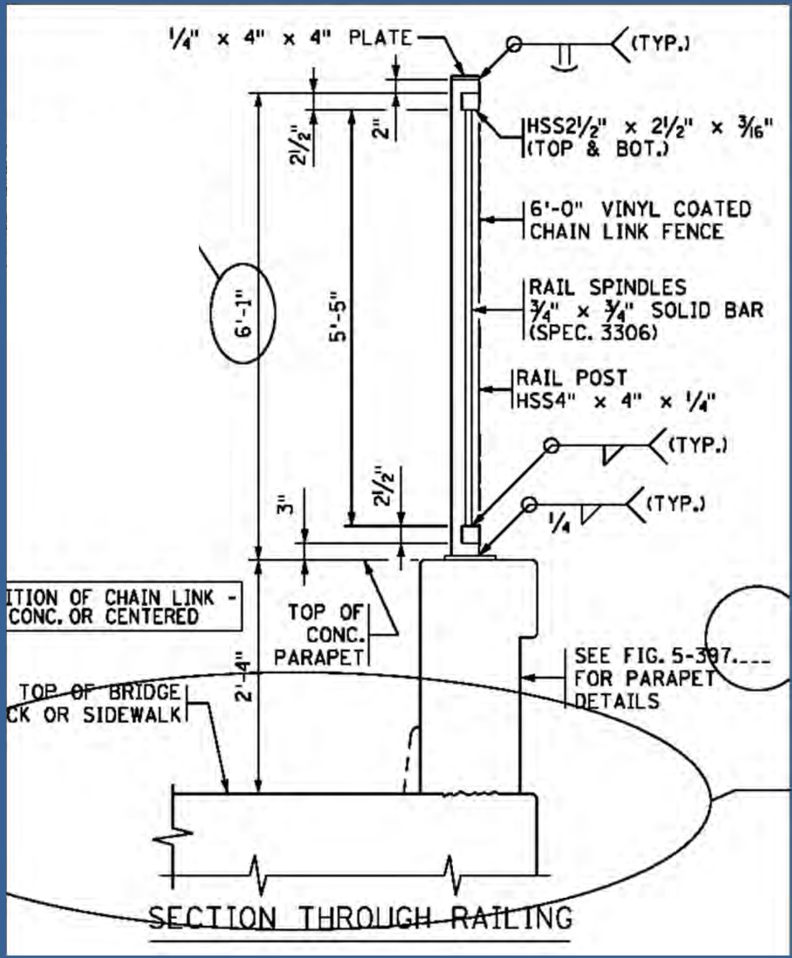
These requirements are only valid when installing anchors on a reinforced bridge deck or approach panel. The anchorage provisions included here are not applicable for non-reinforced concrete or bituminous surfaces. Minimum deployment length and anchorage requirements past the end of the bridge and approach panels are to be determined by the roadway designer and shown in the traffic control plans.

With the release of this memo, Standard Detail B920 (see attached) will be reactivated for use. Note that the details have been modified to reference this memo. Please see me if you have questions on these guidelines.

cc: C. Harer/Design Consultants
M. Elle
J. Rosenow
C. Mittelstadt


OUT-TO-OUT ALONG ℄ ORNAMENTAL METAL RAILING WITH FENCE (DESIGN T-3)
PARTIAL ELEVATION OF ORNAMENTAL METAL RAILING WITH FENCE (DESIGN T-3)
DESIGNER NOTE (REMOVE PRIOR TO PLOTTING FINAL PLAN): RAIL HEIGHTS GREATER THAN SHOWN SHALL REQUIRE REDESIGN.
SECTION THROUGH RAILING
DETAIL "D"
SECTION B-B
DETAIL "A"
DETAIL "C"
BASE PLATE
DETAIL "B"
SECTION A-A
ANCHOR DETAIL
DESIGNER NOTE (REMOVE PRIOR TO PLOTTING FINAL PLAN): DESIGNER SHALL CONSULT WITH BRIDGE OFFICE ARCHITECTURAL SPECIALIST. CHANGE NOTE ACCORDINGLY.
GENERAL NOTES
THE METAL RAILING SHALL BE CONTINUOUSLY GROUNDED. SEE THE SPECIAL PROVISIONS. REFER TO THE ELECTRICAL PLANS AND ELECTRICAL SPECIAL PROVISIONS FOR DETAILS REGARDING BONDING MULTIPLE ELECTRICAL GROUNDING SYSTEMS.
PAYMENT LENGTH OF "ORNAMENTAL METAL RAILING WITH FENCE, DESIGN T-3" SHALL BE MEASURED AS THE OUT TO OUT LENGTH ALONG THE CENTERLINE OF THE RAILING BETWEEN THE OUTSIDE ENDS.
STRUCTURAL STEEL TUBING (HSS) IN THE RAIL SHALL BE A500, GRADE B. MATERIAL SHALL CONFORM TO SPEC. 3361. ALL OTHER STEEL SHALL CONFORM TO SPEC. 3306.
VENT HOLES SHALL BE DRILLED IN THE RAIL POST BASE AND THE RAIL TUBES AS NECESSARY TO FACILITATE GALVANIZING.
GALVANIZE BOLTS, NUTS, AND WASHERS PER SPEC. 3392.
GALVANIZE ALL OTHER STRUCTURAL STEEL PER SPEC. 3394, AFTER FABRICATION.
THE RAILING, BASE PLATES, AND PROTRUDING PORTIONS OF BOLTS, NUTS AND WASHERS SHALL BE PAINTED IN ACCORDANCE WITH THE SPECIAL PROVISIONS.
RAIL POSTS AND SPINDLES SHALL BE [NORMAL TO GRADE OR VERTICAL.]
HORIZONTAL RAILS SHALL BE CURVED WHERE APPLICABLE AND PARALLEL TO THE EDGE OF SIDEWALK PROFILE.
CHAIN LINK FENCE MUST BE USED WITH THIS RAILING. SEE SPECIAL PROVISIONS FOR REQUIREMENTS OF CHAIN LINK FABRIC AND TIES.
SEE SPAFFORD
① ADHESIVE ANCHORAGE WITH ⅝" DIA. ANCHOR ROD PER SPEC. 3385. TYPE A WITH HEX NUT AND WASHER. MINIMUM ULTIMATE PULL-OUT STRENGTH OF ADHESIVE SHALL BE XX.X KIPS WITH A 10" MINIMUM EMBEDMENT. SEE SPECIAL PROVISIONS.
② PLACE ℄ OF END POST 12" FROM END OF CONCRETE PARAPET IF GUARDRAIL CONNECTION PLATE IS PRESENT.
③ IF LIGHT POLE IS MOUNTED ON BLISTER, RAILING MAY BE CONTINUOUS IN FRONT OF LIGHT POLE (SEE PARAPET & LIGHT POLE DETAILS).
④ THE CONTRACTOR SHALL COORDINATE LIGHT POLE DETAILS WITH THE RAILING FABRICATOR TO ENSURE PROPER CLEARANCES AND RAILING CONFIGURATION ADJACENT TO THE POLE.
⑤ SEE SUPERSTRUCTURE AND PARAPET SHEETS FOR CONTROL JOINT SPACING AND DETAILS.
FIG. 5-397.160
REVISION:
APPROVED:
NOT APPROVED
STATE BRIDGE ENGINEER
REFERENCE DATE 03-08-2012
CERTIFIED BY
NAME:
LIC. NO.
TITLE: ORNAMENTAL METAL RAILING PARAPET MOUNT WITH FENCE (DESIGN T-3)
SHEET NO. _ OF __ SHEETS
BRIDGE NO.


OUT-TO-OUT ALONG ℄ ORNAMENTAL METAL RAILING WITH FENCE (DESIGN T-3)
2'-6" MAX.
-- OPEN @ 90° IN METAL RAIL
3" OPEN @ 45° IN METAL RAIL
1" OPEN @ ALL TEMPS.
10'-0" MAXIMUM POST SPACING (TYP.)
10½" MAX.
9" MAXIMUM SPINDLE SPACING (TYP.)
10½" MAX.
(TYP. AT CANTILEVERS ONLY)
DETAIL "C"
¾" x ¾" SOLID BAR SPINDLES (TYP.)
HSS4" x 4" x ¼" RAIL POST (TYP.)
2'-6" MAX.
4" CLEAR MAX.
℄ LIGHT POLE ③④
SEE DETAIL "D"
4" CLR. MAX.
12" MIN. ②
2'-6" MAX. (TYP.)
DETAIL "A"
12" MIN.
6'-0" VINYL COATED CHAIN LINK FENCE
TOP OF CONCRETE PARAPET
CONTROL JOINT⑤
12" MIN. (TYP.)
(TYP. AT CANTIL
SEE FIG. 5-397 FOR JOINT DETAILS
PARTIAL ELEVATION OF ORNAMENTAL METAL RAILING WITH FENCE (DESIGN T-3)



1/4" x 4" x 4" PLATE
(TYP.)
2 1/2"
2"
HSS2 1/2" x 2 1/2" x 3/16"
(TOP & BOT.)
6'-0" VINYL COATED
CHAIN LINK FENCE
6'-1"
5'-5"
RAIL SPINDLES
3/4" x 3/4" SOLID BAR
(SPEC. 3306)
RAIL POST
HSS4" x 4" x 1/4"
(TYP.)
3"
2 1/2"
1/4
(TYP.)
ITION OF CHAIN LINK -
CONC. OR CENTERED
TOP OF
CONC.
PARAPET
SEE FIG. 5-397.___
FOR PARAPET
DETAILS
TOP OF BRIDGE
CK OR SIDEWALK
2'-4"
SECTION THROUGH RAILING

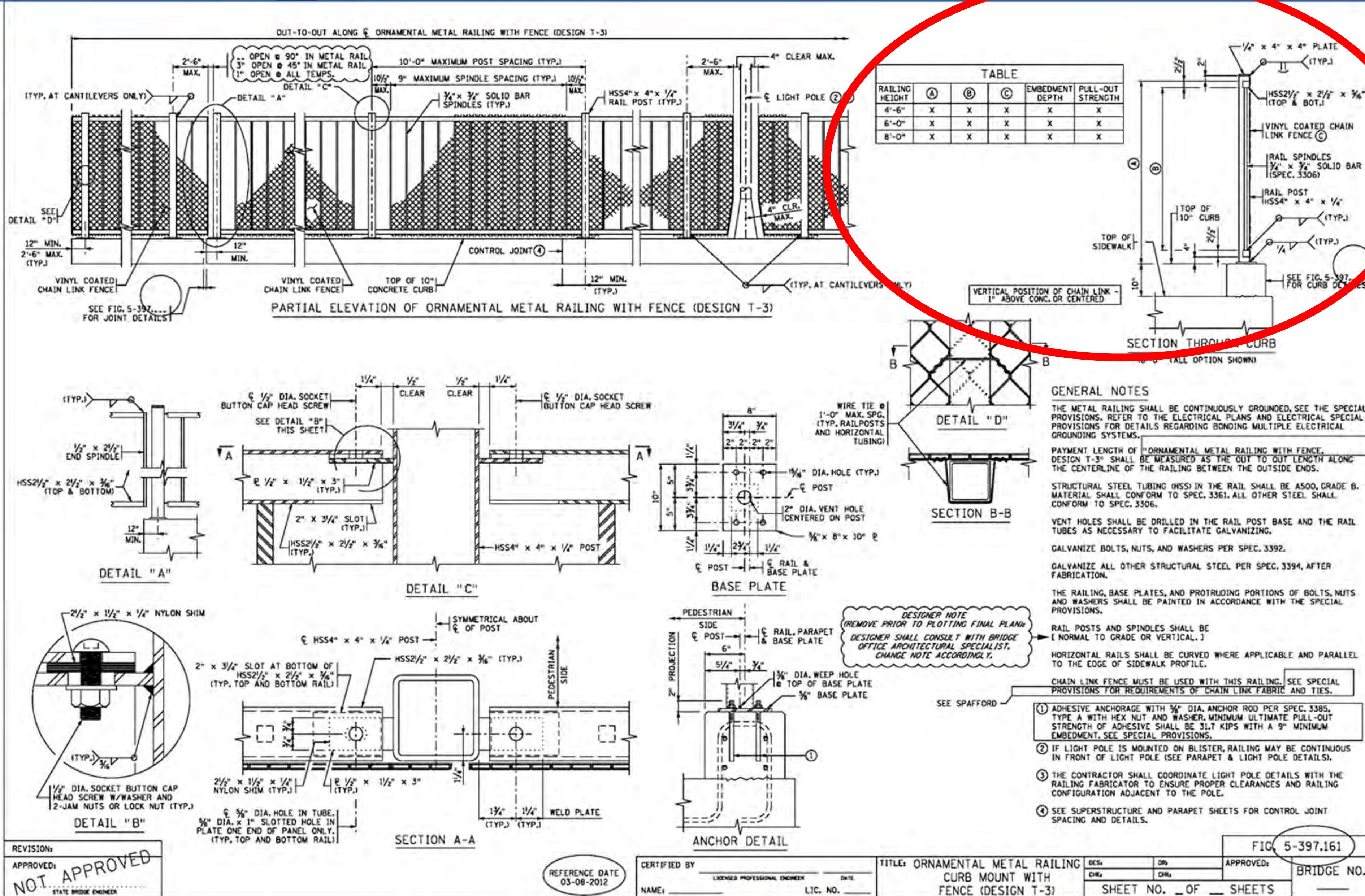
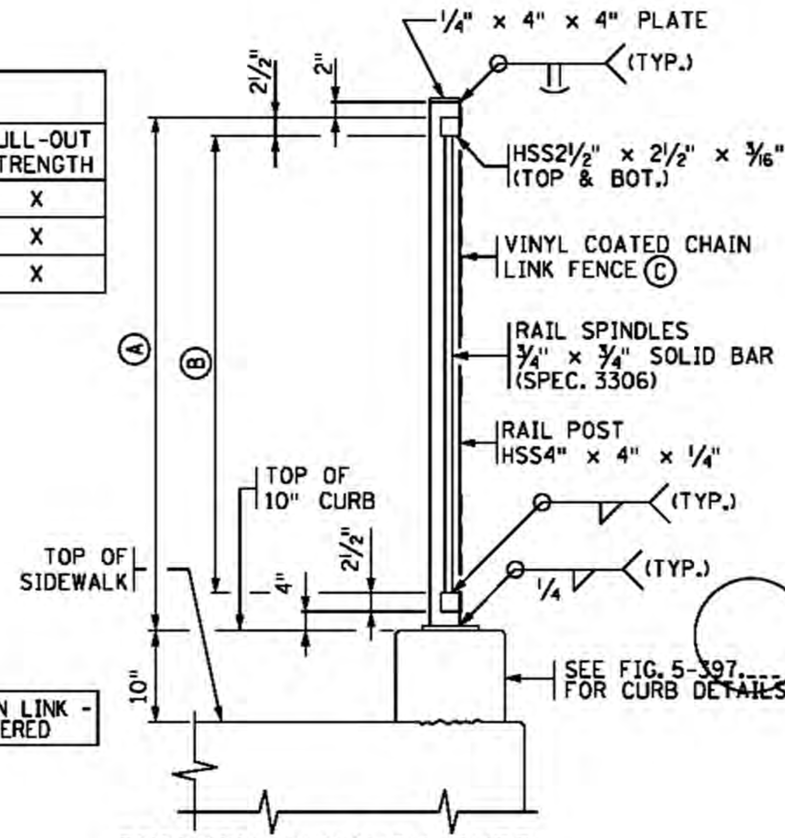


TABLE					
RAILING HEIGHT	Ⓐ	Ⓑ	Ⓒ	EMBEDMENT DEPTH	PULL-OUT STRENGTH
4'-6"	X	X	X	X	X
6'-0"	X	X	X	X	X
8'-0"	X	X	X	X	X

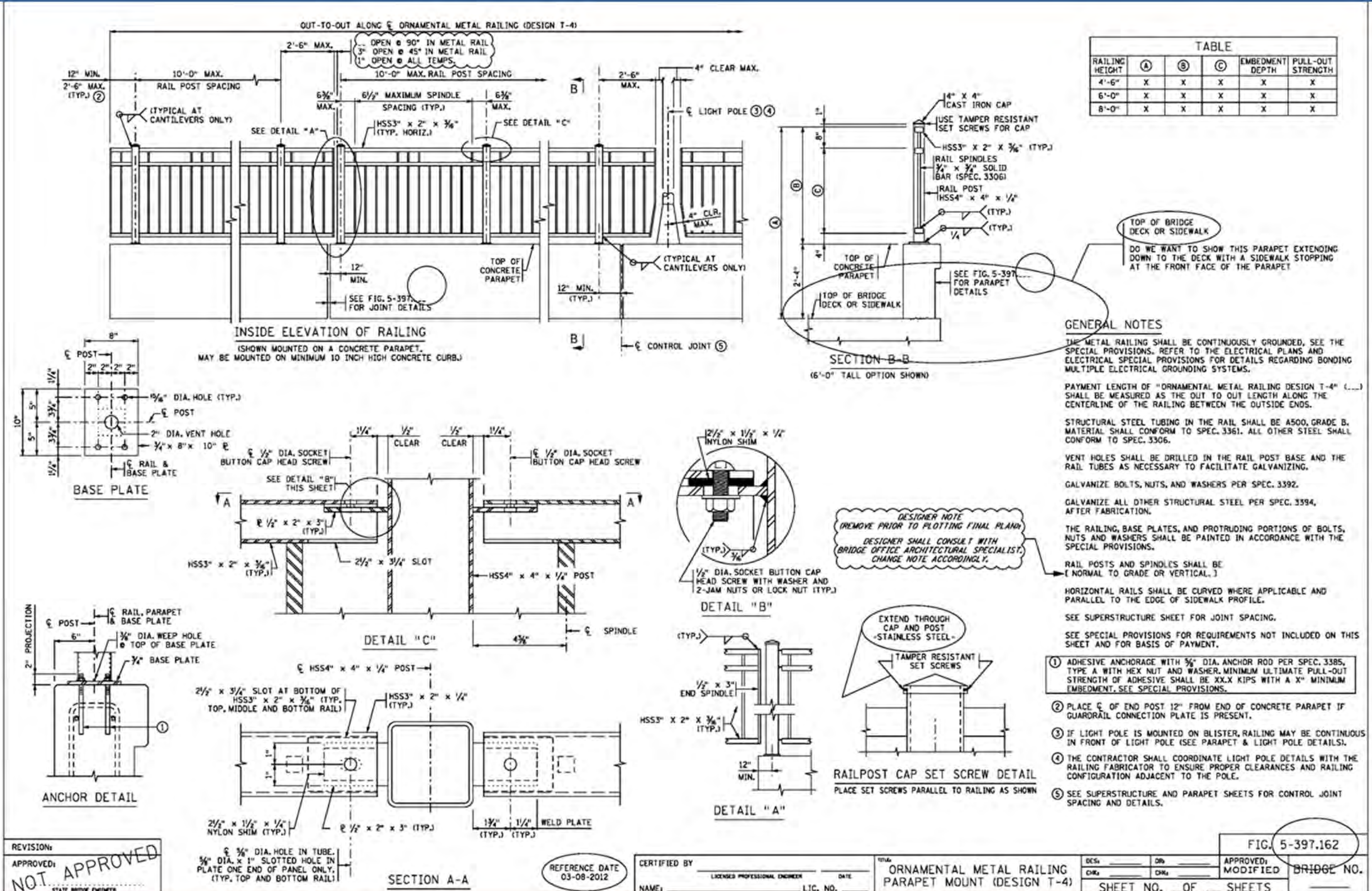
TABLE					
RAILING HEIGHT	Ⓐ	Ⓑ	Ⓒ	EMBEDMENT DEPTH	PULL-OUT STRENGTH
4'-6"	X	X	X	X	X
6'-0"	X	X	X	X	X
8'-0"	X	X	X	X	X

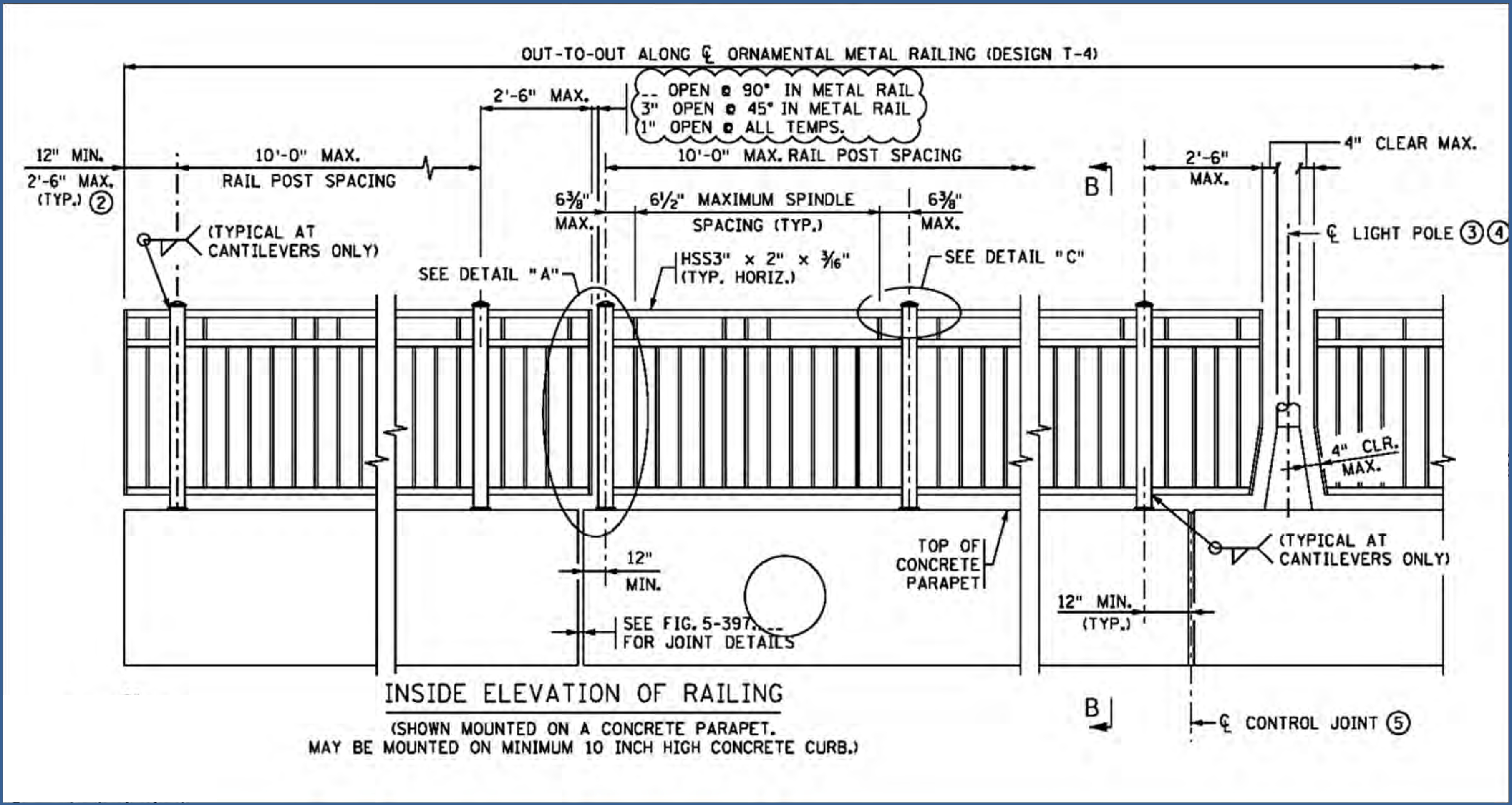


VERTICAL POSITION OF CHAIN LINK - 1" ABOVE CONC. OR CENTERED

SECTION THROUGH CURB

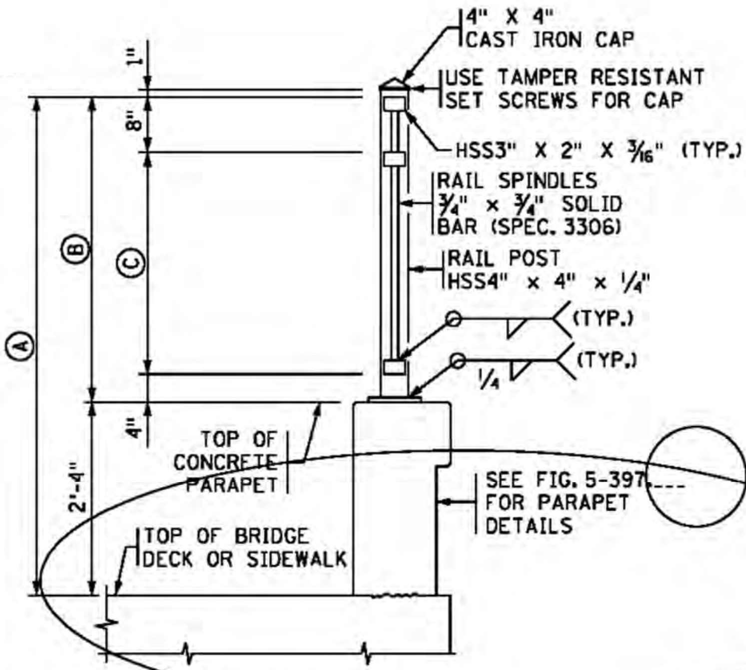
(8'-0" TALL OPTION SHOWN)


OUT-TO-OUT ALONG ℄ ORNAMENTAL METAL RAILING (DESIGN T-4)
INSIDE ELEVATION OF RAILING
(SHOWN MOUNTED ON A CONCRETE PARAPET. MAY BE MOUNTED ON MINIMUM 10 INCH HIGH CONCRETE CURB.)
SECTION B-B
(6'-0" TALL OPTION SHOWN)
TOP OF BRIDGE DECK OR SIDEWALK
DO WE WANT TO SHOW THIS PARAPET EXTENDING DOWN TO THE DECK WITH A SIDEWALK STOPPING AT THE FRONT FACE OF THE PARAPET
TABLE
RAILING HEIGHT | Ⓐ | Ⓑ | Ⓒ | EMBEDMENT DEPTH | PULL-OUT STRENGTH
4'-6" | X | X | X | X | X
6'-0" | X | X | X | X | X
8'-0" | X | X | X | X | X
BASE PLATE
ANCHOR DETAIL
DETAIL "C"
SECTION A-A
DETAIL "B"
DETAIL "A"
DESIGNER NOTE (REMOVE PRIOR TO PLOTTING FINAL PLAN) DESIGNER SHALL CONSULT WITH BRIDGE OFFICE ARCHITECTURAL SPECIALIST. CHANGE NOTE ACCORDINGLY.
RAILPOST CAP SET SCREW DETAIL
PLACE SET SCREWS PARALLEL TO RAILING AS SHOWN
GENERAL NOTES
THE METAL RAILING SHALL BE CONTINUOUSLY GROUNDED. SEE THE SPECIAL PROVISIONS. REFER TO THE ELECTRICAL PLANS AND ELECTRICAL SPECIAL PROVISIONS FOR DETAILS REGARDING BONDING MULTIPLE ELECTRICAL GROUNDING SYSTEMS.
PAYMENT LENGTH OF "ORNAMENTAL METAL RAILING DESIGN T-4" (___) SHALL BE MEASURED AS THE OUT TO OUT LENGTH ALONG THE CENTERLINE OF THE RAILING BETWEEN THE OUTSIDE ENDS.
STRUCTURAL STEEL TUBING IN THE RAIL SHALL BE A500, GRADE B. MATERIAL SHALL CONFORM TO SPEC. 3361. ALL OTHER STEEL SHALL CONFORM TO SPEC. 3306.
VENT HOLES SHALL BE DRILLED IN THE RAIL POST BASE AND THE RAIL TUBES AS NECESSARY TO FACILITATE GALVANIZING.
GALVANIZE BOLTS, NUTS, AND WASHERS PER SPEC. 3392.
GALVANIZE ALL OTHER STRUCTURAL STEEL PER SPEC. 3394, AFTER FABRICATION.
THE RAILING, BASE PLATES, AND PROTRUDING PORTIONS OF BOLTS, NUTS AND WASHERS SHALL BE PAINTED IN ACCORDANCE WITH THE SPECIAL PROVISIONS.
RAIL POSTS AND SPINDLES SHALL BE [NORMAL TO GRADE OR VERTICAL.]
HORIZONTAL RAILS SHALL BE CURVED WHERE APPLICABLE AND PARALLEL TO THE EDGE OF SIDEWALK PROFILE.
SEE SUPERSTRUCTURE SHEET FOR JOINT SPACING.
SEE SPECIAL PROVISIONS FOR REQUIREMENTS NOT INCLUDED ON THIS SHEET AND FOR BASIS OF PAYMENT.
① ADHESIVE ANCHORAGE WITH 5/8" DIA. ANCHOR ROD PER SPEC. 3385, TYPE A WITH HEX NUT AND WASHER. MINIMUM ULTIMATE PULL-OUT STRENGTH OF ADHESIVE SHALL BE XX.X KIPS WITH A X" MINIMUM EMBEDMENT. SEE SPECIAL PROVISIONS.
② PLACE ℄ OF END POST 12" FROM END OF CONCRETE PARAPET IF GUARDRAIL CONNECTION PLATE IS PRESENT.
③ IF LIGHT POLE IS MOUNTED ON BLISTER, RAILING MAY BE CONTINUOUS IN FRONT OF LIGHT POLE (SEE PARAPET & LIGHT POLE DETAILS).
④ THE CONTRACTOR SHALL COORDINATE LIGHT POLE DETAILS WITH THE RAILING FABRICATOR TO ENSURE PROPER CLEARANCES AND RAILING CONFIGURATION ADJACENT TO THE POLE.
⑤ SEE SUPERSTRUCTURE AND PARAPET SHEETS FOR CONTROL JOINT SPACING AND DETAILS.
NOT APPROVED
REFERENCE DATE 03-08-2012
ORNAMENTAL METAL RAILING PARAPET MOUNT (DESIGN T-4)
FIG. 5-397.162
SHEET NO. _ OF __ SHEETS



OUT-TO-OUT ALONG ℄ ORNAMENTAL METAL RAILING (DESIGN T-4)
2'-6" MAX.
-- OPEN @ 90° IN METAL RAIL
3" OPEN @ 45° IN METAL RAIL
1" OPEN @ ALL TEMPS.
12" MIN.
2'-6" MAX. (TYP.) ②
10'-0" MAX.
RAIL POST SPACING
10'-0" MAX. RAIL POST SPACING
4" CLEAR MAX.
2'-6" MAX.
B
6⅜" MAX.
6½" MAXIMUM SPINDLE SPACING (TYP.)
6⅜" MAX.
℄ LIGHT POLE ③④
(TYPICAL AT CANTILEVERS ONLY)
HSS3" × 2" × 3⁄16" (TYP. HORIZ.)
SEE DETAIL "C"
SEE DETAIL "A"
4" CLR. MAX.
TOP OF CONCRETE PARAPET
(TYPICAL AT CANTILEVERS ONLY)
12" MIN.
SEE FIG. 5-397.___ FOR JOINT DETAILS
12" MIN. (TYP.)
INSIDE ELEVATION OF RAILING
(SHOWN MOUNTED ON A CONCRETE PARAPET. MAY BE MOUNTED ON MINIMUM 10 INCH HIGH CONCRETE CURB.)
B
℄ CONTROL JOINT ⑤

TABLE					
RAILING HEIGHT	Ⓐ	Ⓑ	Ⓒ	EMBEDMENT DEPTH	PULL-OUT STRENGTH
4'-6"	X	X	X	X	X
6'-0"	X	X	X	X	X
8'-0"	X	X	X	X	X



SECTION B-B

(6'-0" TALL OPTION SHOWN)

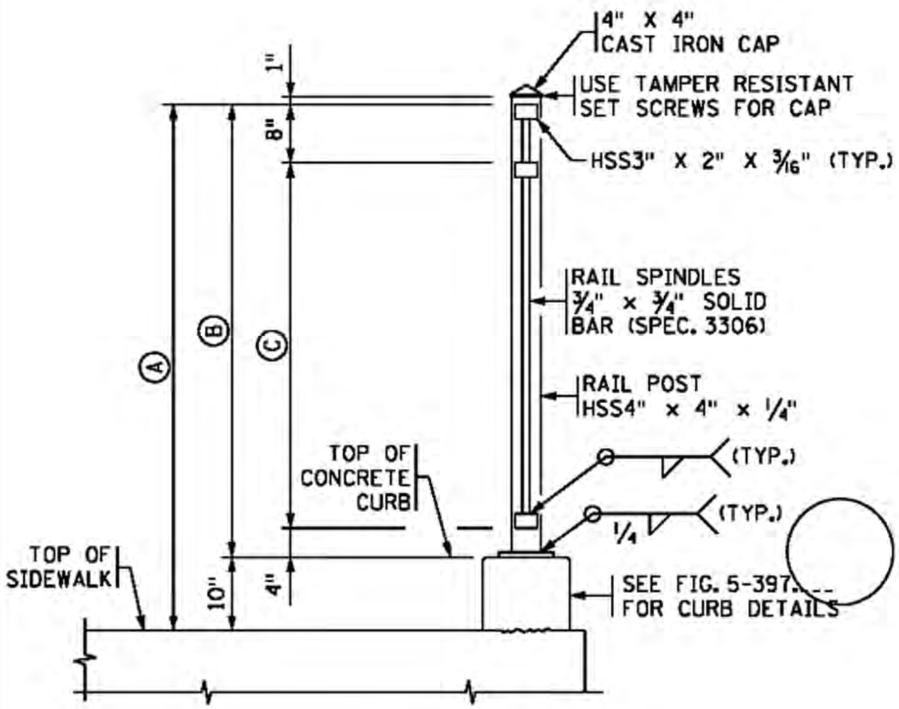
TOP OF BRIDGE DECK OR SIDEWALK

DO WE WANT TO SHOW THIS PARAPET EXTENDING DOWN TO THE DECK WITH A SIDEWALK STOPPING AT THE FRONT FACE OF THE PARAPET

GENERAL NOTES

THE METAL RAILING SHALL BE CONTINUOUSLY GROUNDED, SEE THE SPECIAL PROVISIONS. REFER TO THE ELECTRICAL PLANS AND ELECTRICAL SPECIAL PROVISIONS FOR DETAILS REGARDING BONDING MULTIPLE ELECTRICAL GROUNDING SYSTEMS.

PAYMENT LENGTH OF "ORNAMENTAL METAL RAILING DESIGN T-4" (___ SHALL BE MEASURED AS THE OUT TO OUT LENGTH ALONG THE CENTERLINE OF THE RAILING BETWEEN THE OUTSIDE ENDS.

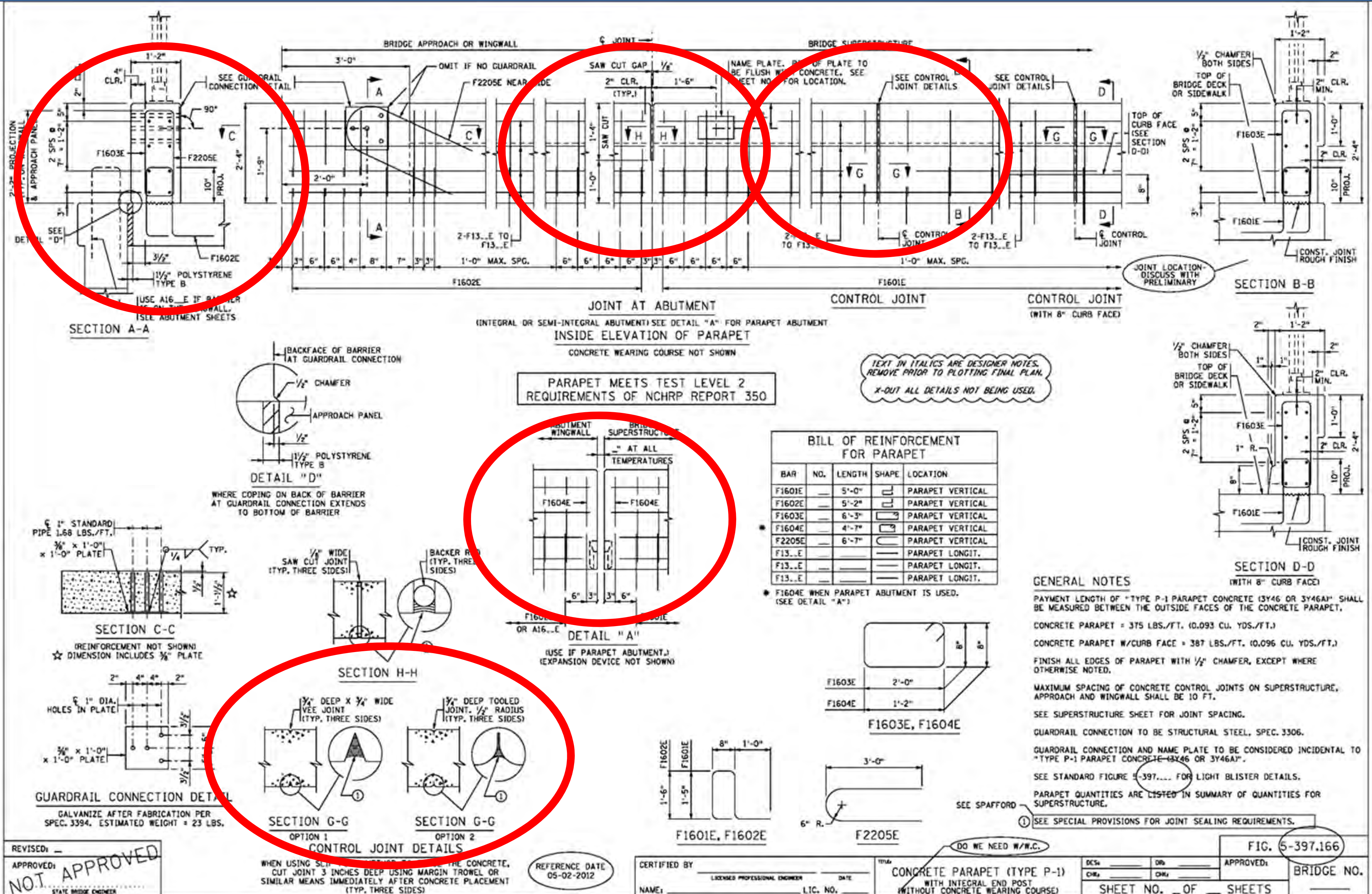


SECTION B-B

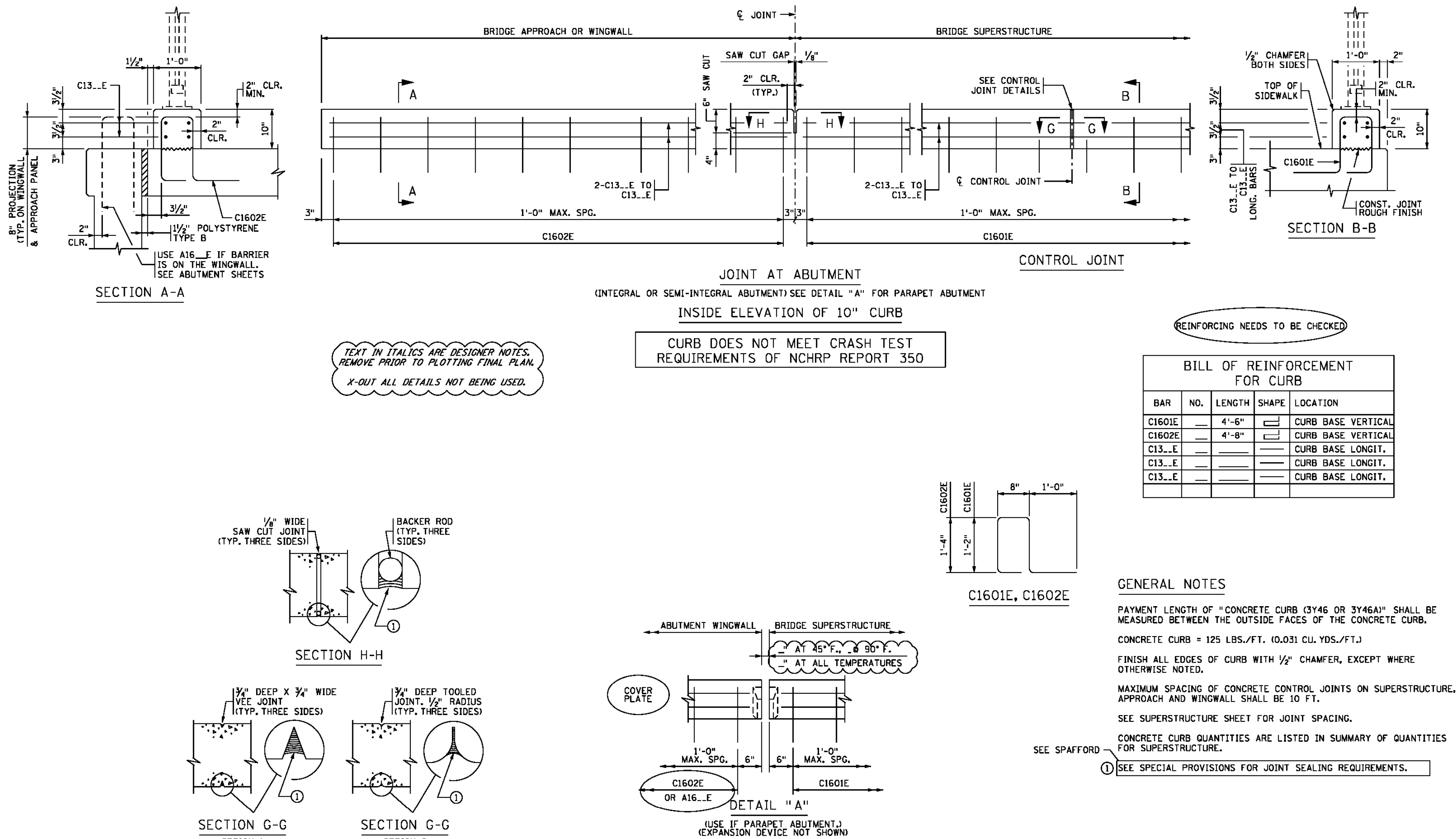
(6'-0" TALL OPTION SHOWN)

TABLE

RAILING HEIGHT	Ⓐ	Ⓑ	Ⓒ	EMBEDMENT DEPTH	PULL-OUT STRENGTH
4'-6"	X	X	X	X	X
6'-0"	X	X	X	X	X
8'-0"	X	X	X	X	X



SECTION A-A
JOINT AT ABUTMENT
CONTROL JOINT
CONTROL JOINT
(WITH 8" CURB FACE)
(INTEGRAL OR SEMI-INTEGRAL ABUTMENT) SEE DETAIL "A" FOR PARAPET ABUTMENT
INSIDE ELEVATION OF PARAPET
CONCRETE WEARING COURSE NOT SHOWN
SECTION B-B
PARAPET MEETS TEST LEVEL 2
REQUIREMENTS OF NCHRP REPORT 350
TEXT IN ITALICS ARE DESIGNER NOTES. REMOVE PRIOR TO PLOTTING FINAL PLAN.
X-OUT ALL DETAILS NOT BEING USED.
DETAIL "D"
WHERE COPING ON BACK OF BARRIER AT GUARDRAIL CONNECTION EXTENDS TO BOTTOM OF BARRIER
BILL OF REINFORCEMENT FOR PARAPET
SECTION C-C
(REINFORCEMENT NOT SHOWN)
DIMENSION INCLUDES 3/8" PLATE
DETAIL "A"
(USE IF PARAPET ABUTMENT.)
(EXPANSION DEVICE NOT SHOWN)
SECTION H-H
SECTION D-D
(WITH 8" CURB FACE)
F1603E, F1604E
GENERAL NOTES
GUARDRAIL CONNECTION DETAIL
GALVANIZE AFTER FABRICATION PER SPEC. 3394. ESTIMATED WEIGHT = 23 LBS.
SECTION G-G
OPTION 1
SECTION G-G
OPTION 2
CONTROL JOINT DETAILS
F1601E, F1602E
F2205E
NOT APPROVED
REFERENCE DATE 05-02-2012
DO WE NEED W/W.C.
CONCRETE PARAPET (TYPE P-1)
WITH INTEGRAL END POST
WITHOUT CONCRETE WEARING COURSE)
FIG. 5-397.166
BRIDGE NO.
SHEET NO. _ OF _ SHEETS



BILL OF REINFORCEMENT FOR CURB

BAR	NO.	LENGTH	SHAPE	LOCATION
C1601E	__	4'-6"		CURB BASE VERTICAL
C1602E	__	4'-8"		CURB BASE VERTICAL
C13__E	__	____	——	CURB BASE LONGIT.
C13__E	__	____	——	CURB BASE LONGIT.
C13__E	__	____	——	CURB BASE LONGIT.

GENERAL NOTES

PAYMENT LENGTH OF "CONCRETE CURB (3Y46 OR 3Y46A)" SHALL BE MEASURED BETWEEN THE OUTSIDE FACES OF THE CONCRETE CURB.

CONCRETE CURB = 125 LBS./FT. (0.031 CU. YDS./FT.)

FINISH ALL EDGES OF CURB WITH ½" CHAMFER, EXCEPT WHERE OTHERWISE NOTED.

MAXIMUM SPACING OF CONCRETE CONTROL JOINTS ON SUPERSTRUCTURE, APPROACH AND WINGWALL SHALL BE 10 FT.

SEE SUPERSTRUCTURE SHEET FOR JOINT SPACING.

CONCRETE CURB QUANTITIES ARE LISTED IN SUMMARY OF QUANTITIES FOR SUPERSTRUCTURE.

① SEE SPECIAL PROVISIONS FOR JOINT SEALING REQUIREMENTS.

REVISED: __
APPROVED: NOT APPROVED
STATE BRIDGE ENGINEER

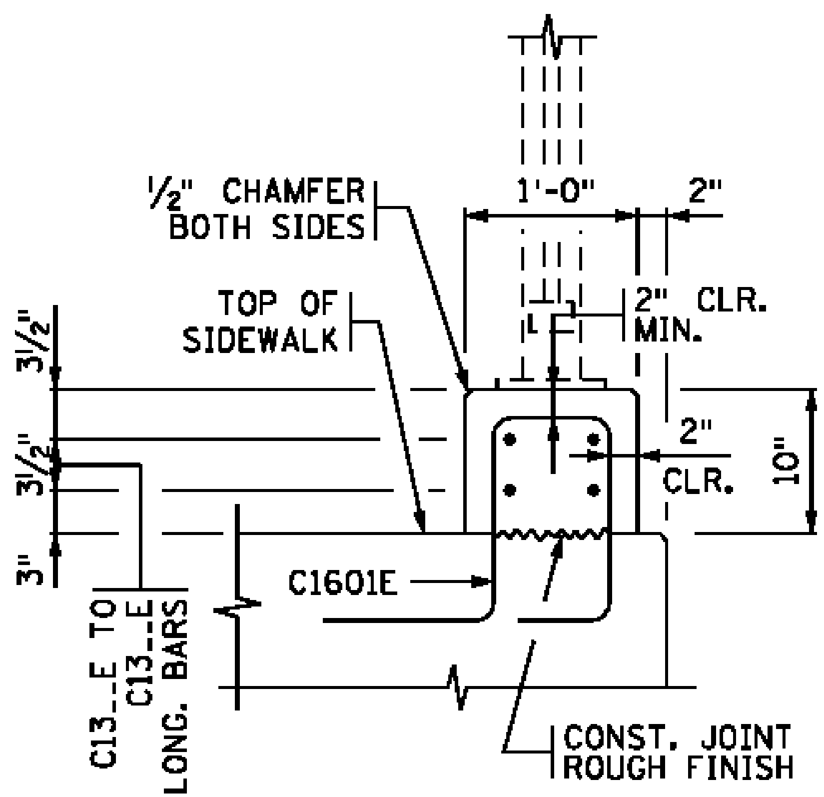
REFERENCE DATE 02-22-2012

CERTIFIED BY
LICENSED PROFESSIONAL ENGINEER DATE
NAME: LIC. NO.

TITLE: CONCRETE CURB

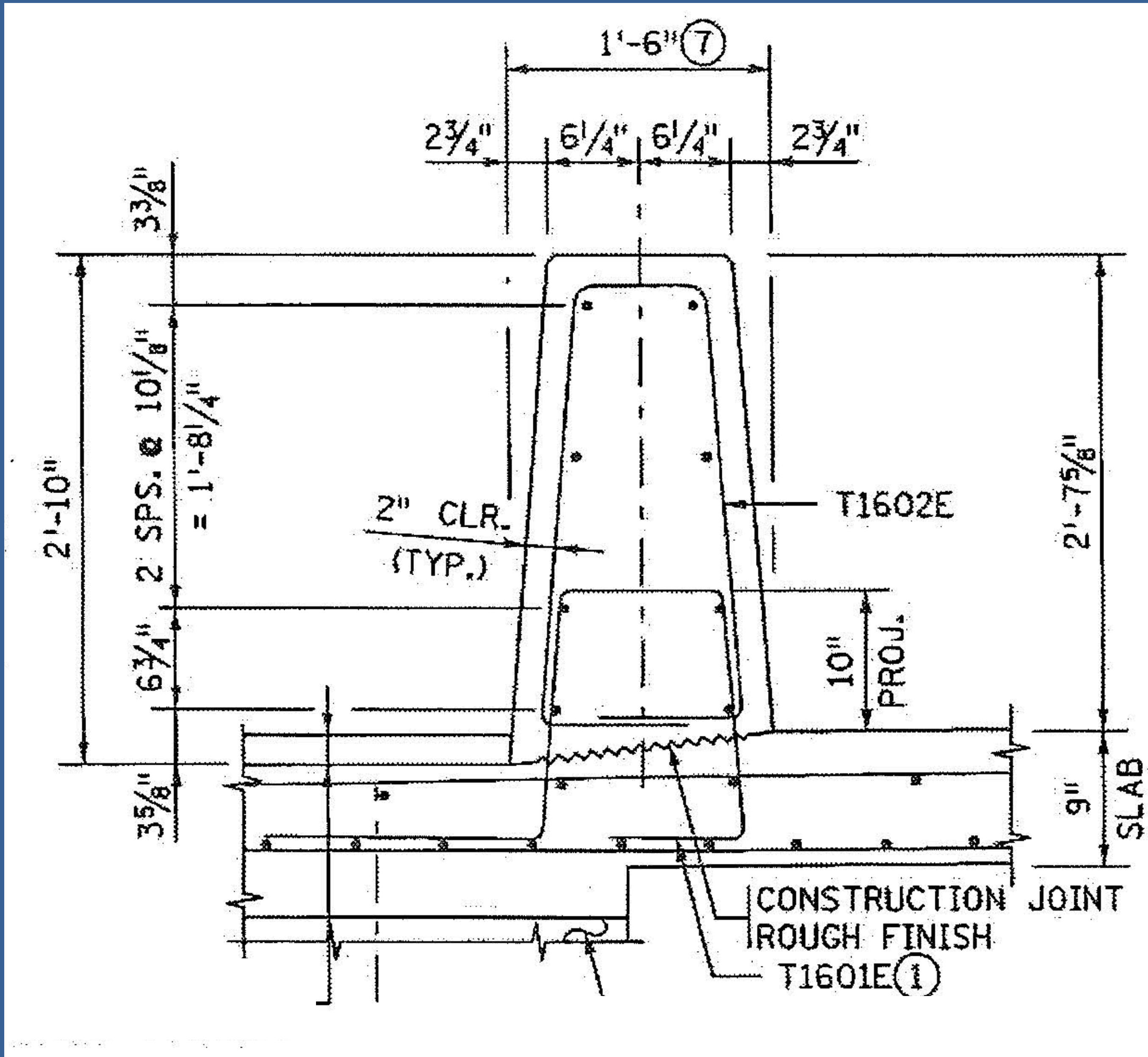
DES: DR: CHK: CHK:
SHEET NO. _ OF __ SHEETS

FIG. 5-397.167
APPROVED:
BRIDGE NO.

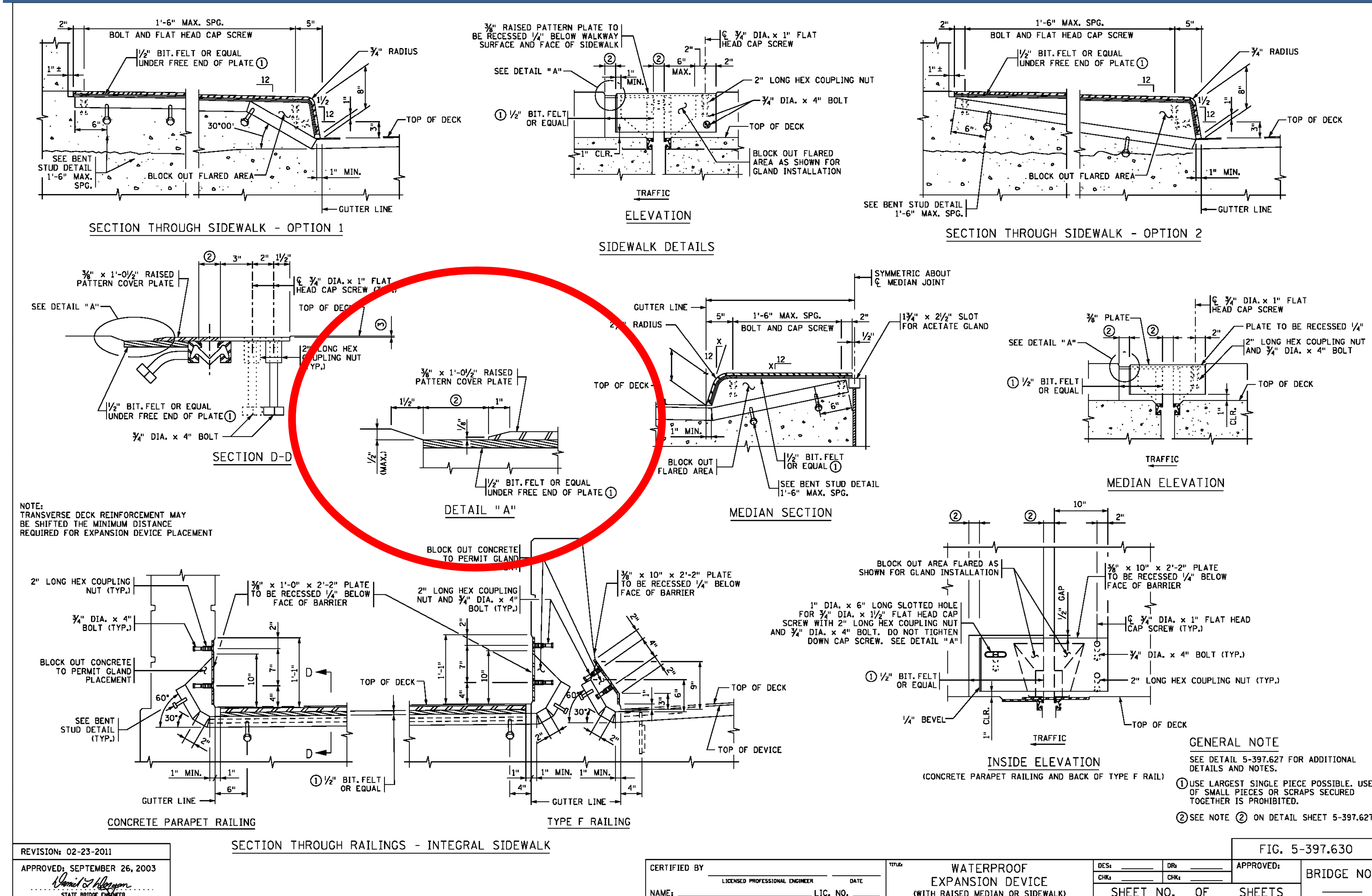


½" CHAMFER BOTH SIDES
1'-0"
2"
TOP OF SIDEWALK
2" CLR. MIN.
3½"
3½"
3"
2" CLR.
10"
C1601E
C13__E TO C13__E LONG. BARS
CONST. JOINT ROUGH FINISH

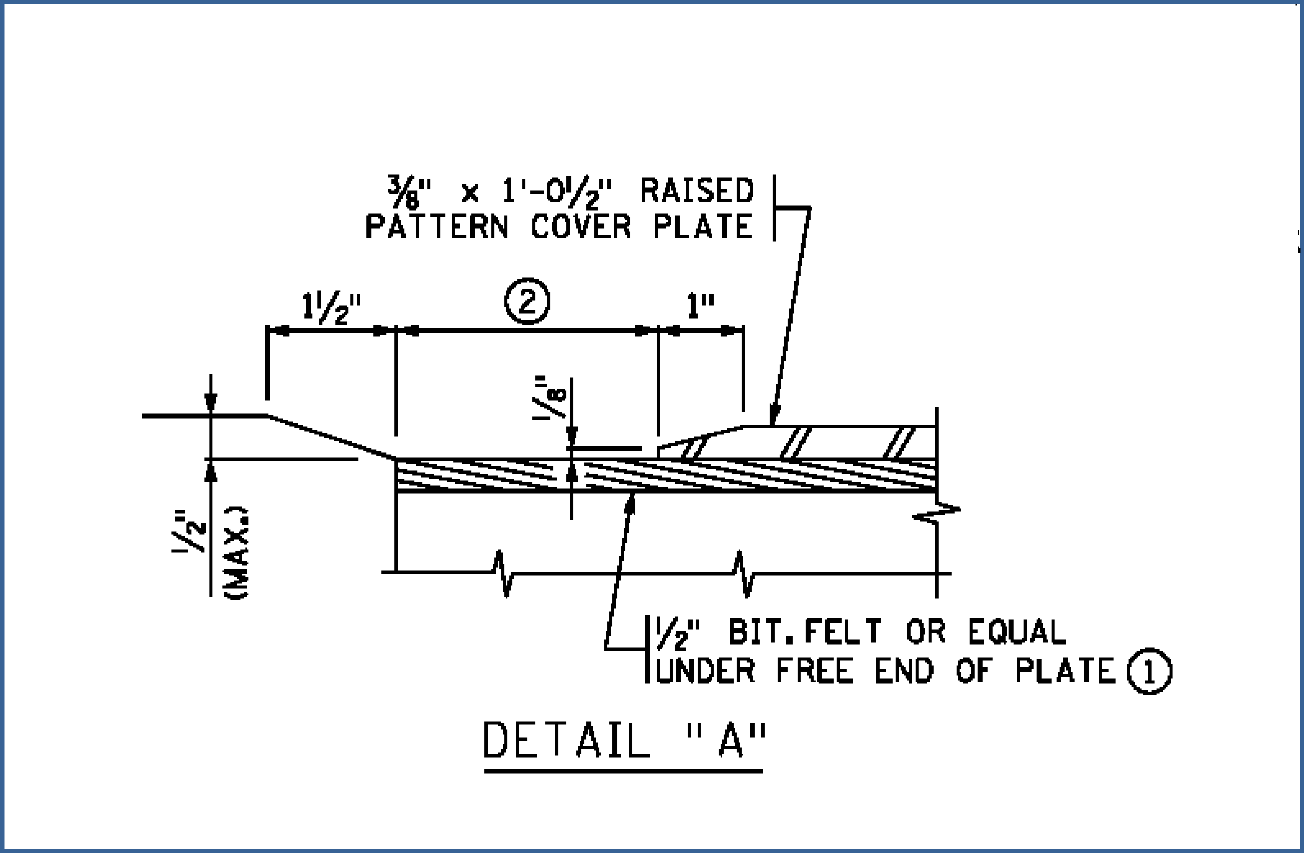
SECTION B-B

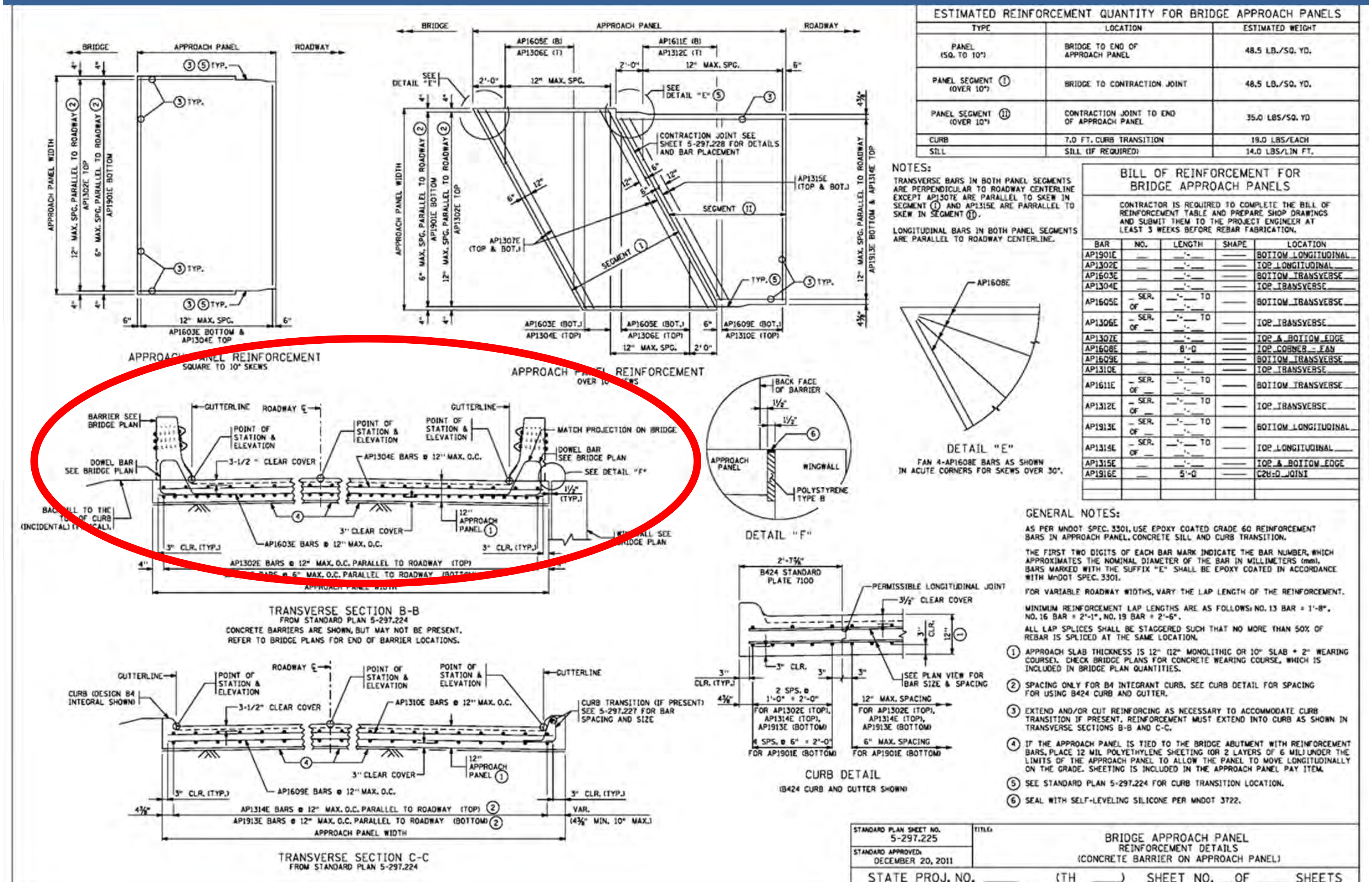


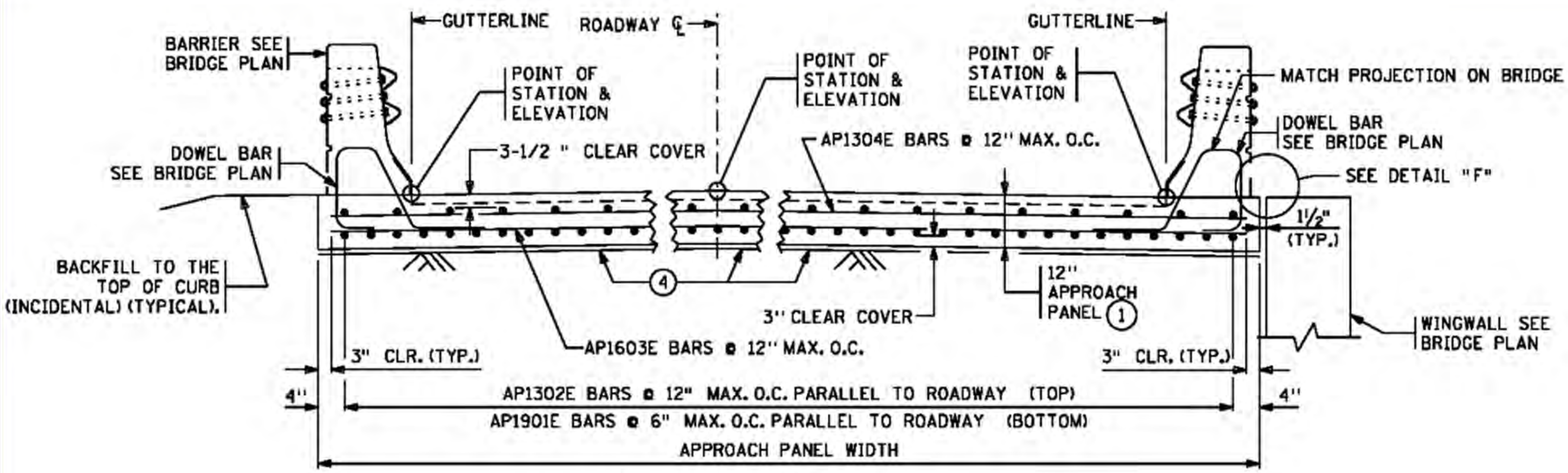
1'-6" (7)
2¾"
6¼"
6¼"
2¾"
3⅜"
2'-10"
2 SPS. @ 10⅛"
= 1'-8¼"
6¾"
3⅝"
2" CLR.
(TYP.)
T1602E
2'-7⅝"
10"
PROJ.
9"
SLAB
CONSTRUCTION JOINT
ROUGH FINISH
T1601E(1)



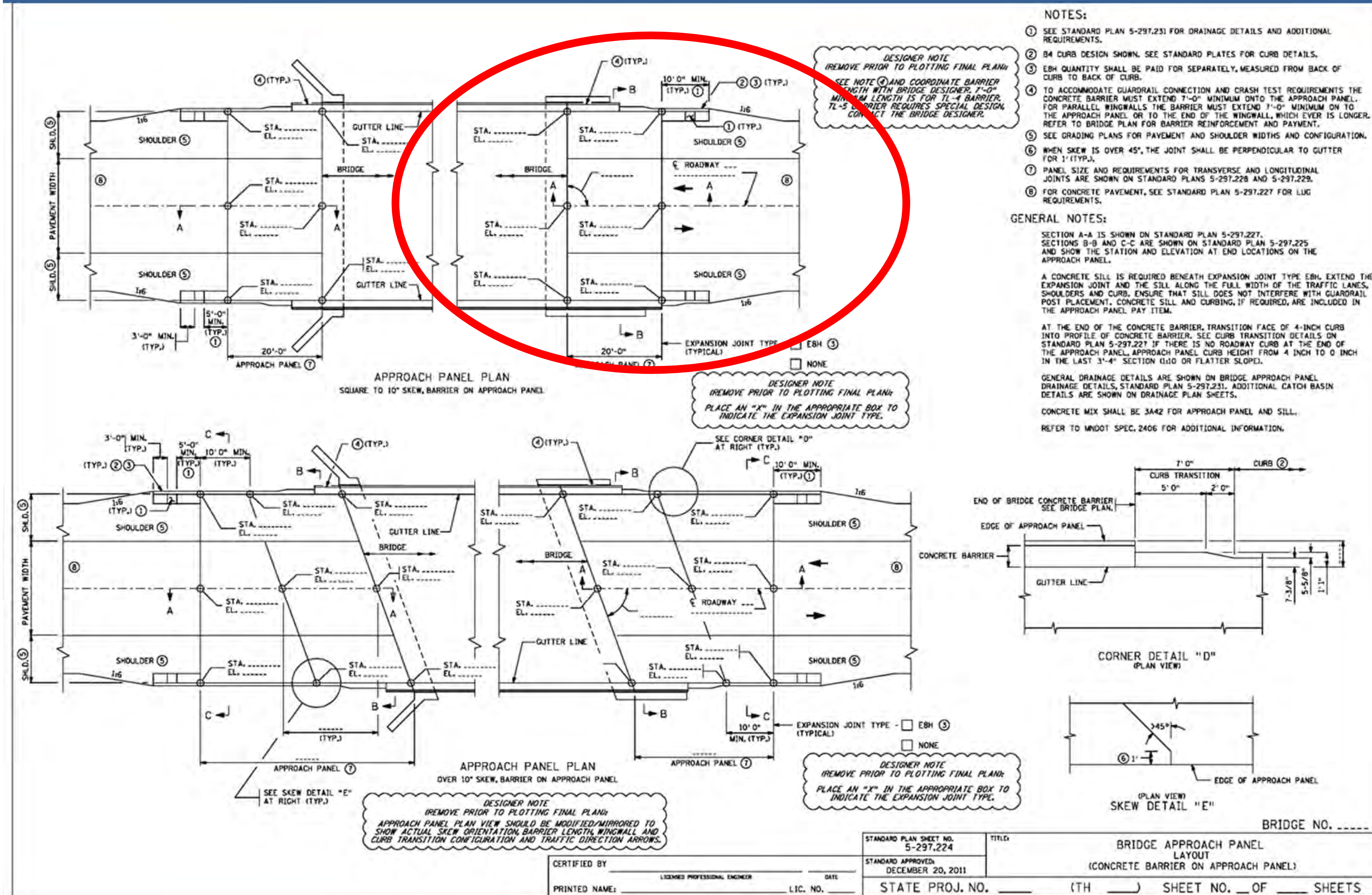
SECTION THROUGH SIDEWALK - OPTION 1
SIDEWALK DETAILS
ELEVATION
SECTION THROUGH SIDEWALK - OPTION 2
SECTION D-D
DETAIL "A"
MEDIAN SECTION
MEDIAN ELEVATION
NOTE:
TRANSVERSE DECK REINFORCEMENT MAY BE SHIFTED THE MINIMUM DISTANCE REQUIRED FOR EXPANSION DEVICE PLACEMENT
CONCRETE PARAPET RAILING
TYPE F RAILING
SECTION THROUGH RAILINGS - INTEGRAL SIDEWALK
INSIDE ELEVATION
(CONCRETE PARAPET RAILING AND BACK OF TYPE F RAIL)
GENERAL NOTE
SEE DETAIL 5-397.627 FOR ADDITIONAL DETAILS AND NOTES.
① USE LARGEST SINGLE PIECE POSSIBLE. USE OF SMALL PIECES OR SCRAPS SECURED TOGETHER IS PROHIBITED.
② SEE NOTE ② ON DETAIL SHEET 5-397.627.
REVISION: 02-23-2011
APPROVED: SEPTEMBER 26, 2003
STATE BRIDGE ENGINEER
CERTIFIED BY
LICENSED PROFESSIONAL ENGINEER
DATE
NAME:
LIC. NO.
WATERPROOF EXPANSION DEVICE
(WITH RAISED MEDIAN OR SIDEWALK)
FIG. 5-397.630
APPROVED:
BRIDGE NO.
SHEET NO. __ OF __ SHEETS

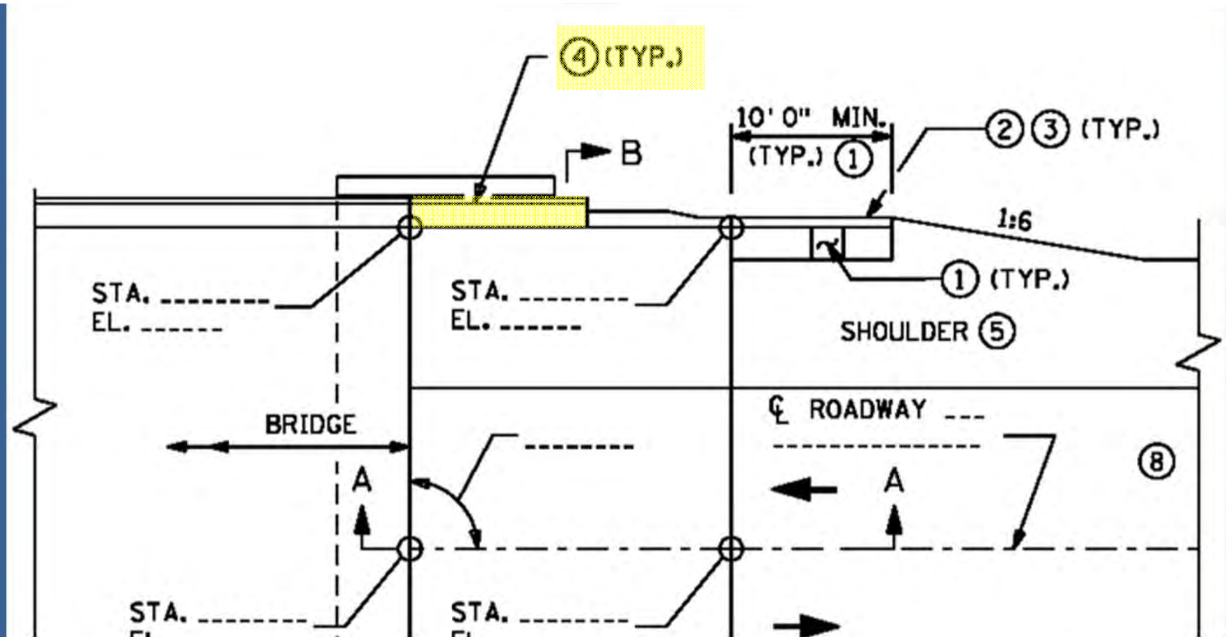

3/8" x 1'-0 1/2" RAISED
PATTERN COVER PLATE
1 1/2"
2
1"
1/8"
1/2"
(MAX.)
1/2" BIT. FELT OR EQUAL
UNDER FREE END OF PLATE 1
DETAIL "A"


ESTIMATED REINFORCEMENT QUANTITY FOR BRIDGE APPROACH PANELS
TYPE | LOCATION | ESTIMATED WEIGHT
PANEL (SQ. TO 10°) | BRIDGE TO END OF APPROACH PANEL | 48.5 LB./SQ. YD.
PANEL SEGMENT ① (OVER 10°) | BRIDGE TO CONTRACTION JOINT | 48.5 LB./SQ. YD.
PANEL SEGMENT ⑪ (OVER 10°) | CONTRACTION JOINT TO END OF APPROACH PANEL | 35.0 LBS/SQ. YD
CURB | 7.0 FT. CURB TRANSITION | 19.0 LBS/EACH
SILL | SILL (IF REQUIRED) | 14.0 LBS/LIN FT.
NOTES:
TRANSVERSE BARS IN BOTH PANEL SEGMENTS ARE PERPENDICULAR TO ROADWAY CENTERLINE EXCEPT AP1307E ARE PARALLEL TO SKEW IN SEGMENT ① AND AP1315E ARE PARALLEL TO SKEW IN SEGMENT ⑪.
LONGITUDINAL BARS IN BOTH PANEL SEGMENTS ARE PARALLEL TO ROADWAY CENTERLINE.
BILL OF REINFORCEMENT FOR BRIDGE APPROACH PANELS
CONTRACTOR IS REQUIRED TO COMPLETE THE BILL OF REINFORCEMENT TABLE AND PREPARE SHOP DRAWINGS AND SUBMIT THEM TO THE PROJECT ENGINEER AT LEAST 3 WEEKS BEFORE REBAR FABRICATION.
BAR | NO. | LENGTH | SHAPE | LOCATION
AP1901E | BOTTOM LONGITUDINAL
AP1302E | TOP LONGITUDINAL
AP1603E | BOTTOM TRANSVERSE
AP1304E | TOP TRANSVERSE
AP1605E | BOTTOM TRANSVERSE
AP1306E | TOP TRANSVERSE
AP1307E | TOP & BOTTOM EDGE
AP1608E | 8'-0 | TOP CORNER - FAN
AP1609E | BOTTOM TRANSVERSE
AP1310E | TOP TRANSVERSE
AP1611E | BOTTOM TRANSVERSE
AP1312E | TOP TRANSVERSE
AP1913E | BOTTOM LONGITUDINAL
AP1314E | TOP LONGITUDINAL
AP1315E | TOP & BOTTOM EDGE
AP1916E | 5'-0 | CURB JOINT
APPROACH PANEL REINFORCEMENT SQUARE TO 10° SKEWS
APPROACH PANEL REINFORCEMENT OVER 10° SKEWS
DETAIL "E"
FAN 4-AP1608E BARS AS SHOWN IN ACUTE CORNERS FOR SKEWS OVER 30°.
DETAIL "F"
TRANSVERSE SECTION B-B
FROM STANDARD PLAN 5-297.224
CONCRETE BARRIERS ARE SHOWN, BUT MAY NOT BE PRESENT. REFER TO BRIDGE PLANS FOR END OF BARRIER LOCATIONS.
TRANSVERSE SECTION C-C
FROM STANDARD PLAN 5-297.224
CURB DETAIL
(B424 CURB AND GUTTER SHOWN)
GENERAL NOTES:
AS PER MnDOT SPEC. 3301, USE EPOXY COATED GRADE 60 REINFORCEMENT BARS IN APPROACH PANEL, CONCRETE SILL AND CURB TRANSITION.
THE FIRST TWO DIGITS OF EACH BAR MARK INDICATE THE BAR NUMBER, WHICH APPROXIMATES THE NOMINAL DIAMETER OF THE BAR IN MILLIMETERS (mm). BARS MARKED WITH THE SUFFIX "E" SHALL BE EPOXY COATED IN ACCORDANCE WITH MnDOT SPEC. 3301.
FOR VARIABLE ROADWAY WIDTHS, VARY THE LAP LENGTH OF THE REINFORCEMENT.
MINIMUM REINFORCEMENT LAP LENGTHS ARE AS FOLLOWS: NO. 13 BAR = 1'-8", NO. 16 BAR = 2'-1", NO. 19 BAR = 2'-6".
ALL LAP SPLICES SHALL BE STAGGERED SUCH THAT NO MORE THAN 50% OF REBAR IS SPLICED AT THE SAME LOCATION.
① APPROACH SLAB THICKNESS IS 12" (12" MONOLITHIC OR 10" SLAB + 2" WEARING COURSE). CHECK BRIDGE PLANS FOR CONCRETE WEARING COURSE, WHICH IS INCLUDED IN BRIDGE PLAN QUANTITIES.
② SPACING ONLY FOR B4 INTEGRANT CURB. SEE CURB DETAIL FOR SPACING FOR USING B424 CURB AND GUTTER.
③ EXTEND AND/OR CUT REINFORCING AS NECESSARY TO ACCOMMODATE CURB TRANSITION IF PRESENT. REINFORCEMENT MUST EXTEND INTO CURB AS SHOWN IN TRANSVERSE SECTIONS B-B AND C-C.
④ IF THE APPROACH PANEL IS TIED TO THE BRIDGE ABUTMENT WITH REINFORCEMENT BARS, PLACE 12 MIL POLYETHYLENE SHEETING (OR 2 LAYERS OF 6 MIL) UNDER THE LIMITS OF THE APPROACH PANEL TO ALLOW THE PANEL TO MOVE LONGITUDINALLY ON THE GRADE. SHEETING IS INCLUDED IN THE APPROACH PANEL PAY ITEM.
⑤ SEE STANDARD PLAN 5-297.224 FOR CURB TRANSITION LOCATION.
⑥ SEAL WITH SELF-LEVELING SILICONE PER MnDOT 3722.
STANDARD PLAN SHEET NO. 5-297.225
STANDARD APPROVED: DECEMBER 20, 2011
BRIDGE APPROACH PANEL REINFORCEMENT DETAILS (CONCRETE BARRIER ON APPROACH PANEL)
STATE PROJ. NO. ____ (TH ____) SHEET NO. __ OF ____ SHEETS



TRANSVERSE SECTION B-B
FROM STANDARD PLAN 5-297.224
CONCRETE BARRIERS ARE SHOWN, BUT MAY NOT BE PRESENT.
REFER TO BRIDGE PLANS FOR END OF BARRIER LOCATIONS.

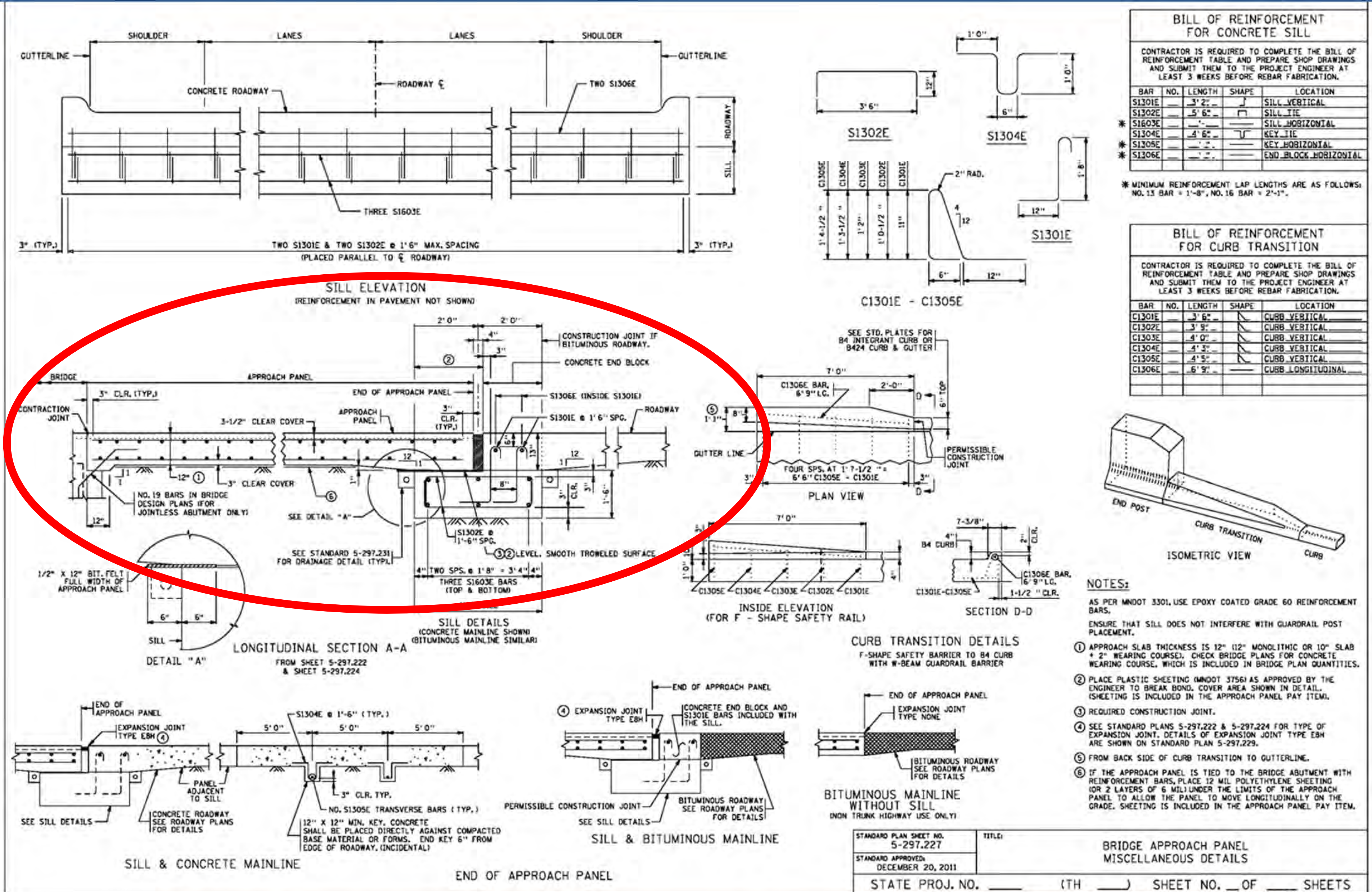

NOTES:
① SEE STANDARD PLAN 5-297.231 FOR DRAINAGE DETAILS AND ADDITIONAL REQUIREMENTS.
② B4 CURB DESIGN SHOWN. SEE STANDARD PLATES FOR CURB DETAILS.
③ E8H QUANTITY SHALL BE PAID FOR SEPARATELY, MEASURED FROM BACK OF CURB TO BACK OF CURB.
④ TO ACCOMMODATE GUARDRAIL CONNECTION AND CRASH TEST REQUIREMENTS THE CONCRETE BARRIER MUST EXTEND 7'-0" MINIMUM ONTO THE APPROACH PANEL. FOR PARALLEL WINGWALLS THE BARRIER MUST EXTEND 7'-0" MINIMUM ON TO THE APPROACH PANEL OR TO THE END OF THE WINGWALL, WHICH EVER IS LONGER. REFER TO BRIDGE PLAN FOR BARRIER REINFORCEMENT AND PAYMENT.
⑤ SEE GRADING PLANS FOR PAVEMENT AND SHOULDER WIDTHS AND CONFIGURATION.
⑥ WHEN SKEW IS OVER 45°, THE JOINT SHALL BE PERPENDICULAR TO GUTTER FOR 1' (TYP.).
⑦ PANEL SIZE AND REQUIREMENTS FOR TRANSVERSE AND LONGITUDINAL JOINTS ARE SHOWN ON STANDARD PLANS 5-297.228 AND 5-297.229.
⑧ FOR CONCRETE PAVEMENT, SEE STANDARD PLAN 5-297.227 FOR LUG REQUIREMENTS.
GENERAL NOTES:
SECTION A-A IS SHOWN ON STANDARD PLAN 5-297.227. SECTIONS B-B AND C-C ARE SHOWN ON STANDARD PLAN 5-297.225 AND SHOW THE STATION AND ELEVATION AT END LOCATIONS ON THE APPROACH PANEL.
A CONCRETE SILL IS REQUIRED BENEATH EXPANSION JOINT TYPE E8H. EXTEND THE EXPANSION JOINT AND THE SILL ALONG THE FULL WIDTH OF THE TRAFFIC LANES, SHOULDERS AND CURB. ENSURE THAT SILL DOES NOT INTERFERE WITH GUARDRAIL POST PLACEMENT. CONCRETE SILL AND CURBING, IF REQUIRED, ARE INCLUDED IN THE APPROACH PANEL PAY ITEM.
AT THE END OF THE CONCRETE BARRIER, TRANSITION FACE OF 4-INCH CURB INTO PROFILE OF CONCRETE BARRIER. SEE CURB TRANSITION DETAILS ON STANDARD PLAN 5-297.227 IF THERE IS NO ROADWAY CURB AT THE END OF THE APPROACH PANEL, APPROACH PANEL CURB HEIGHT FROM 4 INCH TO 0 INCH IN THE LAST 3'-4" SECTION (1:10 OR FLATTER SLOPE).
GENERAL DRAINAGE DETAILS ARE SHOWN ON BRIDGE APPROACH PANEL DRAINAGE DETAILS, STANDARD PLAN 5-297.231. ADDITIONAL CATCH BASIN DETAILS ARE SHOWN ON DRAINAGE PLAN SHEETS.
CONCRETE MIX SHALL BE 3A42 FOR APPROACH PANEL AND SILL.
REFER TO MNDOT SPEC. 2406 FOR ADDITIONAL INFORMATION.
APPROACH PANEL PLAN
SQUARE TO 10° SKEW, BARRIER ON APPROACH PANEL
APPROACH PANEL PLAN
OVER 10° SKEW, BARRIER ON APPROACH PANEL
CORNER DETAIL "D"
(PLAN VIEW)
SKEW DETAIL "E"
(PLAN VIEW)
DESIGNER NOTE
(REMOVE PRIOR TO PLOTTING FINAL PLAN):
PLACE AN "X" IN THE APPROPRIATE BOX TO INDICATE THE EXPANSION JOINT TYPE.
EXPANSION JOINT TYPE - E8H ③
NONE
BRIDGE NO. _____
STANDARD PLAN SHEET NO. 5-297.224
STANDARD APPROVED: DECEMBER 20, 2011
BRIDGE APPROACH PANEL
LAYOUT
(CONCRETE BARRIER ON APPROACH PANEL)
STATE PROJ. NO. _____ (TH ____) SHEET NO. __ OF ____ SHEETS

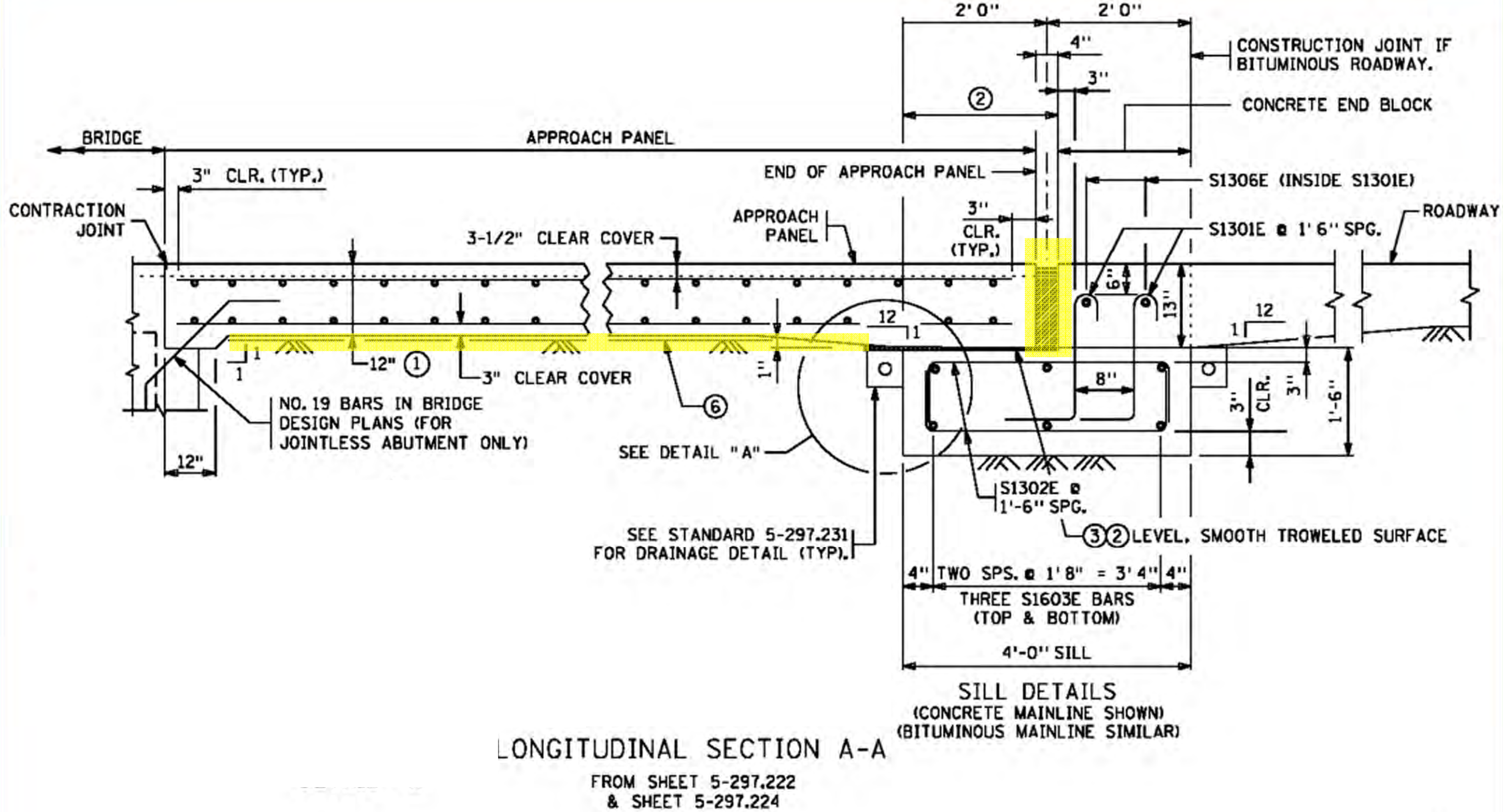


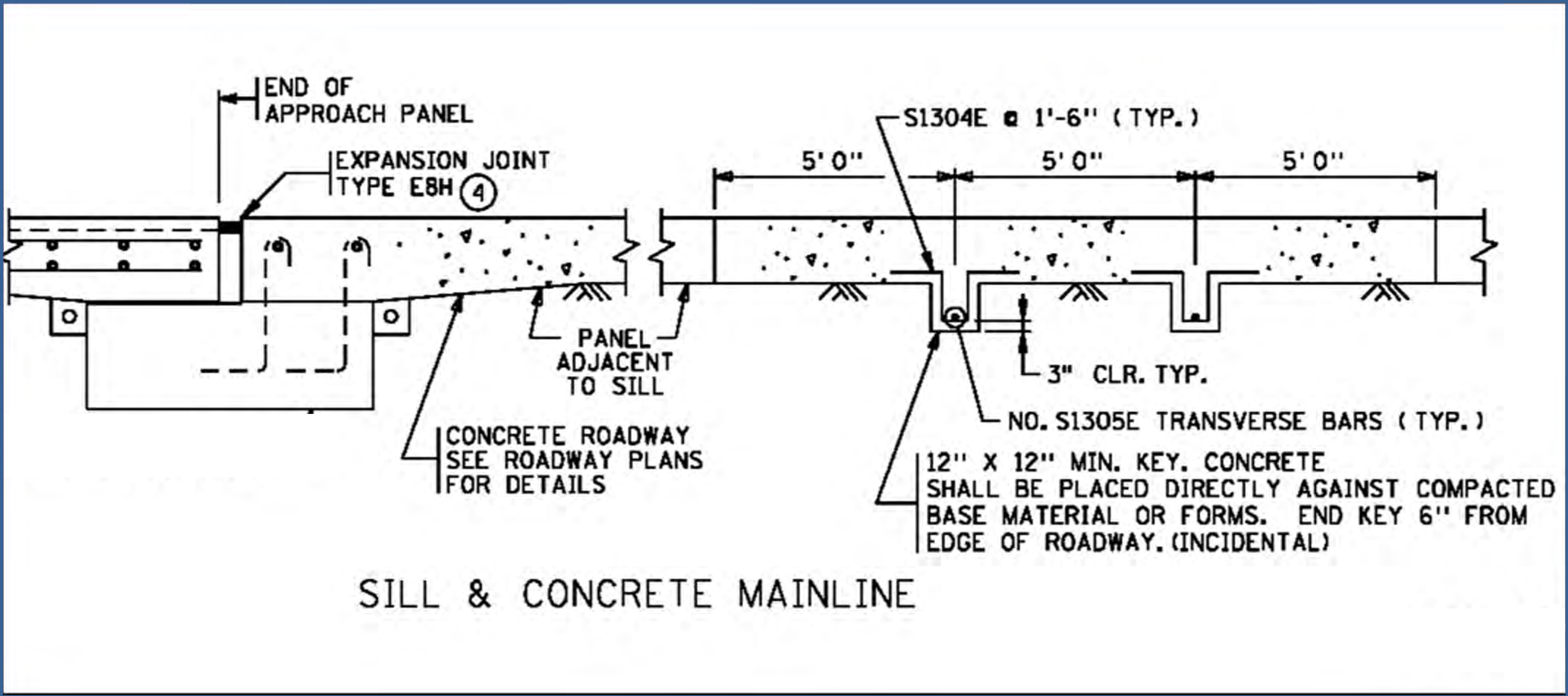
DESIGNER NOTE
(REMOVE PRIOR TO PLOTTING FINAL PLAN):

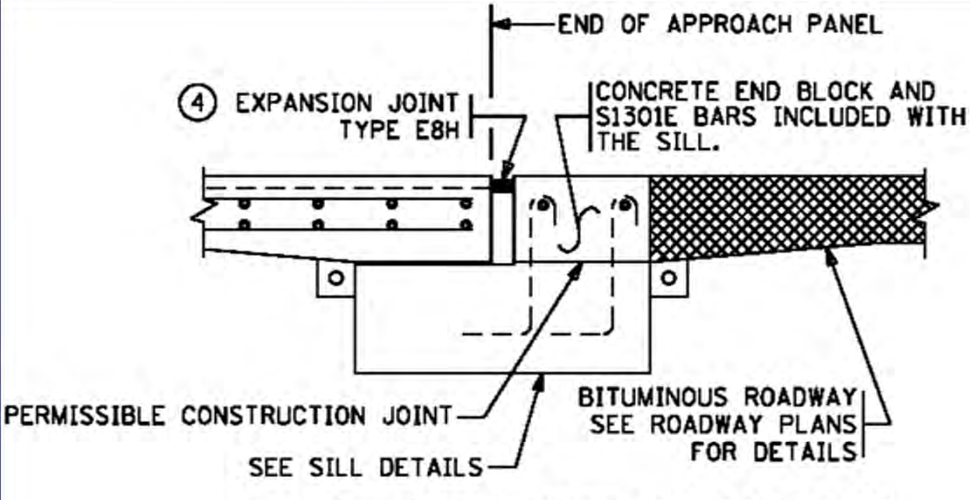
SEE NOTE ④ AND COORDINATE BARRIER LENGTH WITH BRIDGE DESIGNER. 7'-0" MINIMUM LENGTH IS FOR TL-4 BARRIER. TL-5 BARRIER REQUIRES SPECIAL DESIGN, CONTACT THE BRIDGE DESIGNER.

④ TO ACCOMMODATE GUARDRAIL CONNECTION AND CRASH TEST REQUIREMENTS THE CONCRETE BARRIER MUST EXTEND 7'-0" MINIMUM ONTO THE APPROACH PANEL. FOR PARALLEL WINGWALLS THE BARRIER MUST EXTEND 7'-0" MINIMUM ON TO THE APPROACH PANEL OR TO THE END OF THE WINGWALL, WHICH EVER IS LONGER. REFER TO BRIDGE PLAN FOR BARRIER REINFORCEMENT AND PAYMENT.

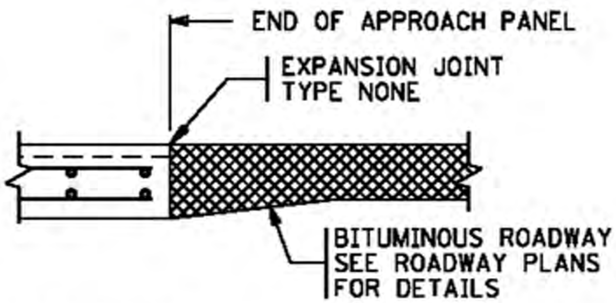

SILL ELEVATION
(REINFORCEMENT IN PAVEMENT NOT SHOWN)
SILL DETAILS
(CONCRETE MAINLINE SHOWN)
(BITUMINOUS MAINLINE SIMILAR)
LONGITUDINAL SECTION A-A
FROM SHEET 5-297.222
& SHEET 5-297.224
DETAIL "A"
S1302E
S1304E
S1301E
C1301E - C1305E
PLAN VIEW
INSIDE ELEVATION
(FOR F - SHAPE SAFETY RAIL)
SECTION D-D
CURB TRANSITION DETAILS
F-SHAPE SAFETY BARRIER TO B4 CURB
WITH W-BEAM GUARDRAIL BARRIER
ISOMETRIC VIEW
BILL OF REINFORCEMENT
FOR CONCRETE SILL
CONTRACTOR IS REQUIRED TO COMPLETE THE BILL OF REINFORCEMENT TABLE AND PREPARE SHOP DRAWINGS AND SUBMIT THEM TO THE PROJECT ENGINEER AT LEAST 3 WEEKS BEFORE REBAR FABRICATION.
BAR | NO. | LENGTH | SHAPE | LOCATION
S1301E | SILL VERTICAL
S1302E | SILL TIE
S1603E | SILL HORIZONTAL
S1304E | KEY TIE
S1305E | KEY HORIZONTAL
S1306E | END BLOCK HORIZONTAL
BILL OF REINFORCEMENT
FOR CURB TRANSITION
CONTRACTOR IS REQUIRED TO COMPLETE THE BILL OF REINFORCEMENT TABLE AND PREPARE SHOP DRAWINGS AND SUBMIT THEM TO THE PROJECT ENGINEER AT LEAST 3 WEEKS BEFORE REBAR FABRICATION.
BAR | NO. | LENGTH | SHAPE | LOCATION
C1301E | 3' 6" | CURB VERTICAL
C1302E | 3' 9" | CURB VERTICAL
C1303E | 4' 0" | CURB VERTICAL
C1304E | 4' 3" | CURB VERTICAL
C1305E | 4' 5" | CURB VERTICAL
C1306E | 6' 9" | CURB LONGITUDINAL
NOTES:
AS PER MNDOT 3301, USE EPOXY COATED GRADE 60 REINFORCEMENT BARS.
ENSURE THAT SILL DOES NOT INTERFERE WITH GUARDRAIL POST PLACEMENT.
1 APPROACH SLAB THICKNESS IS 12" (12" MONOLITHIC OR 10" SLAB + 2" WEARING COURSE). CHECK BRIDGE PLANS FOR CONCRETE WEARING COURSE, WHICH IS INCLUDED IN BRIDGE PLAN QUANTITIES.
2 PLACE PLASTIC SHEETING (MNDOT 3756) AS APPROVED BY THE ENGINEER TO BREAK BOND. COVER AREA SHOWN IN DETAIL. (SHEETING IS INCLUDED IN THE APPROACH PANEL PAY ITEM).
3 REQUIRED CONSTRUCTION JOINT.
4 SEE STANDARD PLANS 5-297.222 & 5-297.224 FOR TYPE OF EXPANSION JOINT. DETAILS OF EXPANSION JOINT TYPE E8H ARE SHOWN ON STANDARD PLAN 5-297.229.
5 FROM BACK SIDE OF CURB TRANSITION TO GUTTERLINE.
6 IF THE APPROACH PANEL IS TIED TO THE BRIDGE ABUTMENT WITH REINFORCEMENT BARS, PLACE 12 MIL POLYETHYLENE SHEETING (OR 2 LAYERS OF 6 MIL) UNDER THE LIMITS OF THE APPROACH PANEL TO ALLOW THE PANEL TO MOVE LONGITUDINALLY ON THE GRADE. SHEETING IS INCLUDED IN THE APPROACH PANEL PAY ITEM.
SILL & CONCRETE MAINLINE
END OF APPROACH PANEL
SILL & BITUMINOUS MAINLINE
BITUMINOUS MAINLINE
WITHOUT SILL
(NON TRUNK HIGHWAY USE ONLY)
STANDARD PLAN SHEET NO. 5-297.227
STANDARD APPROVED: DECEMBER 20, 2011
BRIDGE APPROACH PANEL
MISCELLANEOUS DETAILS
STATE PROJ. NO.
SHEET NO. OF SHEETS


2' 0"
2' 0"
4"
3"
CONSTRUCTION JOINT IF BITUMINOUS ROADWAY.
CONCRETE END BLOCK
BRIDGE
APPROACH PANEL
END OF APPROACH PANEL
S1306E (INSIDE S1301E)
3" CLR. (TYP.)
CONTRACTION JOINT
3-1/2" CLEAR COVER
APPROACH PANEL
3" CLR. (TYP.)
S1301E @ 1' 6" SPG.
ROADWAY
12" ①
3" CLEAR COVER
⑥
NO. 19 BARS IN BRIDGE DESIGN PLANS (FOR JOINTLESS ABUTMENT ONLY)
SEE DETAIL "A"
8"
1'-6"
S1302E @ 1'-6" SPG.
SEE STANDARD 5-297.231 FOR DRAINAGE DETAIL (TYP).
③② LEVEL, SMOOTH TROWELED SURFACE
4" TWO SPS. @ 1' 8" = 3' 4" 4"
THREE S1603E BARS (TOP & BOTTOM)
4'-0" SILL
SILL DETAILS
(CONCRETE MAINLINE SHOWN)
(BITUMINOUS MAINLINE SIMILAR)
LONGITUDINAL SECTION A-A
FROM SHEET 5-297.222
& SHEET 5-297.224

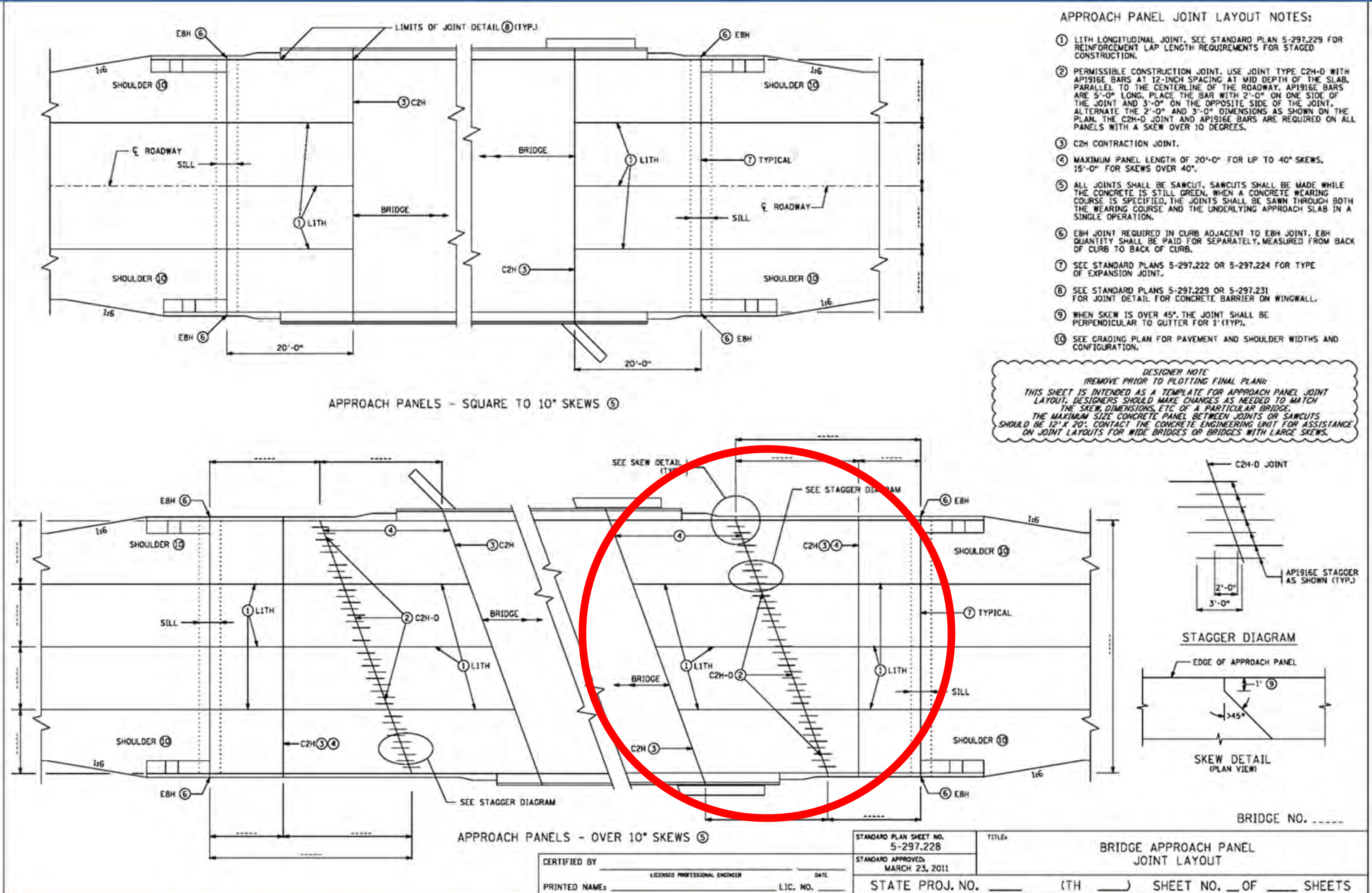

END OF
APPROACH PANEL
EXPANSION JOINT
TYPE E8H (4)
S1304E @ 1'-6" (TYP.)
5' 0"
5' 0"
5' 0"
PANEL
ADJACENT
TO SILL
3" CLR. TYP.
NO. S1305E TRANSVERSE BARS (TYP.)
CONCRETE ROADWAY
SEE ROADWAY PLANS
FOR DETAILS
12" X 12" MIN. KEY. CONCRETE
SHALL BE PLACED DIRECTLY AGAINST COMPACTED
BASE MATERIAL OR FORMS. END KEY 6" FROM
EDGE OF ROADWAY. (INCIDENTAL)
SILL & CONCRETE MAINLINE

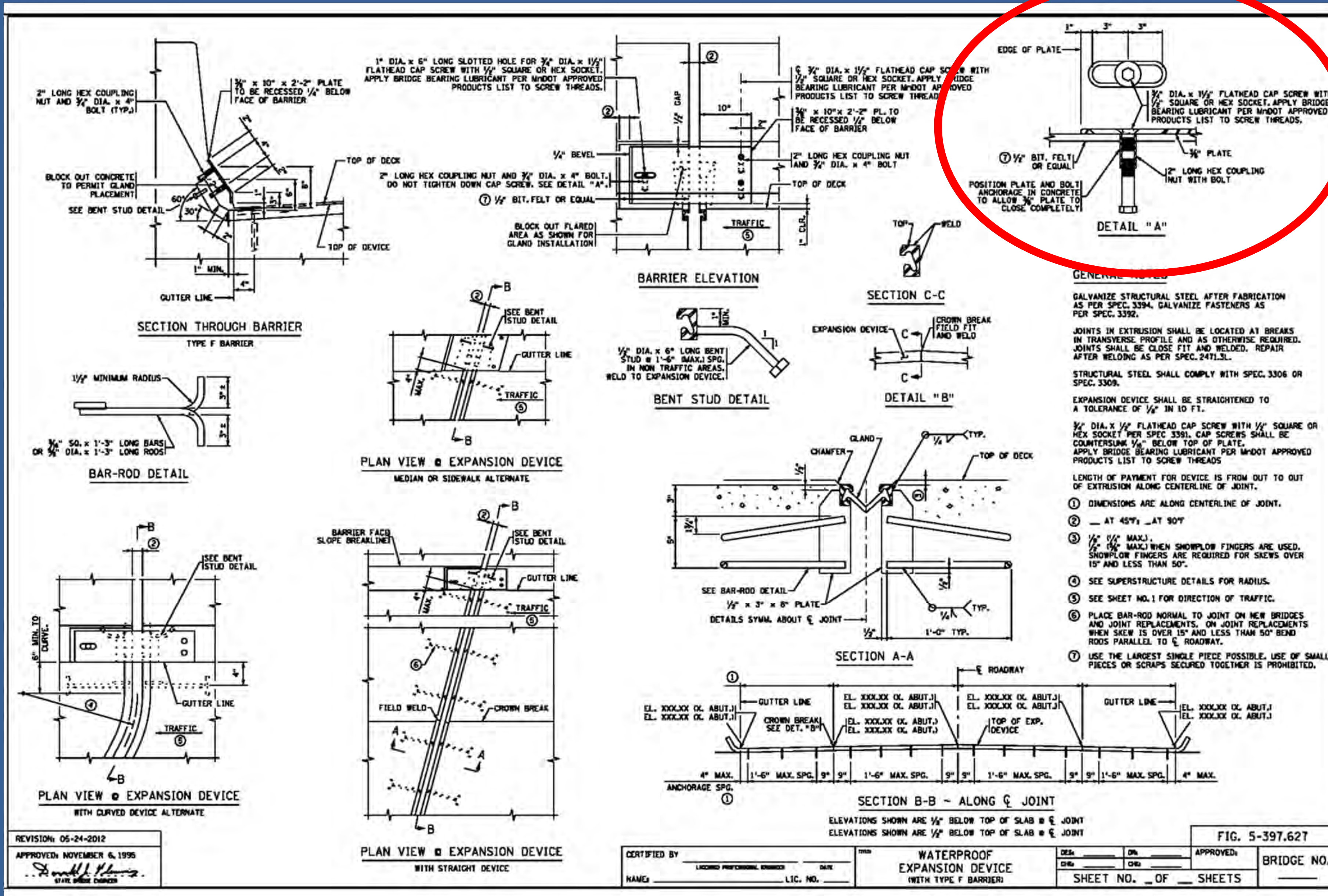


SILL & BITUMINOUS MAINLINE

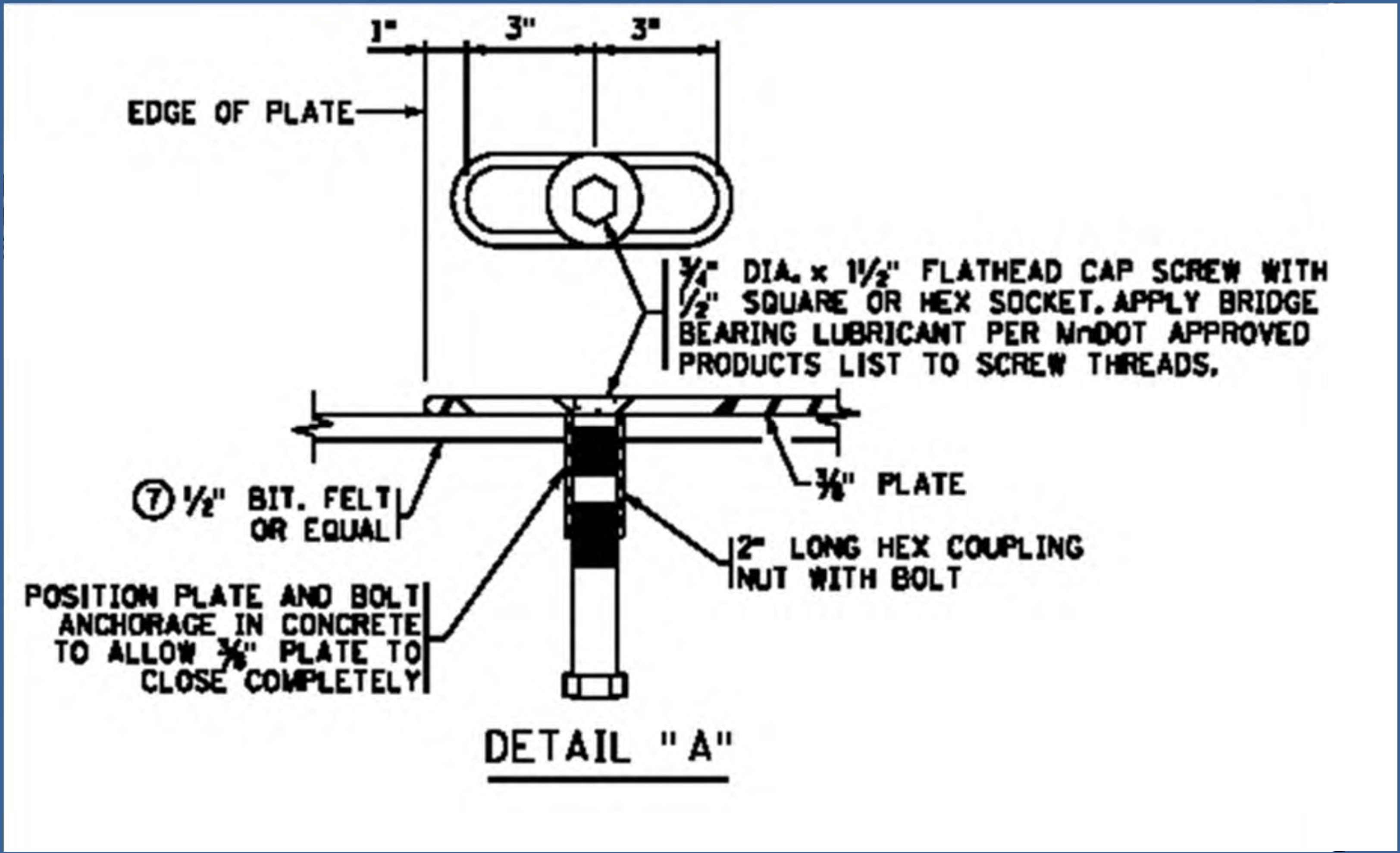


BITUMINOUS MAINLINE WITHOUT SILL
(NON TRUNK HIGHWAY USE ONLY)

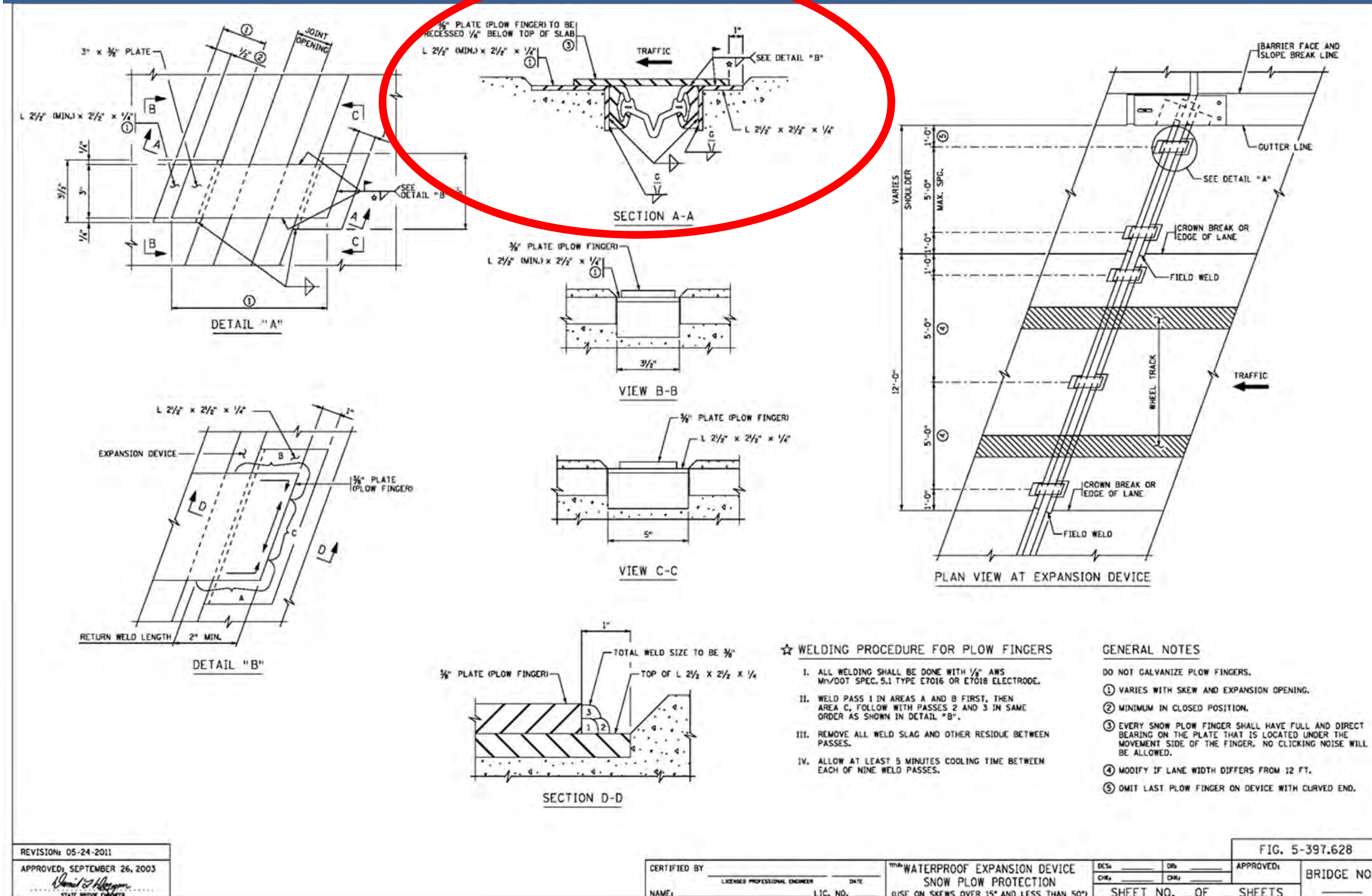

LIMITS OF JOINT DETAIL ⑧ (TYP.)
E8H ⑥
SHOULDER ⑩
℄ ROADWAY
SILL
① L1TH
③ C2H
BRIDGE
⑦ TYPICAL
20'-0"
APPROACH PANELS - SQUARE TO 10° SKEWS ⑤
APPROACH PANEL JOINT LAYOUT NOTES:
① L1TH LONGITUDINAL JOINT. SEE STANDARD PLAN 5-297.229 FOR REINFORCEMENT LAP LENGTH REQUIREMENTS FOR STAGED CONSTRUCTION.
② PERMISSIBLE CONSTRUCTION JOINT. USE JOINT TYPE C2H-D WITH AP1916E BARS AT 12-INCH SPACING AT MID DEPTH OF THE SLAB. PARALLEL TO THE CENTERLINE OF THE ROADWAY. AP1916E BARS ARE 5'-0" LONG. PLACE THE BAR WITH 2'-0" ON ONE SIDE OF THE JOINT AND 3'-0" ON THE OPPOSITE SIDE OF THE JOINT. ALTERNATE THE 2'-0" AND 3'-0" DIMENSIONS AS SHOWN ON THE PLAN. THE C2H-D JOINT AND AP1916E BARS ARE REQUIRED ON ALL PANELS WITH A SKEW OVER 10 DEGREES.
③ C2H CONTRACTION JOINT.
④ MAXIMUM PANEL LENGTH OF 20'-0" FOR UP TO 40° SKEWS. 15'-0" FOR SKEWS OVER 40°.
⑤ ALL JOINTS SHALL BE SAWCUT. SAWCUTS SHALL BE MADE WHILE THE CONCRETE IS STILL GREEN. WHEN A CONCRETE WEARING COURSE IS SPECIFIED, THE JOINTS SHALL BE SAWN THROUGH BOTH THE WEARING COURSE AND THE UNDERLYING APPROACH SLAB IN A SINGLE OPERATION.
⑥ E8H JOINT REQUIRED IN CURB ADJACENT TO E8H JOINT. E8H QUANTITY SHALL BE PAID FOR SEPARATELY, MEASURED FROM BACK OF CURB TO BACK OF CURB.
⑦ SEE STANDARD PLANS 5-297.222 OR 5-297.224 FOR TYPE OF EXPANSION JOINT.
⑧ SEE STANDARD PLANS 5-297.229 OR 5-297.231 FOR JOINT DETAIL FOR CONCRETE BARRIER ON WINGWALL.
⑨ WHEN SKEW IS OVER 45°. THE JOINT SHALL BE PERPENDICULAR TO GUTTER FOR 1' (TYP).
⑩ SEE GRADING PLAN FOR PAVEMENT AND SHOULDER WIDTHS AND CONFIGURATION.
DESIGNER NOTE
(REMOVE PRIOR TO PLOTTING FINAL PLAN):
THIS SHEET IS INTENDED AS A TEMPLATE FOR APPROACH PANEL JOINT LAYOUT. DESIGNERS SHOULD MAKE CHANGES AS NEEDED TO MATCH THE SKEW, DIMENSIONS, ETC OF A PARTICULAR BRIDGE.
THE MAXIMUM SIZE CONCRETE PANEL BETWEEN JOINTS OR SAWCUTS SHOULD BE 12' X 20'. CONTACT THE CONCRETE ENGINEERING UNIT FOR ASSISTANCE ON JOINT LAYOUTS FOR WIDE BRIDGES OR BRIDGES WITH LARGE SKEWS.
SEE SKEW DETAIL (TYP.)
SEE STAGGER DIAGRAM
② C2H-D
C2H ③ ④
C2H-D JOINT
AP1916E STAGGER AS SHOWN (TYP.)
2'-0"
3'-0"
STAGGER DIAGRAM
EDGE OF APPROACH PANEL
1' ⑨
>45°
SKEW DETAIL
(PLAN VIEW)
APPROACH PANELS - OVER 10° SKEWS ⑤
BRIDGE NO. _____
CERTIFIED BY
LICENSED PROFESSIONAL ENGINEER
DATE
PRINTED NAME:
LIC. NO.
STANDARD PLAN SHEET NO.
5-297.228
STANDARD APPROVED:
MARCH 23, 2011
TITLE:
BRIDGE APPROACH PANEL
JOINT LAYOUT
STATE PROJ. NO. _____ (TH ____) SHEET NO. __ OF ____ SHEETS



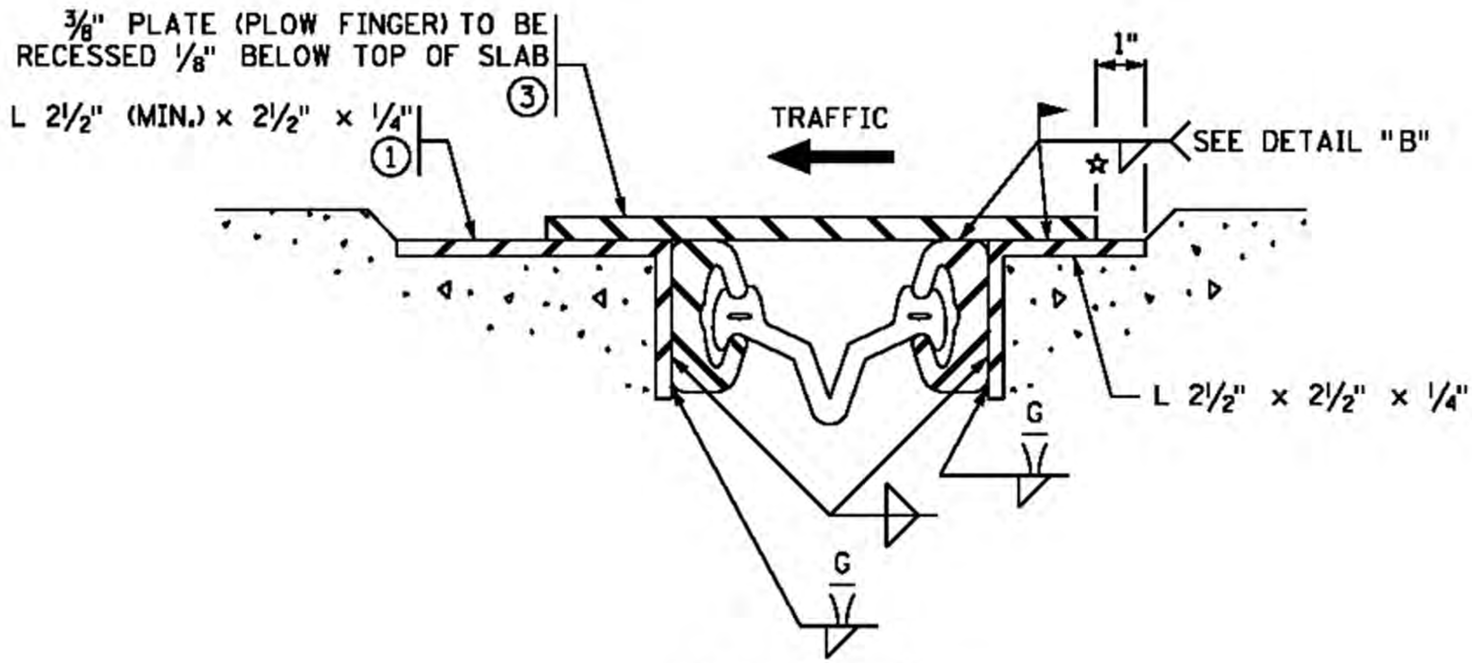
SECTION THROUGH BARRIER
TYPE F BARRIER
BAR-ROD DETAIL
BARRIER ELEVATION
BENT STUD DETAIL
SECTION C-C
DETAIL "B"
DETAIL "A"
PLAN VIEW @ EXPANSION DEVICE
MEDIAN OR SIDEWALK ALTERNATE
PLAN VIEW @ EXPANSION DEVICE
WITH CURVED DEVICE ALTERNATE
PLAN VIEW @ EXPANSION DEVICE
WITH STRAIGHT DEVICE
SECTION A-A
SECTION B-B ~ ALONG ℄ JOINT
GENERAL NOTES
GALVANIZE STRUCTURAL STEEL AFTER FABRICATION AS PER SPEC. 3394. GALVANIZE FASTENERS AS PER SPEC. 3392.
JOINTS IN EXTRUSION SHALL BE LOCATED AT BREAKS IN TRANSVERSE PROFILE AND AS OTHERWISE REQUIRED. JOINTS SHALL BE CLOSE FIT AND WELDED. REPAIR AFTER WELDING AS PER SPEC. 2471.3L.
STRUCTURAL STEEL SHALL COMPLY WITH SPEC. 3306 OR SPEC. 3309.
EXPANSION DEVICE SHALL BE STRAIGHTENED TO A TOLERANCE OF 1/8" IN 10 FT.
LENGTH OF PAYMENT FOR DEVICE IS FROM OUT TO OUT OF EXTRUSION ALONG CENTERLINE OF JOINT.
REVISION: 05-24-2012
APPROVED: NOVEMBER 6, 1995
WATERPROOF
EXPANSION DEVICE
(WITH TYPE F BARRIER)
FIG. 5-397.627
BRIDGE NO.



1"
3"
3"
EDGE OF PLATE
3/4" DIA. x 1 1/2" FLATHEAD CAP SCREW WITH 1/2" SQUARE OR HEX SOCKET. APPLY BRIDGE BEARING LUBRICANT PER MnDOT APPROVED PRODUCTS LIST TO SCREW THREADS.
3/8" PLATE
⑦ 1/2" BIT. FELT OR EQUAL
2" LONG HEX COUPLING NUT WITH BOLT
POSITION PLATE AND BOLT ANCHORAGE IN CONCRETE TO ALLOW 3/8" PLATE TO CLOSE COMPLETELY
DETAIL "A"



DETAIL "A"
3" x 3/8" PLATE
L 2 1/2" (MIN.) x 2 1/2" x 1/4"
JOINT OPENING
SEE DETAIL "B"
SECTION A-A
3/8" PLATE (PLOW FINGER) TO BE RECESSED 1/8" BELOW TOP OF SLAB
L 2 1/2" (MIN.) x 2 1/2" x 1/4"
TRAFFIC
SEE DETAIL "B"
L 2 1/2" x 2 1/2" x 1/4"
VIEW B-B
3/8" PLATE (PLOW FINGER)
L 2 1/2" (MIN.) x 2 1/2" x 1/4"
3 1/2"
VIEW C-C
3/8" PLATE (PLOW FINGER)
L 2 1/2" x 2 1/2" x 1/4"
5"
DETAIL "B"
L 2 1/2" x 2 1/2" x 1/4"
EXPANSION DEVICE
3/8" PLATE (PLOW FINGER)
RETURN WELD LENGTH
2" MIN.
SECTION D-D
3/8" PLATE (PLOW FINGER)
TOTAL WELD SIZE TO BE 3/8"
TOP OF L 2 1/2 X 2 1/2 X 1/4
PLAN VIEW AT EXPANSION DEVICE
BARRIER FACE AND SLOPE BREAK LINE
GUTTER LINE
SEE DETAIL "A"
CROWN BREAK OR EDGE OF LANE
FIELD WELD
WHEEL TRACK
TRAFFIC
VARIES SHOULDER
5'-0" MAX. SPG.
12'-0"
☆ WELDING PROCEDURE FOR PLOW FINGERS
I. ALL WELDING SHALL BE DONE WITH 1/8" AWS Mn/DOT SPEC. 5.1 TYPE E7016 OR E7018 ELECTRODE.
II. WELD PASS 1 IN AREAS A AND B FIRST. THEN AREA C. FOLLOW WITH PASSES 2 AND 3 IN SAME ORDER AS SHOWN IN DETAIL "B".
III. REMOVE ALL WELD SLAG AND OTHER RESIDUE BETWEEN PASSES.
IV. ALLOW AT LEAST 5 MINUTES COOLING TIME BETWEEN EACH OF NINE WELD PASSES.
GENERAL NOTES
DO NOT GALVANIZE PLOW FINGERS.
① VARIES WITH SKEW AND EXPANSION OPENING.
② MINIMUM IN CLOSED POSITION.
③ EVERY SNOW PLOW FINGER SHALL HAVE FULL AND DIRECT BEARING ON THE PLATE THAT IS LOCATED UNDER THE MOVEMENT SIDE OF THE FINGER. NO CLICKING NOISE WILL BE ALLOWED.
④ MODIFY IF LANE WIDTH DIFFERS FROM 12 FT.
⑤ OMIT LAST PLOW FINGER ON DEVICE WITH CURVED END.
REVISION: 05-24-2011
APPROVED: SEPTEMBER 26, 2003
STATE BRIDGE ENGINEER
CERTIFIED BY
LICENSED PROFESSIONAL ENGINEER
DATE
NAME:
LIC. NO.
WATERPROOF EXPANSION DEVICE SNOW PLOW PROTECTION
(USE ON SKEWS OVER 15° AND LESS THAN 50°)
FIG. 5-397.628
APPROVED:
BRIDGE NO.
SHEET NO. _ OF _ SHEETS


3/8" PLATE (PLOW FINGER) TO BE RECESSED 1/8" BELOW TOP OF SLAB
3
L 2 1/2" (MIN.) × 2 1/2" × 1/4"
1
TRAFFIC
1"
SEE DETAIL "B"
L 2 1/2" × 2 1/2" × 1/4"
G
G

SECTION A-A

BASIS OF DESIGN

DESIGNED IN ACCORDANCE WITH 2010 AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, FIFTH EDITION AND Mn/DOT BRIDGE DESIGN MANUAL.

MATERIAL PROPERTIES:
- WELDED WIRE FABRIC REINFORCEMENT, MINIMUM SPECIFIED YIELD STRESS .... 65 KSI
- REBAR REINFORCEMENT, MINIMUM SPECIFIED YIELD STRESS .... 60 KSI
- CONCRETE, MINIMUM SPECIFIED COMPRESSIVE STRENGTH .... 5 OR 6 KSI (SEE TABLES)

SOIL DATA:
- UNIT WEIGHT .... 120 lb/ft³
- RATIO OF LATERAL TO VERTICAL PRESSURE FROM WEIGHT OF EARTH .... 0.50 MAX TO 0.25 MIN
- SOIL STRUCTURE INTERACTION FACTOR, F_e .... $F_e = 1 + 0.20(H/B_c)$
  - B_c = OUTSIDE WIDTH OF CULVERT
  - H = FILL HEIGHT, DEFINED AS THE DISTANCE FROM THE TOP OF THE CULVERT TO THE TOP OF THE ROADWAY OR FILL.
  - $F_{e\,max} \leq 1.15$

RESISTANCE FACTORS (FROM AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS):
- FLEXURE 1.0
- SHEAR 0.90

LOADING DATA:
- LOAD MODIFIERS:
- DUCTILE STRUCTURES .... $\eta = 1.0$
- FOR EARTH FILL: NON-REDUNDANT MEMBER .... $\eta = 1.05$
- FOR LIVE LOAD: REDUNDANT MEMBER .... $\eta = 1.0$
- LOAD FACTORS: (STRENGTH)
- DEAD LOAD .... MAX DC = 1.25, MIN DC = 0.90
- EARTH LOAD (VERTICAL) .... MAX EV = 1.30, MIN EV = 0.90
- EARTH LOAD (HORIZONTAL) .... MAX EH = 1.35, MIN EH = 0.90
- LIVE LOAD .... LL = 1.75
- APPROACHING VEHICLE LOAD .... LS = 1.75
- WATER .... WA = 1.0
- LOAD COMBINATIONS ....

STRENGTH LIMIT STATE	
MAX V/MAX H	1.25DC + 1.30EV + 1.75(LL+IM) + 1.35EHmax + 1.75LS
MAX V/MIN H	1.25DC + 1.30EV + 1.75(LL+IM) + 1.00WA + 0.9EHmin
MIN V/MAX H	0.9DC + 0.9EV + 1.35EHmin + 1.75LS

SERVICE LIMIT STATE	
MAX V/MAX H	1.0DC + 1.0EV + 1.0(LL+IM) + 1.0EHmax + 1.0LS
MAX V/MIN H	1.0DC + 1.0EV + 1.0(LL+IM) + 1.0WA + 1.0EHmin
MIN V/MAX H	1.0DC + 1.0EV + 1.0EHmin + 1.0LS

LIVE LOAD
- GREATER OF:
  - TRUCK AXLE LOAD .... 32 kips
  - TANDEM AXLE LOAD .... 2 AT 25 kips EACH
- LIVE LOAD DISTRIBUTION
  - IF DEPTH OF FILL, H< 2 FT.
    - DIRECTION PERPENDICULAR TO SPAN .... E = 96 (in.) + 1.44SPAN (ft.)
    - DIRECTION PARALLEL TO SPAN .... Espan = 10 (in.) + 1.15H (in.)
  - IF DEPTH OF FILL, H≥ 2 FT.
    - DIRECTION PERPENDICULAR TO SPAN .... W = 20 (in) + 1.15H (in.)
    - DIRECTION PARALLEL TO SPAN .... L = 10 (in) + 1.15H (in.)
- CONSTRUCTION COMPACTOR LOAD .... 55 kips DISTRIBUTED OVER 84 in. X 24 in.
- MULTIPLE PRESENCE FACTOR .... MPF = 1.2 (FOR ONE LANE)
- DYNAMIC LOAD ALLOWANCE (VARIABLE WITH DEPTH) .... IM = 0.33(1-0.125H), H ≤ 8, IF H>8 IM = 0
- LANE LOAD (APPLIED TO BOXES WITH SPANS OF 15 ft. OR GREATER) .... 640 plf DISTRIBUTED PER AASHTO 3.6.1.2.4
- APPROACHING VEHICLE LOAD (PARALLEL TO SPAN) (TRAPEZOIDAL PRESSURE) (2) .... LS = K • Ys • heq
  - K = 0.33 (2)
  - Ys = 120 lb/ft³
  - heq =

EQUIVALENT FILL HEIGHT	
ABUTMENT HEIGHT (FT.) (1)	heq (ft.)
< 5.0	4.0
5.0 TO 10.0	5- 0.2•(ABUTMENT HEIGHT)
10.0 TO 20.0	4- 0.1•(ABUTMENT HEIGHT)
> 20.0	2.0

(1) THE ABUTMENT HEIGHT CORRESPONDING TO THE LATERAL PRESSURE AT THE TOP OF THE CULVERT IS THE DISTANCE FROM THE TOP OF THE TOP SLAB TO THE TOP OF THE PAVEMENT OR FILL.

THE ABUTMENT HEIGHT CORRESPONDING TO THE LATERAL PRESSURE AT THE BOTTOM OF THE CULVERT IS THE DISTANCE FROM THE BOTTOM OF THE BOTTOM SLAB TO THE TOP OF THE PAVEMENT OR FILL.

(2) TRAPEZOIDAL LATERAL LIVE LOAD PRESSURE METHODOLOGY WAS USED TO APPROXIMATE A BOUSSINESQ DISTRIBUTION.

WATER
- DEPTH OF WATER IN BOX SECTION .... EQUAL TO INSIDE HEIGHT

STRUCTURAL ARRANGEMENT:

REINFORCEMENT AREAS SHOWN ON FIGURES 5-395.100(B)-(E) ARE IN SQUARE INCHES PER LINEAL FOOT OF BARREL. ALL REINFORCEMENT LENGTHS AND AREAS ARE MINIMUM REQUIREMENTS. REINFORCEMENT REQUIREMENTS AND AREAS ARE FOR WELDED WIRE FABRIC. IF BAR REINFORCEMENT IS SUBSTITUTED FOR WELDED WIRE FABRIC, THE AREAS OF REINFORCEMENT SHALL BE INCREASED BY 8%.

TRANSVERSE REINFORCEMENT IS PARALLEL TO THE CULVERT SPAN.

LONGITUDINAL REINFORCEMENT IS PERPENDICOLAR TO THE CULVERT SPAN.

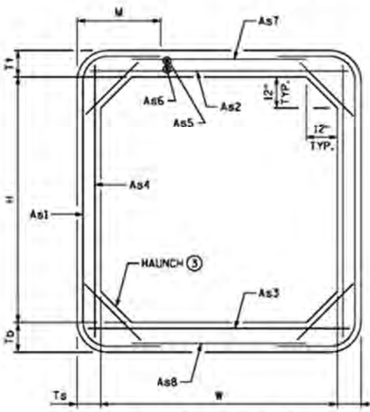
- REINFORCEMENT SPACING .... 4.0 in. MAX. THE SPACING CENTER TO CENTER OF THE TRANSVERSE WIRES SHALL NOT BE LESS THAN 2 in. NOR MORE THAN 4 in. THE SPACING CENTER TO CENTER OF THE LONGITUDINAL WIRES SHALL NOT BE MORE THAN 8 in.
- CONCRETE COVER OVER REINFORCEMENT (ALL FACES) .... 1½ in. MIN., 2 in. MAX.
- (3) HAUNCH DIMENSIONS .... 12 in. VERTICAL, 12 in. HORIZONTAL (ALL SPANS AND RISES)
  - CULVERTS CONSTRUCTED WITHOUT HAUNCHES REQUIRE SPECIAL DESIGN NOT INCLUDED IN THESE STANDARDS.
- MINIMUM REINFORCING PARALLEL TO SPAN, INCLUDING As1, As2, As3, As4, As7, As8 .... 0.002 • b • h, (b = THICKNESS OF SLAB, h = 12 in.)
- PERPENDICULAR TO SPAN, INCLUDING As5, As6 .... 0.06 in²/ft

SKEW .... BOX CULVERT SECTIONS WERE DESIGNED ASSUMING TRAFFIC TRAVELING PARALLEL TO THE SPAN AND UP TO A SKEW ANGLE OF 45°. IF CULVERT SECTIONS ARE PLACED IN A DIFFERENT ARRANGEMENT, THEY MAY NEED TO BE REDESIGNED. BOX CULVERT END SECTIONS WERE DESIGNED FOR SKEW EFFECTS AND ARE LOCATED ON FIG. 5-395.102 THROUGH 5-395.110(B).

AXIAL THRUST .... THE BENEFIT OF AXIAL THRUST WAS NOT INCLUDED IN THE BOX CULVERT DESIGN FOR THE STRENGTH LIMIT STATE, HOWEVER WAS INCLUDED IN THE SERVICE LIMIT STATE CRACK CONTROL CHECK.

SHEAR .... SHEAR CHECKED AT 1.0 dv FROM TIP OF HAUNCH PER AASHTO 5.13.3.6.1. FOR SLABS OF BOXES WITH LESS THAN 2.0 ft. OF FILL AND FOR WALLS OF BOXES OF ALL FILL HEIGHTS SHEAR RESISTANCE CALCULATED PER AASHTO 5.8, SECTIONAL METHOD GENERAL PROCEDURE. FOR SLABS OF BOXES WITH 2 FT. OF FILL OR GREATER THE SHEAR RESISTANCE WAS CALCULATED PER AASHTO 5.14.5.3. UP TO A MAXIMUM THICKNESS OF 12 INCHES. FOR SUCH SLABS WITH THICKNESSES EXCEEDING 12 IN., CONTACT THE BRIDGE STANDARDS UNIT FOR SHEAR PROVISIONS.

CRACK CONTROL .... CRACK CONTROL CHECK PER AASHTO 5.7.3.4 ASSUMING CLASS 2 EXPOSURE CONDITIONS. THE STRESS IN THE STEEL REINFORCEMENT CALCULATED PER AASHTO C12.11.3 AND LIMITED TO 0.6•fy. INCLUDE AXIAL THRUST IN SERVICE LIMIT STATE ANALYSIS.



BOX CULVERT CROSS SECTION

REVISION: 06-06-2011

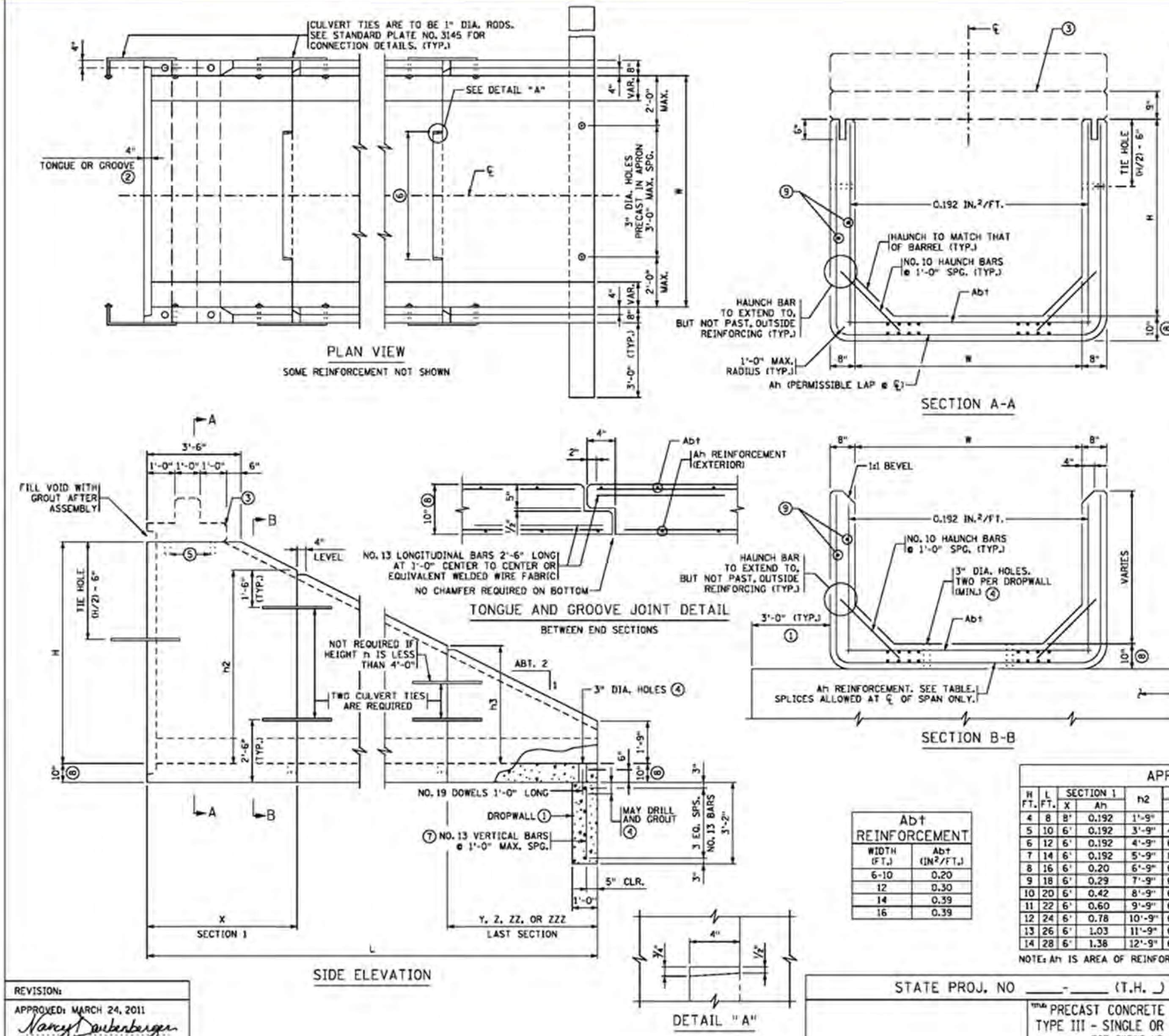
APPROVED: MARCH 24, 2011

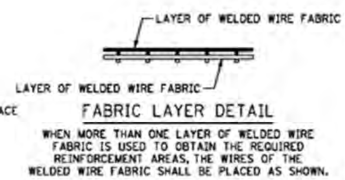
Nancy Daubenberger
STATE BRIDGE ENGINEER

DO NOT INCLUDE WITH PLAN

FIG. 5-395.100(A)

PRECAST CONCRETE BOX CULVERT-BASIS OF DESIGN





CONSTRUCTION NOTES

SEE FIG. 5-395.101(A) AND FIG. 5-395.101(B) FOR ADDITIONAL DIMENSIONS AND CONSTRUCTION NOTES.

ON ALL END SECTIONS FOR WATERWAYS, USE DROPWALLS ON INLET AND OUTLET ENDS.

SEE FIG. 5-395.115 FOR EMBANKMENT PROTECTION.

FINISH ALL EXPOSED EDGES OF CONCRETE WITH ½" OR ¾" CHAMFER OR RADIUS UNLESS OTHERWISE NOTED.

① WITH DOUBLE BOXES LOCATE DROPWALL JOINTS BETWEEN END SECTIONS. SEE FIG. 5-395.111 FOR ALTERNATE DROPWALLS. LIMITS OF EXCAVATION FOR DROPWALL TO BE APPROXIMATELY THE SAME AS DROPWALL DIMENSIONS. DROPWALL TO BE CONCRETE MIX NO. 1A43 OR 3Y43. FURNISHING AND INSTALLATION OF DROPWALL TO BE INCLUDED IN PRICE BID FOR END SECTIONS. DROPWALL NOT REQUIRED FOR NON-WATERWAY USE.

② CHECK LOCATION TO DETERMINE WHETHER A TONGUE OR A GROOVE IS USED.

③ SEE FIG. 5-395.104(B) FOR LINTEL BEAM DETAILS.

④ FILL HOLE WITH GROUT. GROUT SHALL CONSIST OF 1 PART CEMENT AND 2 PARTS SAND. USE TYPE 1A AIR ENTRAINED PORTLAND CEMENT. GROUT MIX SHALL HAVE A MAXIMUM SLUMP OF 4".

⑤ 2" DIAMETER HOLE, 6" DEEP IN TOP OF THE SECTION WALL.

⑥ 3'-6" TONGUE AND 3'-7" GROOVE FOR 6'-0" WIDE CULVERTS. 5'-0" TONGUE AND 5'-1" GROOVE FOR CULVERTS OVER 6'-0" WIDE. CENTER TONGUE AND GROOVE ON ℄ OF EACH APRON JOINT.

⑦ AS AN ALTERNATE TO THE ONE LAYER WELDED WIRE FABRIC, PROVIDE TWO LAYERS OF REBAR OR WELDED WIRE FABRIC WITH THE STEEL AREA EQUAL TO HALF OF THE TEMPERATURE STEEL PER CODE REQUIREMENTS IN EACH FACE OF THE DROPWALL.

⑧ APRON BOTTOM SLAB THICKNESS MAY BE 8" FOR CULVERTS WITH 6' SPANS ONLY. THE SLAB MAY BE THICKENED AT CONTRACTOR/FABRICATOR REQUEST.

⑨ LONGITUDINAL REINFORCEMENT PERPENDICULAR TO THE CULVERT SPAN SHALL HAVE A MINIMUM OF 0.06 SQUARE INCHES PER PERIPHERAL FOOT ON ALL FACES OF THE BARREL.

Abt REINFORCEMENT

WIDTH (FT.)	Abt (IN²/FT.)
6-10	0.20
12	0.30
14	0.39
16	0.39

APRON DIMENSIONS & Ah REINFORCEMENT

H FT.	L FT.	SECTION 1 X	SECTION 1 Ah	h2	SECTION 2 Y	SECTION 2 Ah	h3	SECTION 3 Z	SECTION 3 Ah	h4	SECTION 4 ZZ	SECTION 4 Ah	h5	SECTION 5 ZZZ	SECTION 5 Ah	h6
4	8	8'	0.192	1'-9"												
5	10	6'	0.192	3'-9"	4'	0.192	1'-9"									
6	12	6'	0.192	4'-9"	6'	0.192	1'-9"									
7	14	6'	0.192	5'-9"	8'	0.192	1'-9"									
8	16	6'	0.20	6'-9"	6'	0.192	3'-9"	4'	0.192	1'-9"						
9	18	6'	0.29	7'-9"	6'	0.20	4'-9"	6'	0.192	1'-9"						
10	20	6'	0.42	8'-9"	6'	0.29	5'-9"	8'	0.192	1'-9"						
11	22	6'	0.60	9'-9"	6'	0.42	6'-9"	6'	0.192	3'-9"	4'	0.192	1'-9"			
12	24	6'	0.78	10'-9"	6'	0.60	7'-9"	6'	0.20	4'-9"	6'	0.192	1'-9"			
13	26	6'	1.03	11'-9"	6'	0.78	8'-9"	6'	0.28	5'-9"	8'	0.192	1'-9"			
14	28	6'	1.38	12'-9"	6'	1.03	9'-9"	6'	0.40	6'-9"	6'	0.192	3'-9"	4'	0.192	1'-9"

NOTE: Ah IS AREA OF REINFORCEMENT PER FOOT OF LENGTH (IN²/FT.)

REVISION:

APPROVED: MARCH 24, 2011
Nancy Daubenberger
STATE BRIDGE ENGINEER

STATE PROJ. NO ____-____ (T.H. _) STA. __+__._

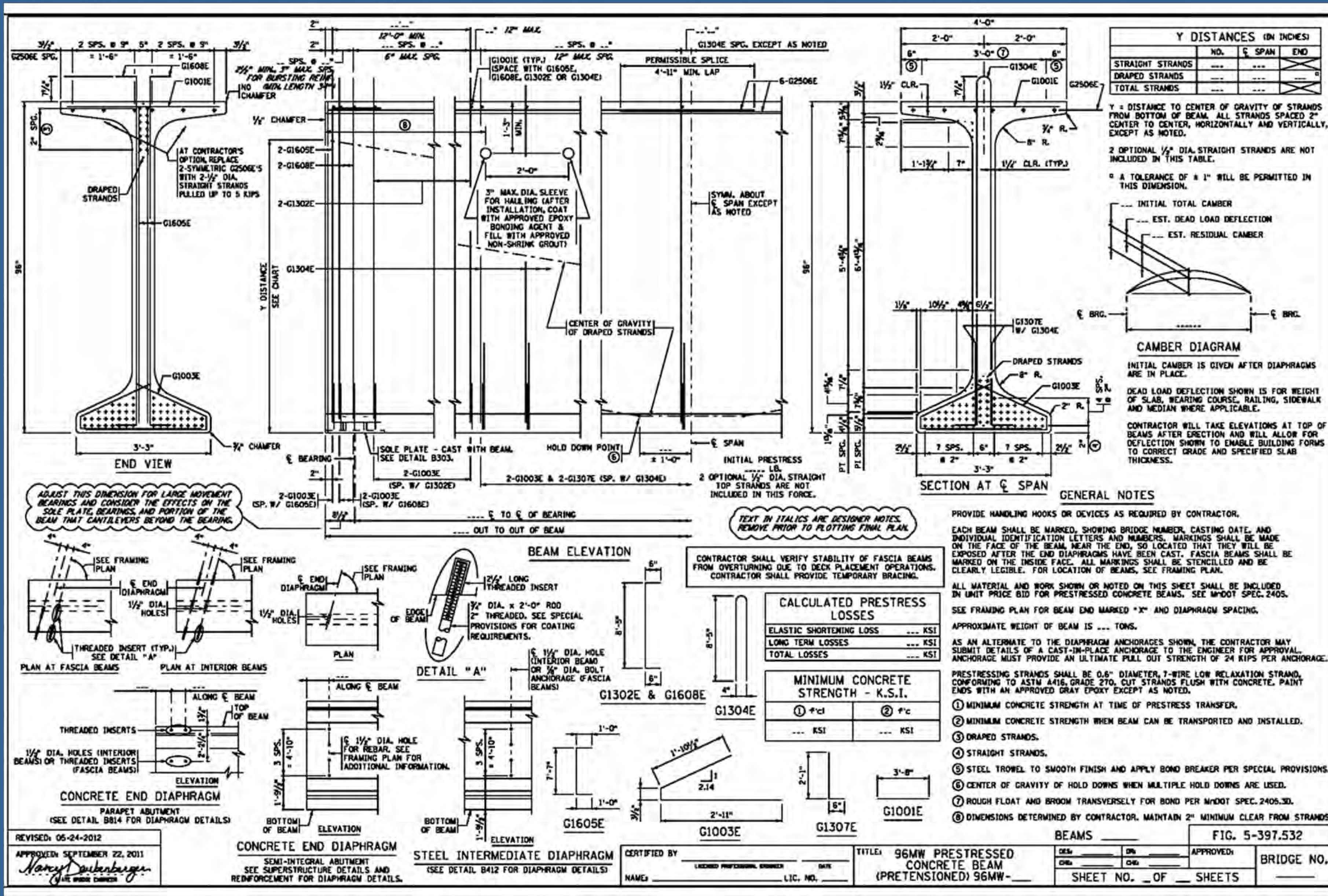
FIG. 5-395.104(A)

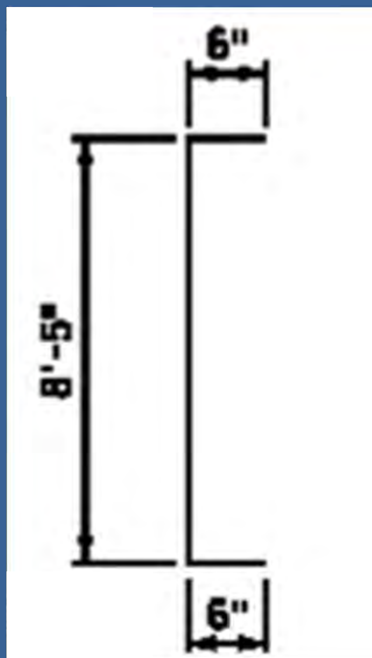
TITLE: PRECAST CONCRETE END SECTION
TYPE III - SINGLE OR DOUBLE BARREL
FOR SKEWS UP TO 7½°

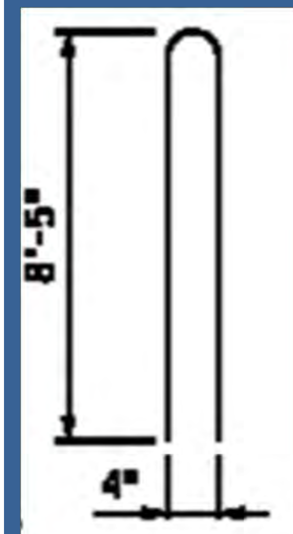
DES: ____ DR: ____
CHK: ____ CHK: ____
APPROVED:

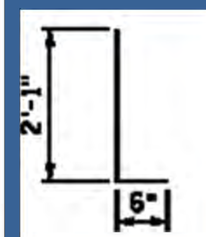
SHEET NO. _ OF __ SHEETS

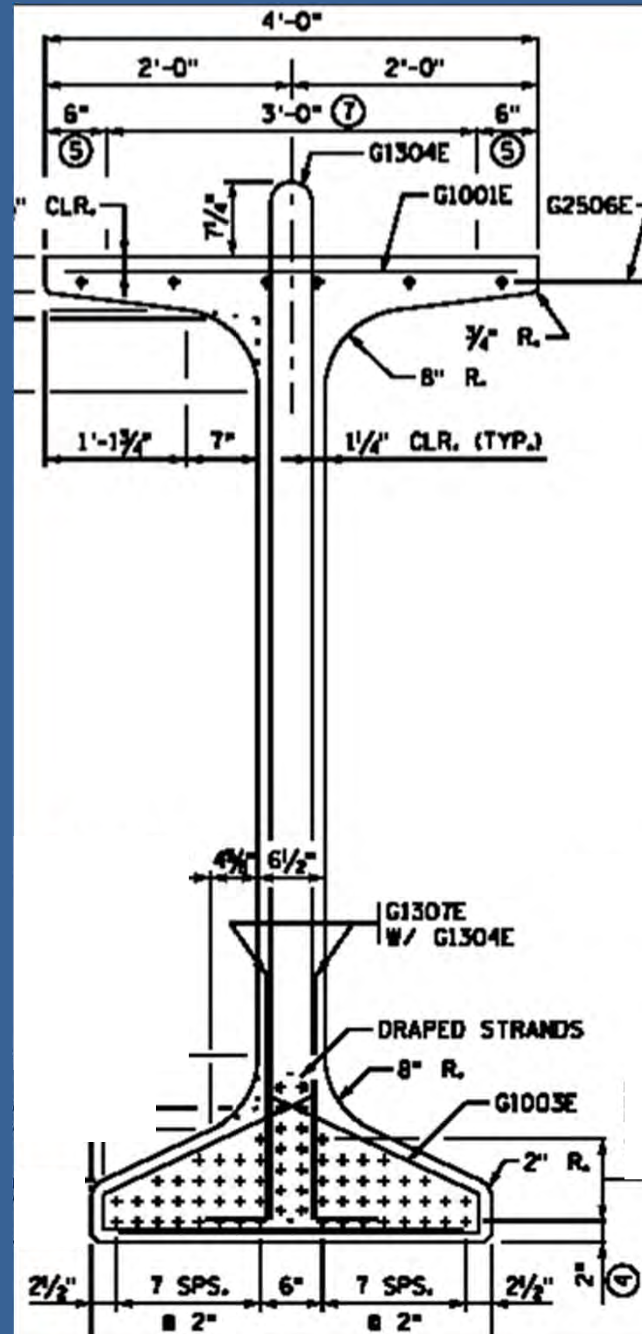
BRIDGE NO. ____

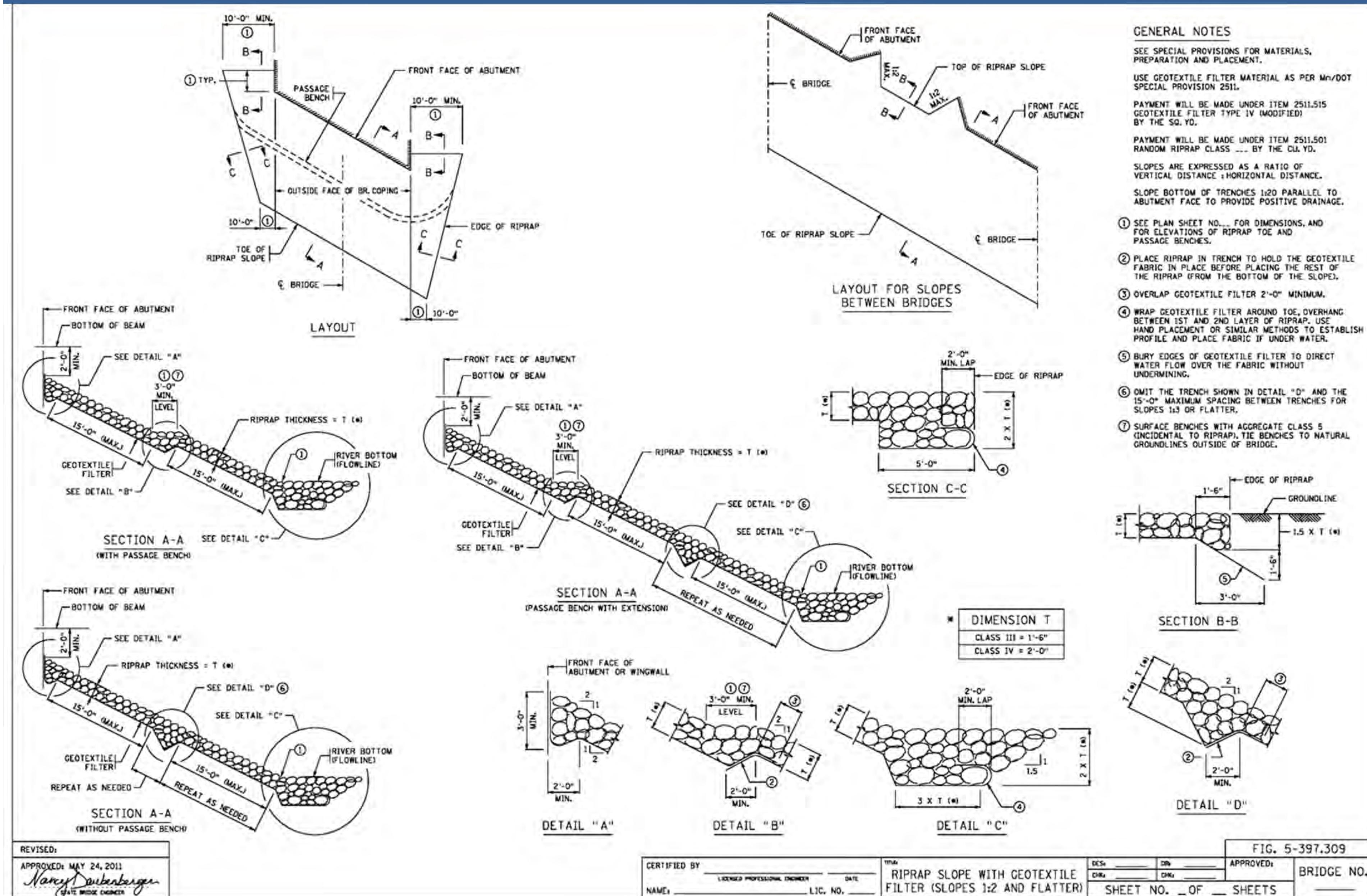


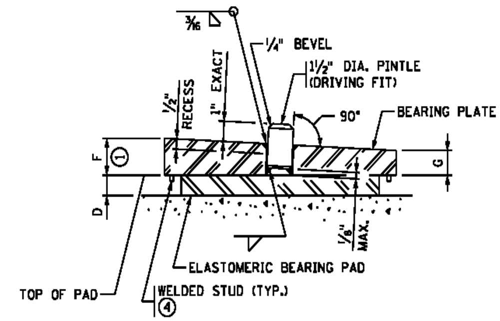

6"
8'-5"
6"


8'-5"
4"

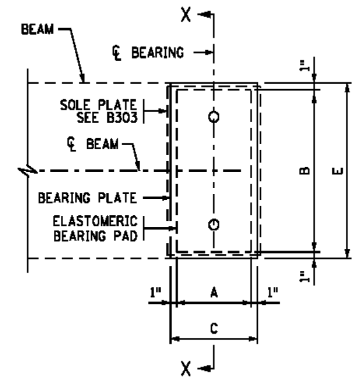

2'-1"
6"


4'-0"
2'-0"
2'-0"
6"
3'-0" 7
6"
5
G1304E
5
CLR.
G1001E
G2506E
¾" R.
8" R.
1'-1¾"
7"
1¼" CLR. (TYP.)
6½"
G1307E
W/ G1304E
DRAPED STRANDS
8" R.
G1003E
2" R.
2½"
7 SPS.
@ 2"
6"
7 SPS.
@ 2"
2½"
4

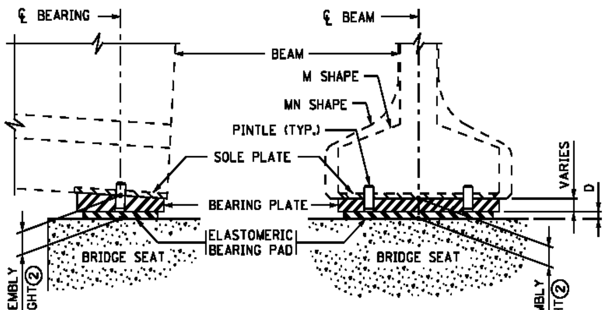

LAYOUT
10'-0" MIN.
FRONT FACE OF ABUTMENT
PASSAGE BENCH
OUTSIDE FACE OF BR. COPING
EDGE OF RIPRAP
TOE OF RIPRAP SLOPE
℄ BRIDGE
LAYOUT FOR SLOPES BETWEEN BRIDGES
TOP OF RIPRAP SLOPE
1:2 MAX.
GENERAL NOTES
SEE SPECIAL PROVISIONS FOR MATERIALS, PREPARATION AND PLACEMENT.
USE GEOTEXTILE FILTER MATERIAL AS PER Mn/DOT SPECIAL PROVISION 2511.
PAYMENT WILL BE MADE UNDER ITEM 2511.515 GEOTEXTILE FILTER TYPE IV (MODIFIED) BY THE SQ. YD.
PAYMENT WILL BE MADE UNDER ITEM 2511.501 RANDOM RIPRAP CLASS ___ BY THE CU. YD.
SLOPES ARE EXPRESSED AS A RATIO OF VERTICAL DISTANCE : HORIZONTAL DISTANCE.
SLOPE BOTTOM OF TRENCHES 1:20 PARALLEL TO ABUTMENT FACE TO PROVIDE POSITIVE DRAINAGE.
① SEE PLAN SHEET NO.__ FOR DIMENSIONS, AND FOR ELEVATIONS OF RIPRAP TOE AND PASSAGE BENCHES.
② PLACE RIPRAP IN TRENCH TO HOLD THE GEOTEXTILE FABRIC IN PLACE BEFORE PLACING THE REST OF THE RIPRAP (FROM THE BOTTOM OF THE SLOPE).
③ OVERLAP GEOTEXTILE FILTER 2'-0" MINIMUM.
④ WRAP GEOTEXTILE FILTER AROUND TOE, OVERHANG BETWEEN 1ST AND 2ND LAYER OF RIPRAP. USE HAND PLACEMENT OR SIMILAR METHODS TO ESTABLISH PROFILE AND PLACE FABRIC IF UNDER WATER.
⑤ BURY EDGES OF GEOTEXTILE FILTER TO DIRECT WATER FLOW OVER THE FABRIC WITHOUT UNDERMINING.
⑥ OMIT THE TRENCH SHOWN IN DETAIL "D" AND THE 15'-0" MAXIMUM SPACING BETWEEN TRENCHES FOR SLOPES 1:3 OR FLATTER.
⑦ SURFACE BENCHES WITH AGGREGATE CLASS 5 (INCIDENTAL TO RIPRAP). TIE BENCHES TO NATURAL GROUNDLINES OUTSIDE OF BRIDGE.
FRONT FACE OF ABUTMENT
BOTTOM OF BEAM
SEE DETAIL "A"
3'-0" MIN. LEVEL
RIPRAP THICKNESS = T (*)
15'-0" (MAX.)
GEOTEXTILE FILTER
SEE DETAIL "B"
SEE DETAIL "C"
RIVER BOTTOM (FLOWLINE)
SECTION A-A
(WITH PASSAGE BENCH)
SEE DETAIL "D" ⑥
REPEAT AS NEEDED
SECTION A-A
(PASSAGE BENCH WITH EXTENSION)
SECTION A-A
(WITHOUT PASSAGE BENCH)
2'-0" MIN. LAP
SECTION C-C
SECTION B-B
GROUNDLINE
1.5 X T (*)
* DIMENSION T
CLASS III = 1'-6"
CLASS IV = 2'-0"
FRONT FACE OF ABUTMENT OR WINGWALL
DETAIL "A"
DETAIL "B"
DETAIL "C"
DETAIL "D"
3 X T (*)
2 X T (*)
REVISED:
APPROVED: MAY 24, 2011
STATE BRIDGE ENGINEER
CERTIFIED BY
LICENSED PROFESSIONAL ENGINEER
DATE
NAME:
LIC. NO.
RIPRAP SLOPE WITH GEOTEXTILE FILTER (SLOPES 1:2 AND FLATTER)
SHEET NO. _ OF __ SHEETS
FIG. 5-397.309
APPROVED:
BRIDGE NO.



BEARING PLATE DETAIL



PLAN



SIDE ELEVATION

SECTION X-X

DESIGNER NOTE
(REMOVE DESIGNER NOTE PRIOR TO PLOTTING FINAL PLAN):
USE TAPERED PLATE FOR GRADES EXCEEDING 3%. MAINTAIN SAME TAPERED PLATE THICKNESS FOR SLOPES IN EACH OF THE FOLLOWING RANGES: 3-5%, 5-7%, 7-9%, >9%.
MINIMUM THICKNESS OF TAPERED PLATE IS 1/2".
ROUND ASSEMBLY HEIGHT TO NEAREST 1/8".
MODIFY FRAMING PLAN PER NOTE ①.
USE 1/2" UNREINFORCED PAD WITH CONTINUITY DIAPHRAGMS OR INTEGRAL ABUTMENTS.

TABLE

ASSEMBLY TYPE	LOCATION	BEAM SIZE	BEARING PAD SIZE			SHAPE FACTOR	BEARING PLATE SIZE				ASSEMBLY HEIGHT
			A	B	D③		C	E	F	G	HT.②
___	___	___	12	24	1/2	8.0	14"	26"	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___
___	___	___	___	___	___	___	___	___	___	___	___

NOTES:

ELASTOMERIC MATERIALS AND PAD CONSTRUCTION SHALL COMPLY WITH SPEC. 3741.

ALL STEEL PLATES SHALL COMPLY WITH SPEC. 3306.

PINTLES SHALL COMPLY WITH SPEC. 3309.

GALVANIZE STRUCTURAL STEEL BEARING ASSEMBLY AFTER FABRICATION PER SPEC. 3394. AREAS WELDED SHALL BE REPAIRED PER SPEC. 2471.3L.

PAYMENT FOR "TAPERED BEARING PLATE ASSEMBLY" IS PER EACH, AND SHALL INCLUDE ALL MATERIAL ON THIS DETAIL.

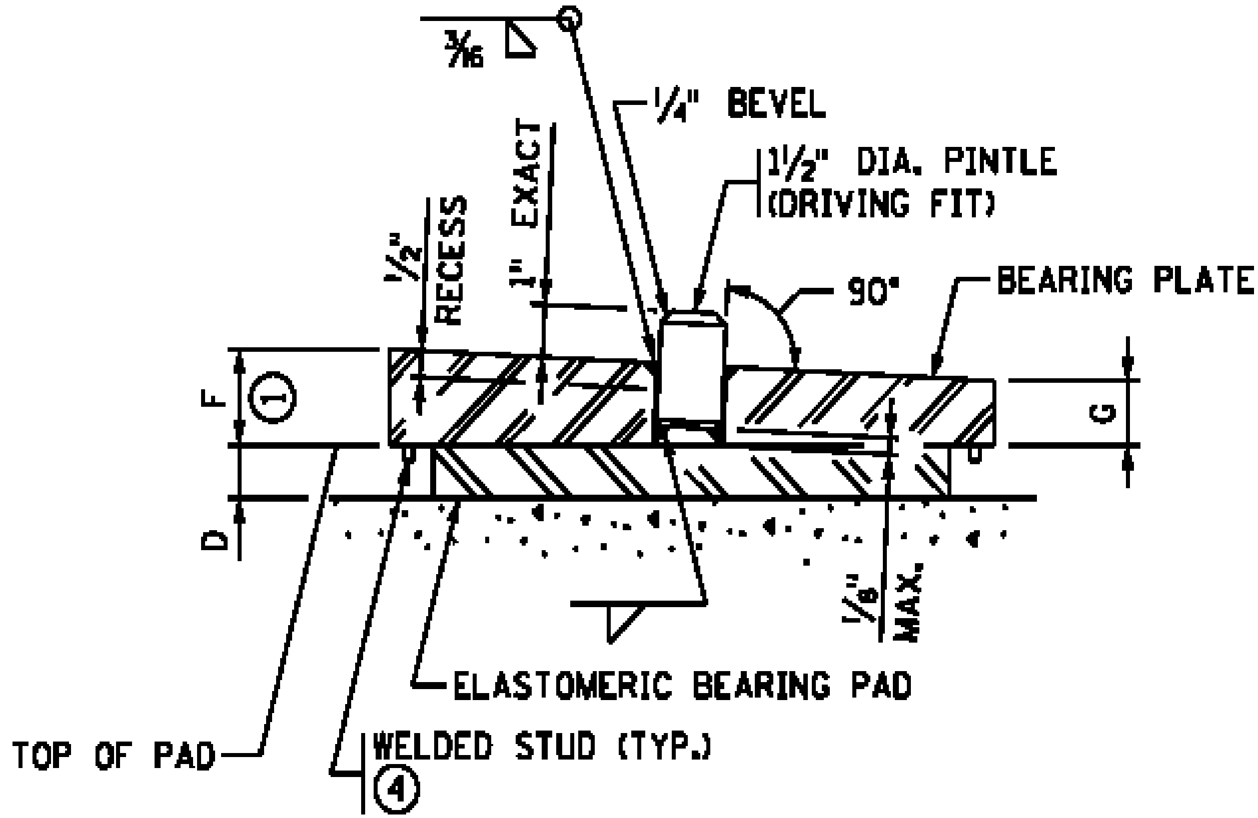
① MARK THICKER SIDE OF SLOPED PLATES WITH AN "H" FOR PLACEMENT. SEE FRAMING PLAN SHEET NO. __.

② BEARING PAD AND BEARING PLATE THICKNESS AT ℄ BEARING.

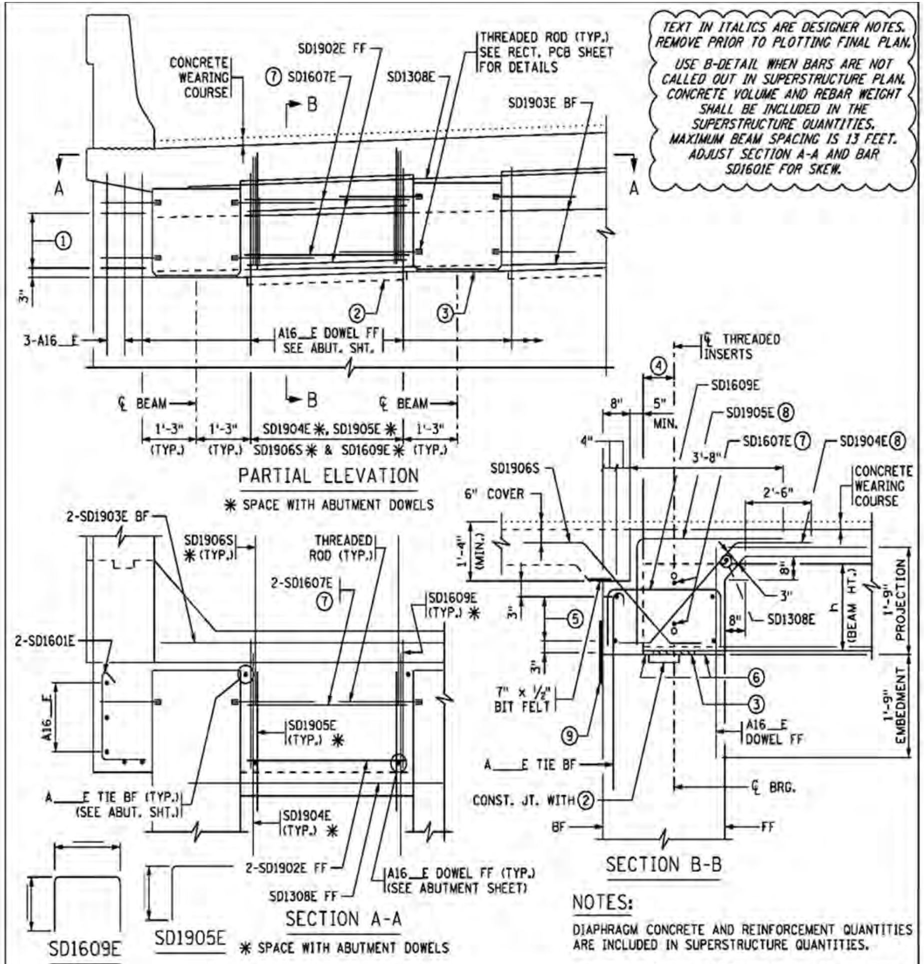
③ "D" INDICATES THE THICKNESS OF THE BEARING PAD.

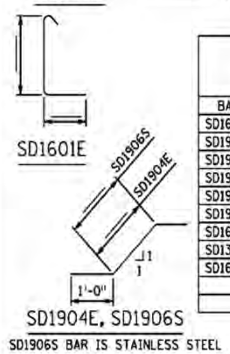
④ 5/16" DIA. x 3/8" KNOCK-OFF WELD STUDS INSTALLED ON BEARING PLATE AROUND PERIMETER OF BEARING PAD. CENTERLINE STUD TO EDGE OF PAD DIMENSION = 1/2". MAX. STUD SPACING = 4", AND MAX. SPACING TO PAD CORNER = 2".

APPROVED: XXXXXXX XX, XXXX NOT APPROVED STATE BRIDGE ENGINEER	REFERENCE DATE: 5-09-2012 STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION TAPERED BEARING PLATE ASSEMBLY (FOR INTEGRAL ABUTMENTS OR PIERS WITH CONTINUITY DIAPHRAGMS)	REVISION	DETAIL NO. B309



BEARING PLATE DETAIL





BILL OF REINFORCEMENT FOR END DIAPHRAGM				
BAR	NO.	LENGTH	SHAPE	LOCATION
SD1601E	___	__'-__"		HORIZONTAL END TIE
SD1902E	___	__'-__"		HORIZONTAL FF
SD1903E	___	__'-__"		HORIZONTAL BF
SD1904E	___	__'-__"		DIAPH./FILLET TIE
SD1905E	___	__'-__"		DIAPH./DECK TIE
SD1906S	___	__'-__"		DIAPH./APPROACH TIE
SD1607E	___	__'-__"		HORIZONTAL
SD1308E	___	__'-__"		FILLET HORIZONTAL
SD1609E	___	__'-__"		DIAPHRAGM TIE

NOTES:

DIAPHRAGM CONCRETE AND REINFORCEMENT QUANTITIES ARE INCLUDED IN SUPERSTRUCTURE QUANTITIES.

CONCRETE FOR END DIAPHRAGMS SHALL BE THE SAME MIX AS USED IN DECK.

BF DENOTES BACK FACE. FF DENOTES FRONT FACE.

① SD1601E END TIE

② 2" × 12" KEYWAY (BETWEEN BEAMS ONLY)

③ 12" × 24" × ½" ELASTOMERIC BEARING PAD

④ SEE BEAM DETAIL SHEETS FOR DIMENSION.

⑤ SD1903E BF & SD1902E FF HORIZONTAL

⑥ ½" MIN. TYPE B POLYSTYRENE UNDER COMPLETE FLANGE

⑦ SPACE WITH THREADED RODS.

⑧ TIE BAR TO TOP MAT.

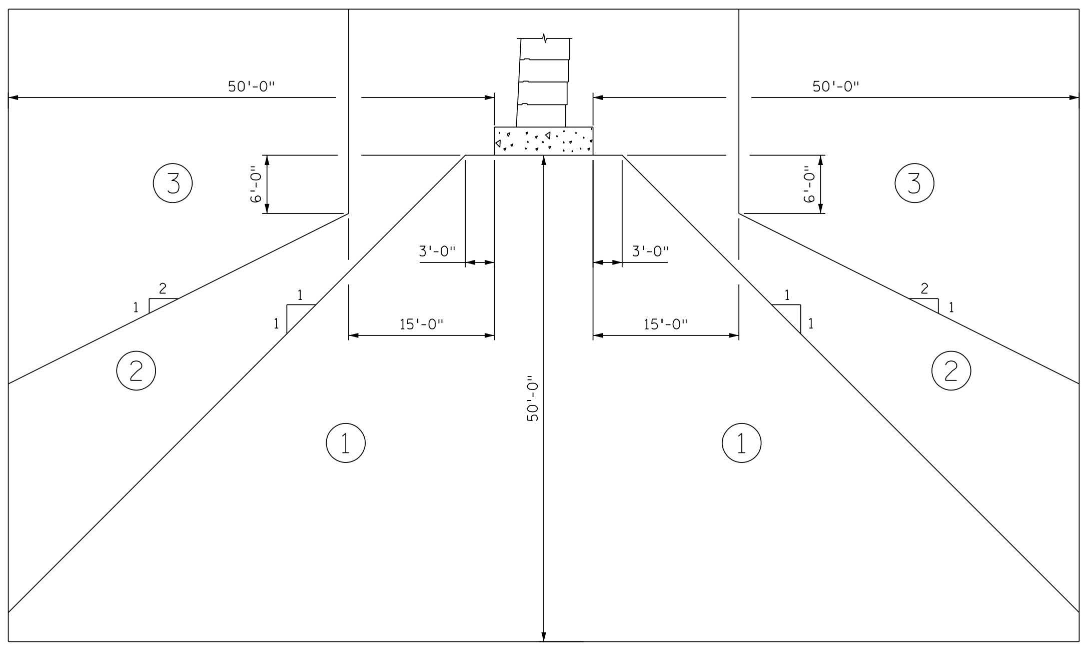
⑨ MEMBRANE WATERPROOFING SYSTEM PER SPEC. 2481.3B

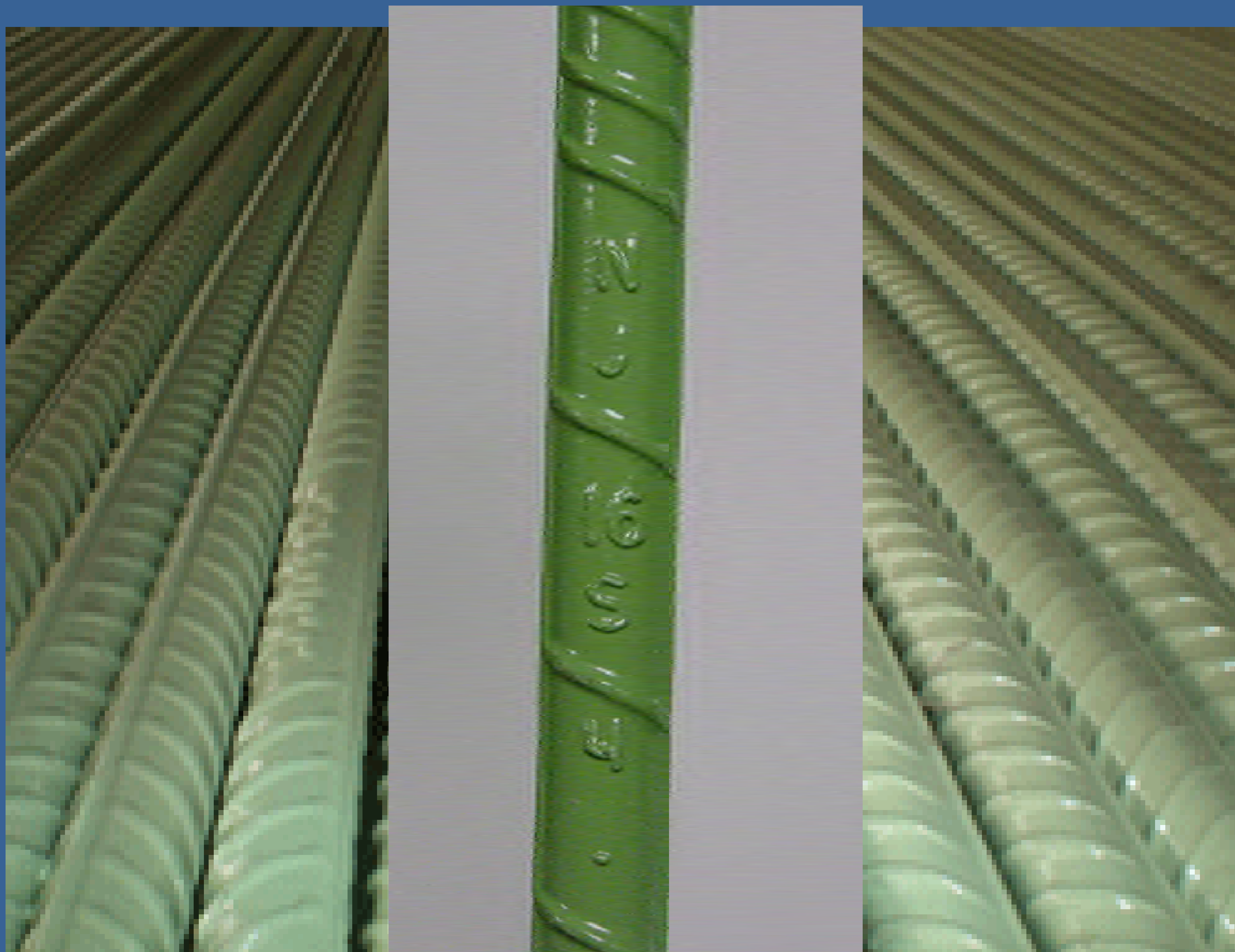
APPROVED: May 24, 2012	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION	REVISED	DETAIL NO.
Nancy Daubenberger STATE BRIDGE ENGINEER	CONCRETE END DIAPHRAGM (14", 18" AND 22" RECTANGULAR PRESTRESSED CONCRETE BEAMS) (INTEGRAL ABUTMENT)		B816

Miscellaneous Issues

- High Performance Concrete Deck Mixes
- Inverted T's
- CIP Retaining Wall Standards
- MSE Walls – Special Provisions & Standards
- Noise Walls – Concrete
- Utility Policy

Utility Policy





CRSI. Concrete Reinforcing Steel Institute

Inches or Millimeters?

NOTE: *CRSI Board of Directors, through the Engineering Practice Committee, is encouraging producer Members to revert to an inch-pound bar marking system for all sizes and grades of deformed reinforcing steel products. The intention of this resolution is to reduce confusion and the chance of errors/delays from the construction supply chain. Click here to view the full resolution.* ***JANUARY 1st, 2014***

ASTM STANDARD INCH-POUND REINFORCING BARS

BAR SIZE DESIGNATION	NOMINAL DIMENSIONS		
	AREA (in^2)	WEIGHT (lb/ft)	DIAMETER (in.)
#3	0.11	0.376	0.375
#4	0.20	0.668	0.500
#5	0.31	1.043	0.625
#6	0.44	1.502	0.750
#7	0.60	2.044	0.875
#8	0.79	2.670	1.000
#9	1.00	3.400	1.128
#10	1.27	4.303	1.270
#11	1.56	5.313	1.410
#14	2.25	7.65	1.693
#18	4.00	13.60	2.257

The current A615 specification covers bar sizes #14 and #18 in Grade 60, and bar sizes #11, #14 and #18 in Grade 75. The current A706 specification also covers bar sizes #14 and #18. Bar sizes #9 through #18 are not included in the A996 specification.

ASTM STANDARD METRIC REINFORCING BARS

BAR SIZE DESIGNATION	NOMINAL DIMENSIONS		
	AREA (mm^2)	WEIGHT (kg/m)	DIAMETER (mm)
#10	71	0.560	9.5
#13	129	0.994	12.7
#16	199	1.552	15.9
#19	284	2.235	19.1
#22	387	3.042	22.2
#25	510	3.973	25.4
#29	645	5.060	28.7
#32	819	6.404	32.3
#36	1006	7.907	35.8
#43	1452	11.38	43.0
#57	2581	20.24	57.3

The current A615M specification covers bar sizes #43 and #57 in Grade 420, and bar sizes #36, #43, and #57 in Grade 520. The current A706 specification also covers bar sizes #43 and #57. Bar sizes #29 through #57 are not included in the A996M specification.

MINNESOTA DEPARTMENT OF TRANSPORTATION

Bridge Standards Update

Paul Rowekamp
Bridge Standards Engineer

Bridge Load Ratings

Yihong Gao
MnDOT Bridge Rating Engineer

Outline

1. Introduction
2. Loads and Load Factors
3. Process of Load and Resistance Factor Rating (LRFR)
4. Limit States & Reliability
5. Special Type Superstructures
6. Load Posting
7. Assigned Bridge Ratings & Physical Inspection Rating (PIR)
8. MnDOT Rating Forms

Introduction

- Purposes of Load Rating
  - Ensure Bridge Safety
  - Comply with Federal Regulations
  - Rehabilitation or Replacement Needs
  - Processing of Overload Permits
  - Posting Needs

MINNESOTA DEPARTMENT OF TRANSPORTATION

Introduction

- When Should a Load Rating be Performed?
  - New Bridges
  - Change in the Live Loads
  - Change in the Dead Loads
  - Change in the Physical Condition
  - Change in the Specifications, Laws, or Software

Introduction

Introduction

- References
  - The Manual for Bridge Evaluation (MBE), 2^{nd} Edition, AASHTO
  - MnDOT LRFD Bridge Design Manual, Chapter 15
  - MnDOT Inspection Manual, Appendix B
  - AASHTO LRFD Bridge Design Specifications, 5^{th} Edition

Introduction

- Definition of Load Rating
  - Live Load Capacity of a Bridge
    - Using as-built bridge plans including all modification/rehabilitation plans
    - Using latest field inspection report (NBIS)
  - Expressed as a Rating Factor (RF) – LRFR
    - For example: RF = 1.3
  - Expressed in a Tonnage for a Particular Vehicle – LFR/ASR
    - For example: HS 26

Introduction

- Rating Levels
  - Inventory Rating
    - ➢ Safe for state legal loads within federal weight laws (Formula B) and LRFD exclusion limits
    - ➢ Comparable to new design
  - Operating Rating
    - ➢ Safe for state legal loads within federal weight laws
    - ➢ Safe for permit crossing

Introduction

- Rating Methods
  - Load and Resistance Factor Rating (LRFR)
    - Uniform reliability
    - Probabilistic methods to derive load and resistance factors
  - Load Factor Rating
    - Strength Based
    - No guidance on adjusting Load & Resistance factors
  - Allowable Stress Rating

Introduction

- MnDOT Status
  - Load and Resistance Factor Rating (LRFR) is used for
    - ➢ New bridges (mainly after 2010)
    - ➢ Major rehab bridges designed by HL-93
    - ➢ Major complex bridges
    - ➢ Some existing curved steel girder bridges
  - Load Factor Rating is used for
    - ➢ Existing bridges
    - ➢ Minor rehab/repair bridges
    - ➢ Posting and permitting requests
  - Allowable Stress Rating is used for
    - Timber bridges
    - Any bridges can not be rated by other methods

Loads and Load Factors

- Loads for Ratings
  - Design Load – HL-93 (LRFR) or HS 20 (LFR/ASR)
    - ➢Notional load for screening
    - ➢Inventory rating level and Operating rating level
    - ➢Bridge plan data block
  - MN Legal Trucks and AASHTO Special Hauling Vehicles (SHVs)
    - ➢Operating rating level only
    - ➢Bridge posting determination
  - MN Standard Permit Trucks
    - ➢Operating rating level only
    - ➢Overweight permit determination

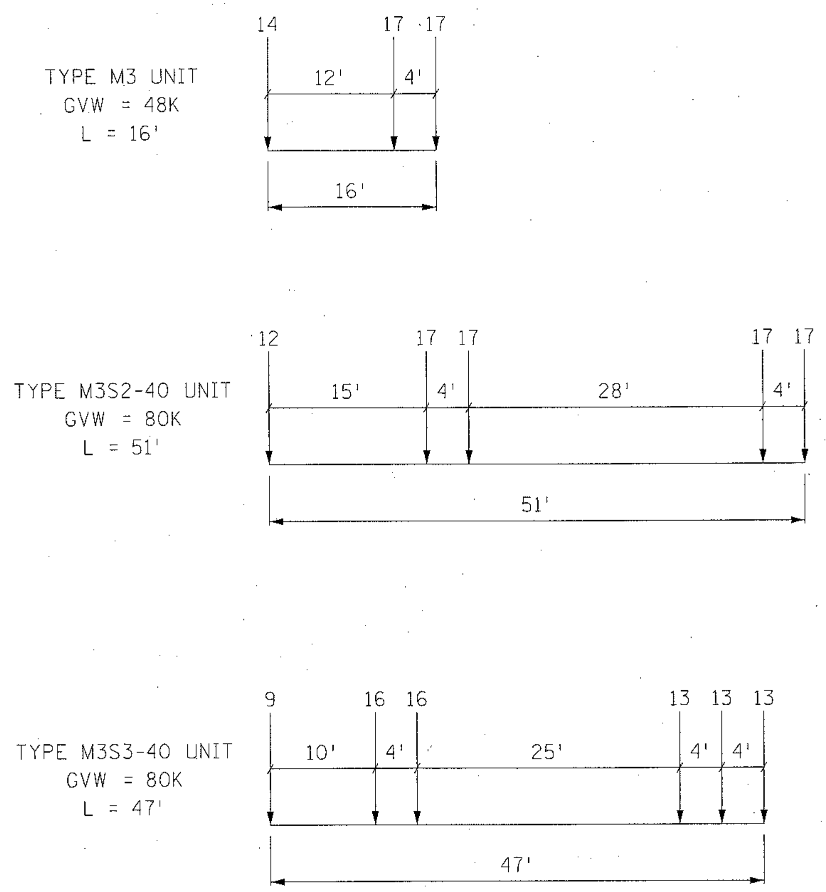
Loads and Load Factors

- MN Legal Loads

OCTOBER 2011 LRFD BRIDGE DESIGN 15-26.1

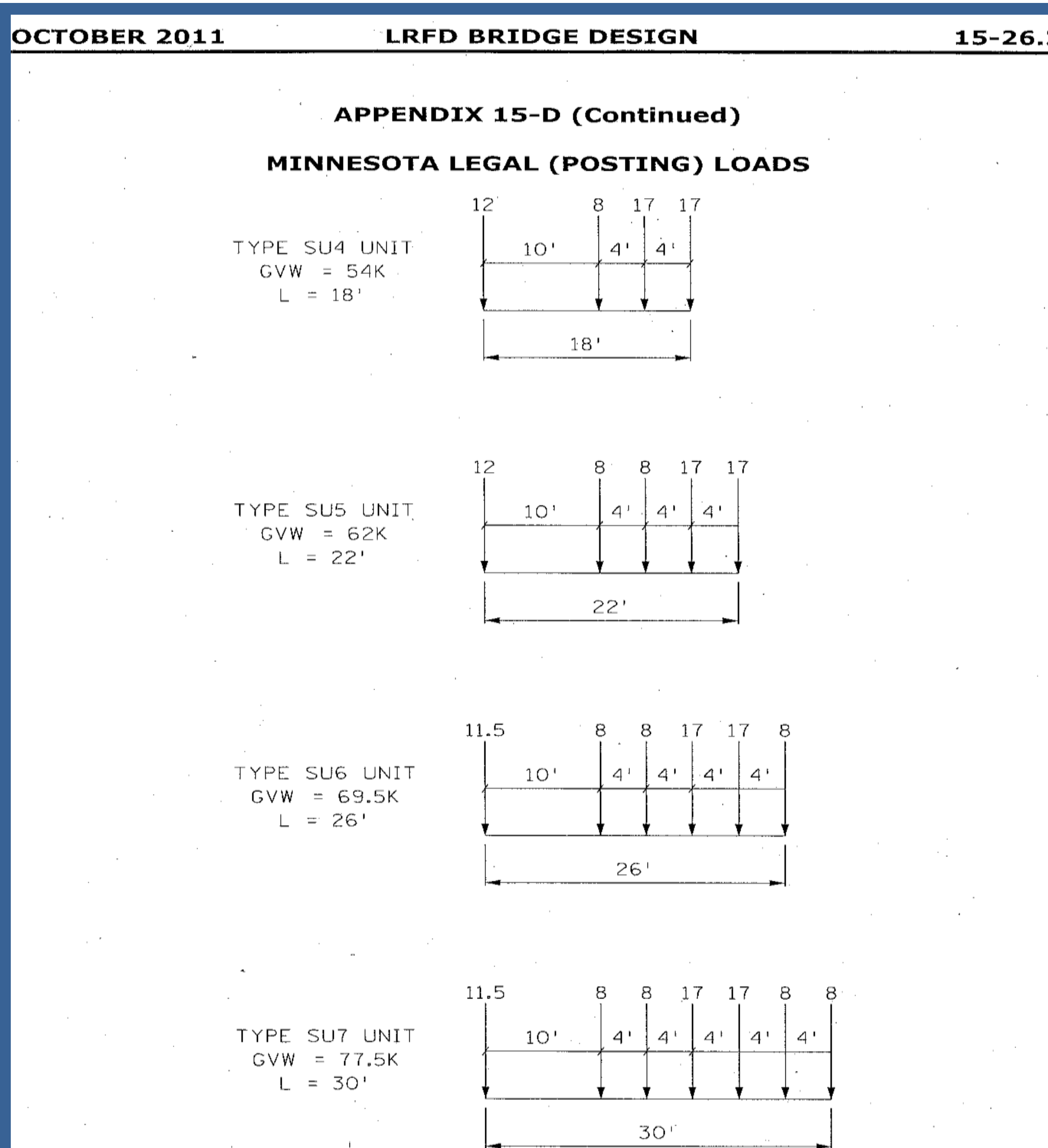
APPENDIX 15-D

MINNESOTA LEGAL (POSTING) LOADS



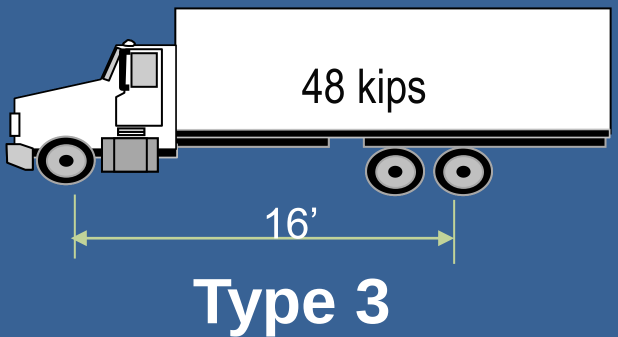
Loads and Load Factors

- AASHTO SHVs

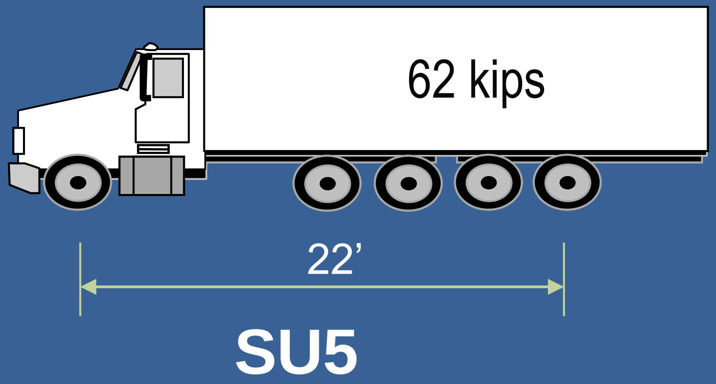


Loads and Load Factors

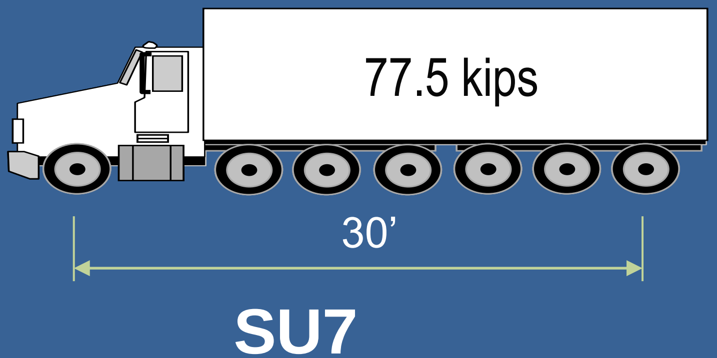
MnDOT Single Truck
Posting Model



New AASHTO Specialized Hauling
Vehicle – 5 axle Posting Model



New AASHTO Specialized Hauling
Vehicle – 7 axle Posting Model



Loads and Load Factors

1960 -1970 's

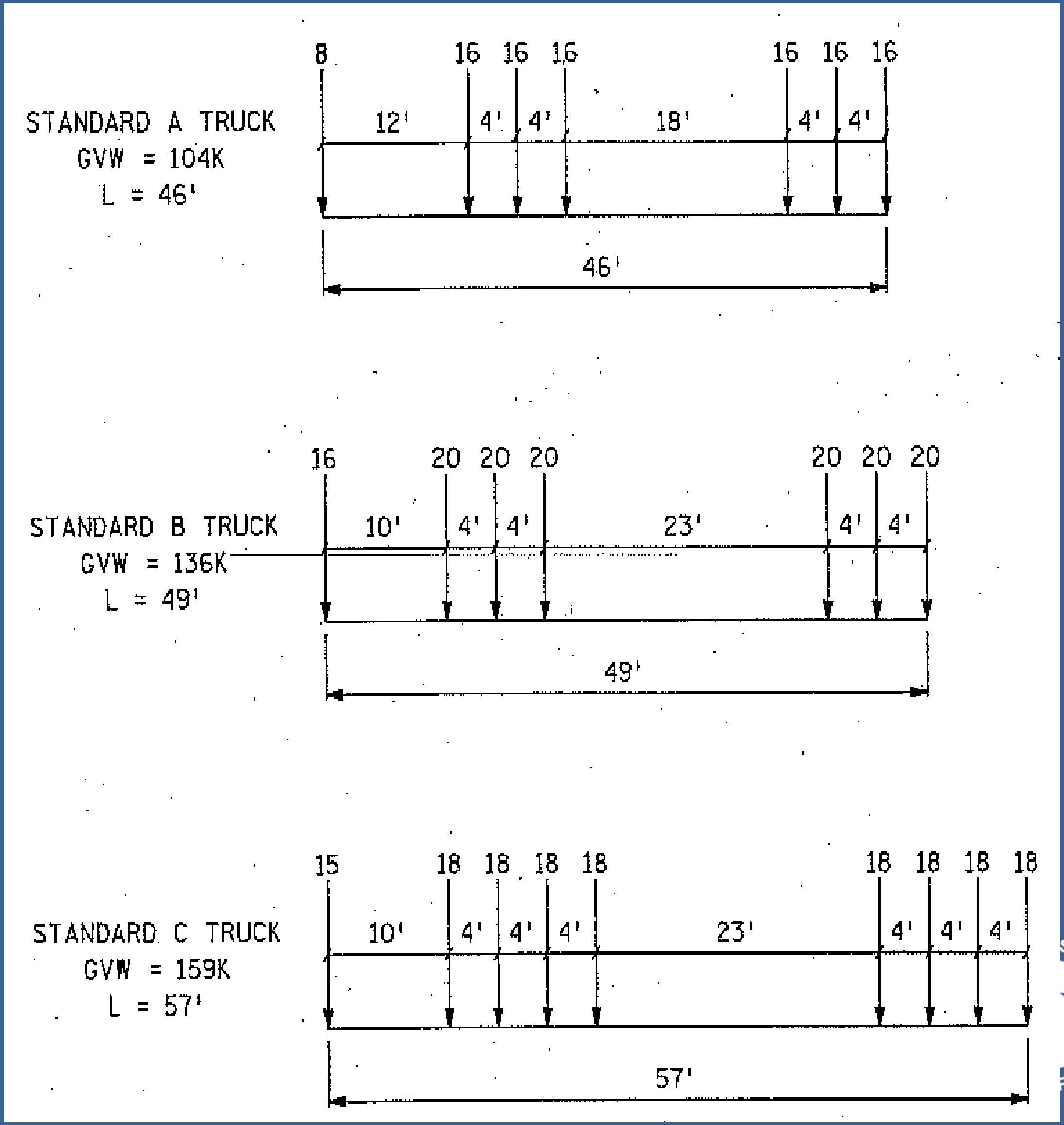
Today

Loads and Load Factors

- MnDOT Standard Permit Loads
  - Annual Permit Truck Models
    - Standard A, B, and C
    - Total Weight ≤145,000 LB
  - Single Trip Permit Trucks Models
    - P411 and P413
    - Additional Standard Permit Trucks G-07
  - Uniform Lane Load of 200 PLF for Span>200'

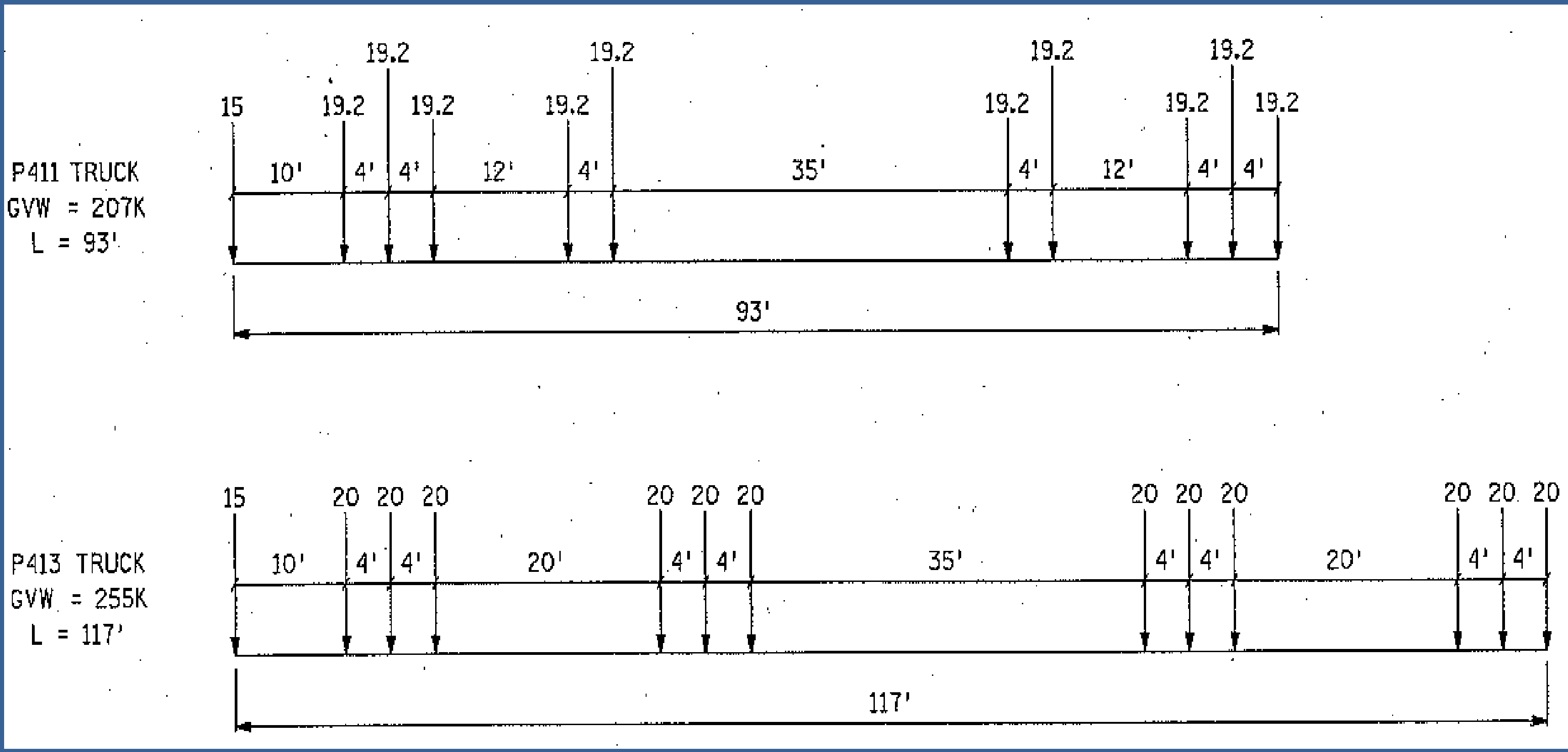
Loads and Load Factors

MnDOT
Standard
Annual Permit
Load Models



Loads and Load Factors

MnDOT Standard Single Trip Permit Load Models



Loads and Load Factors

Total Weight = 703,000 LB

Loads and Load Factors

- LFR Load Factors

  DL load factor = 1.3

  LL load factor at inventory level = 2.17

  LL load factor at operating level = 1.3

Loads and Load Factors

- LRFR Load Factors

Table B6A-1—Limit States and Load Factors for Load Rating (6A.4.2.2-1)

Bridge Type	Limit State*	Dead Load *DC*	Dead Load *DW*	Design Load Inventory *LL*	Design Load Operating *LL*	Legal Load *LL*	Permit Load *LL*
Steel	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service II	1.00	1.00	1.30	1.00	1.30	1.00
	Fatigue	0.00	0.00	0.75	—	—	—
Reinforced Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service I	1.00	1.00	—	—	—	1.00
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service III	1.00	1.00	0.80	—	1.00	—
	Service I	1.00	1.00	—	—	—	1.00
Wood	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1

Loads and Load Factors

- LRFR Load Factors

Table B6A-2—Generalized Live Load Factors for Legal Loads: γ_L (6A.4.4.2.3a-1)

Traffic Volume (one direction)	Load Factor
Unknown	1.80
$ADTT \geq 5000$	1.80
$ADTT = 1000$	1.65
$ADTT \leq 100$	1.40

Table B6A-3—Generalized Live Load Factors, γ_L for Specialized Hauling Vehicles (6A.4.4.2.3b-1)

Traffic Volume (one direction)	Load Factor for NRL, SU4, SU5, SU6, and SU7
Unknown	1.60
$ADTT \geq 5000$	1.60
$ADTT = 1000$	1.40
$ADTT \leq 100$	1.15

Loads and Load Factors

- LRFR Load Factors

Table B6A-4—Permit Load Factors: γ_L (6A.4.5.4.2a-1)

					Load Factor by Permit Weight[b]	
Permit Type	Frequency	Loading Condition	*DF*[a]	*ADTT* (one direction)	Up to 100 kips	≥150 kips
Routine or Annual	Unlimited Crossings	Mix with traffic (other vehicles may be on the bridge)	Governing of one lane or two or more lanes	>5000	1.80	1.30
				=1000	1.60	1.20
				<100	1.40	1.10
					All Weights	
Special or Limited Crossing	Single-Trip	Escorted with no other vehicles on the bridge	One lane	N/A	1.15	
	Single-Trip	Mix with traffic (other vehicles may be on the bridge)	One lane	>5000	1.50	
				=1000	1.40	
				<100	1.35	
	Multiple-Trips (less than 100 crossings)	Mix with traffic (other vehicles may be on the bridge)	One lane	>5000	1.85	
				=1000	1.75	
				<100	1.55	

Notes:

[a] *DF* = LRFD distribution factor. When one-lane distribution factor is used, the built-in multiple presence factor should be divided out.

[b] For routine permits between 100 kips and 150 kips, interpolate the load factor considering also the *ADTT* value. Use only axle weights on the bridge.

Loads and Load Factors

- LRFR Multiple Presence Factor (MPF)
  - HL-93 per AASHTO LRFD
  - MN Legal Loads and SHV trucks per AASHTO LRFD
  - Annual Permit Loads per AASHTO LRFD
  - Single Trip Permit Loads MPF=1.0

- Number of Lanes (LRFR)
  - Number of design lanes shall be used for all strength checks at both inventory and operating levels
  - Number of striped lanes shall be used for service check at operating level

LRFR Process

- Process based on Live Load Distribution Factors
  - Use LRFD distribution analysis methods in LRFD Article 4.6.2
  - One or Two+ lane distribution factor
  - Virtis Software

- Process based on Finite Element model
  - Complex bridges only
  - Load patterning for HL93 only and combinations of HL93 and permit loads

LRFR Process

- LRFR Basic Formula

Rating Factor:

$$RF = \frac{\emptyset_c \emptyset_s \emptyset R - \gamma_{DL} DL}{\gamma_{LL}(LL + I)}$$

$$\emptyset_c \emptyset_s \geq 0.85$$ MBE 6A4.2.1-1

$\gamma_{(DL)}$ – MBE table 6A.4.2.2-1

$\gamma_{(LL)}$ – MBE table 6A.4.2.2-1

LRFR Process

- System Factor ϕ_s
  - MBE Table 6A.4.2.4-1
  - System Factor = 1.0 for shear at the strength limit state.

LRFR Process

- Condition Factor ϕ_c

Table 6A.4.2.3-1—Condition Factor: φ_c

Structural Condition of Member	φ_c
Good or Satisfactory	1.00
Fair	0.95
Poor	0.85

Table C6A.4.2.3-1—Approximate Conversion in Selecting φ_c

Superstructure Condition Rating (SI & A Item 59)	Equivalent Member Structural Condition
6 or higher	Good or Satisfactory
5	Fair
4 or lower	Poor

Limit States

- MnDOT Requirements
  - No fatigue check required
  - For new HL-93 designed bridges, service state checks of permit loads are required

Table B6A-1—Limit States and Load Factors for Load Rating (6A.4.2.2-1)

Bridge Type	Limit State*	Dead Load DC	Dead Load DW	Design Load Inventory LL	Design Load Operating LL	Legal Load LL	Permit Load LL
Steel	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service II	1.00	1.00	1.30	1.00	1.30	1.00
	Fatigue	0.00	0.00	0.75	—	—	—
Reinforced Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service I	1.00	1.00	—	—	—	1.00
Prestressed Concrete	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	—	Table 6A.4.5.4.2a-1
	Service III	1.00	1.00	0.80	—	1.00	—
	Service I	1.00	1.00	—	—	—	1.00
Wood	Strength I	1.25	1.50	1.75	1.35	Tables 6A.4.4.2.3a-1 and 6A.4.4.2.3b-1	—
	Strength II	1.25	1.50	—	—	–	Table 6A.4.5.4.2a-1

Limit States

- Service I Permit Load Check
  - Limiting the steel stress to 90% of yield stress

    $f_r = 0.9\ f_y$ or $0.9\ f_{py}$

  - Ensure no permanent deformations from overweight loads
  - Alternate approach – Limit unfactored moments to 75% of nominal flexural capacity (Mn),

    MBE C6A.5.4.2.2b

Reliability

- Reliability Index
  - Inventory Level = 3.5 (same as design)
  - Operation Level = 2.5 (target inspection cycle)

Special Type Superstructures

- Curved Steel Superstructure
  - Load Patterning – One/Two HL-93 or Permit Trucks
  - Load Factors – Using MBE Tables
  - MnDOT Guidance – Under development

- Post-Tensioned concrete segmental box
  - Load Patterning – All combinations
  - Design Loads - Including permit trucks
  - Load Factors – Past:1.35 used
    Future: new MBE revision

Special Type Superstructures

- Truss and Gusset Plates
  - MnDOT Bridge Design Memo – will be revised
  - FHWA Guidance and Examples – Flexure not required
  - AASHTO – Future Revisions

- Prestressed Concrete Beam Bridges with Shear Issue
  - Current University of Minnesota's Research Project
  - Shear Analysis Process

Load Posting

- Posting Rules
  - AASHTO and Minnesota rules require posting bridges when bridge condition has deteriorated and reduced its capacity to safely carry legal loads
  - Must close a bridge when the capacity of a bridge is less than 3 Ton
  - A vehicle type shall not be allowed when the rating factor of that vehicle type falls below 0.3

Load Posting

- LFR/ASR Methods – Currently Used

  Follow MnDOT LRFD Design Manual Chapter 15

- LRFR Method – Currently not Implemented by MnDOT

  Safe Posting Load= $\frac{W}{0.7}[(RF) - 0.3]$

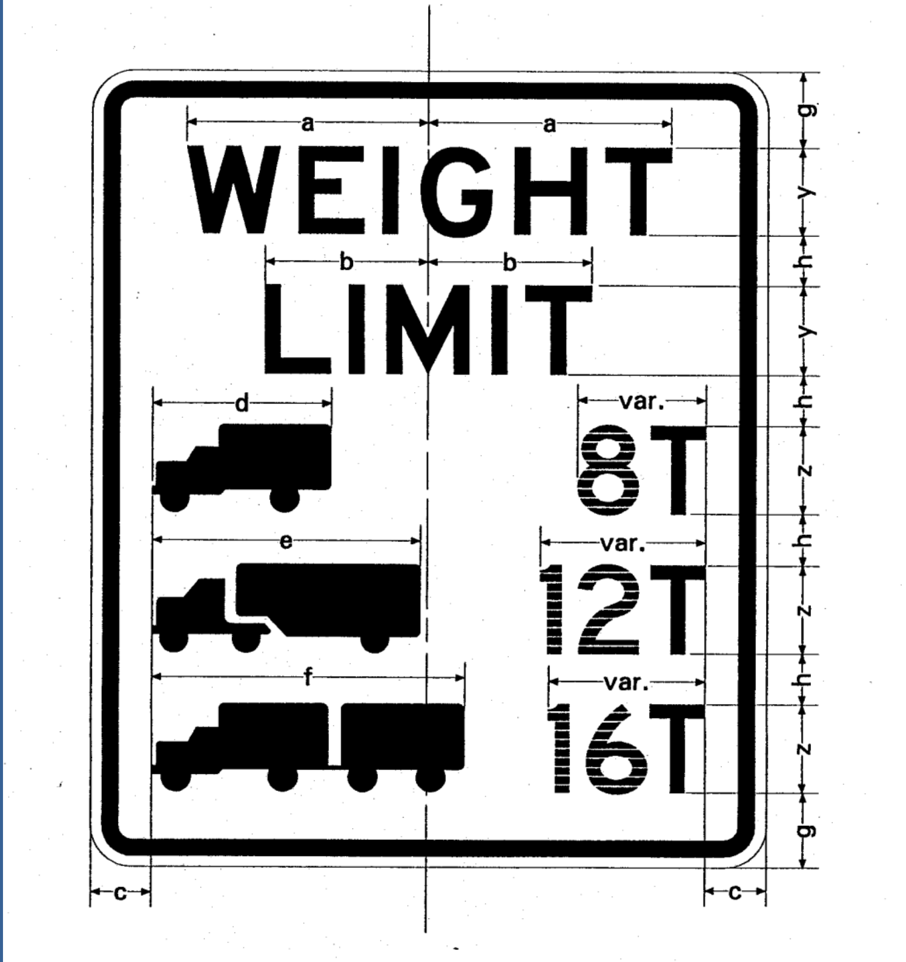
  W = Weight of rating vehicle

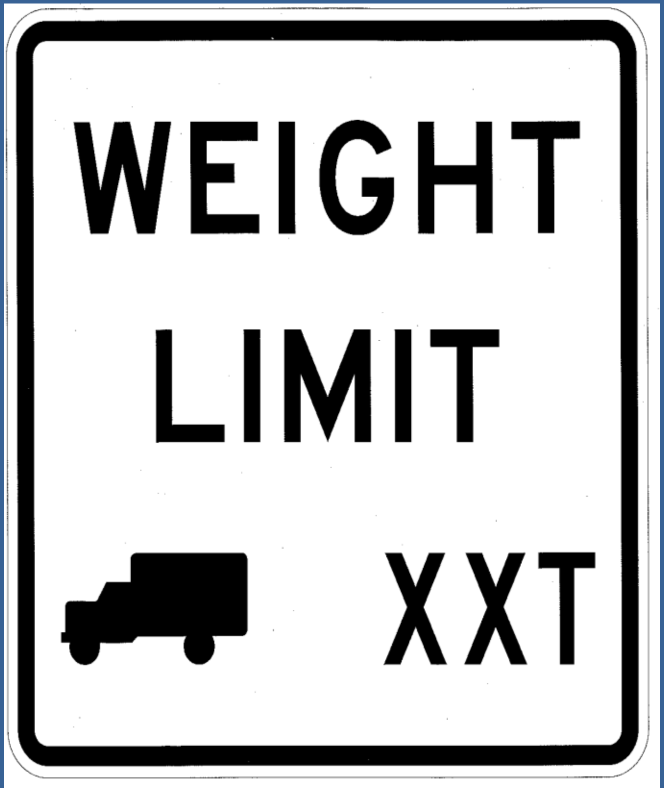
  RF = Legal load rating factor

MBE 6A.8.3-1

Load Posting

- Sign Samples – R12-5 and R12-5a





Assigned Rating

- MBE requirements
  - Bridges designed by HL-93 or HS 20/HS 25
  - Bridge condition not changed
  - Bridges only carry MN Legal loads
    - ➢ Inventory Rating Factor = 1.0
    - ➢ HL93 Operating Rating Factor = 1.3 or
    - ➢ HS 20 Operating Rating = HS 33.4
- FHWA requirements

Physical Inspection Rating (PIR)

Use when a numerical rating value cannot readily be calculated.

The reason can be:

- No bridge plan available
- Concrete with unknown reinforcement
- Deteriorated culverts

Physical Inspection Rating (PIR)

- PIR Procedure
  - Form PIR + cover sheet (form RC-TH or RC-CL)
  - Consider condition, age, type, redundancy, ADTT, loading, etc.
  - Rating determined by the engineer based on all available information and his/her judgment

Rating Forms

- All forms are available online

http://www.dot.state.mn.us/bridge/docsdown.html

Rating Form for County & Local Agencies

FORM RC-CL
Revised Jan. 2012

MnDOT BRIDGE RATING AND LOAD POSTING REPORT FOR COUNTY AND LOCAL AGENCIES

Bridge Location and Description

Hwy. No. ______ Over ☐ Under ☐ ______ **Bridge No.** ______

Year Built ______ Year Remodeled ______ Replaces Br. ______

Type ______ County ______ Ref. Pt. ______

Description ______

Location ______

Data for Basis of Report (Check all that apply)

☐ Bridge Inventory File
☐ Previous Bridge Rating and Load Posting Report
☐ Bridge Plans
- ☐ New ☐ Overlay
- ☐ Repair/Reconstruction ______
- ☐ Other Dead Load Modifications ______

☐ Bridge Inspected by ______ Date ______
- ☐ Damaged Component ______
- ☐ Deteriorated Component ______

Types of Analysis:
☐ Manual ☐ Computer* ☐ BARS ☐ Virtis, V.____ ☐ Other*
* ______

NBI Condition Ratings
Deck ______
Superstructure ______
Substructure ______
ADTT ______

Method of Rating (Check appropriate box)
☐ Load Factor (LF) ☐ Assigned Load Ratings
☐ Allowable Stress (AS)
☐ Load & Resistance Factor (LRFR)
☐ Load Testing
☐ No Rating Computations performed

Design Load ______
Design Method ______

Summary of Rating and Load Posting Analysis

Load Posting Required ☐ Not Required ☐

Sign	TONS		
R12-1A ☐			
R12-5a ☐			
R12-5 ☐	M3	M3S2	M3-3
R12-X11 ☐		45	

Bridge Rating

Inventory	Operating
HS ☐ RF ☐ ______	HS ☐ RF ☐ ______

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Signature: ______ Date: ______
(Typed or Printed) Name: ______ License No. ______
(Typed or Printed) Employed by (☐Agency/☐Firm): ______

My signature below indicates that I have read and fully agreed with the load rating report.

Program Administrator's Signature: ______ Date: ______

FORM RD-CL
Revised Jan. 2012

BRIDGE RATING DETAILS

Bridge Type ______
Rating Method ______
Roadway Width ______
☐ Curved ☐ Tapered
Beam Spacing ______
☐ Live Load Distribution Factor
Single ______ Multiple ______
☐ Finite/Grid Element Analysis

Bridge No. ______
Design Load: ______
Inventory Rating: ______
Operating Rating: ______
Rated ______ Checked ______
Date ______
Sheet ______ of ______

BEAM ELEVATION [2]
Show span lengths, structure/beam depths.

Truck	Rating Factor	Span/ Pier	Location	Limit State [1]	Notes/Comments
HS 20 Inventory					
HS 20 Operating					
Post, M3					
Post, M3S2					
Post, M3S3					
Type SU4					
Type SU5					
Type SU6					
Type SU7					

1 Choose from: service or ultimate; shear or moment
2 Elevation may be on back or another sheet if it won't fit here.

Culvert Rating (Form 90)

OLD

FORM 90
PHYSICAL INSPECTION RATING
FOR ALL CULVERTS

Revised 8/96

Bridge No. ________ County ____________ Year Built ______ Year Extended ______

Route ____________ Feature Crossed ____________

Culvert Type and Size ____________ Barrel Length ________ Ft

Remarks ____________

MATERIAL	DESIGN	INVENTORY	OPERATING
CAST IN PLACE CONCRETE (See Note Below)	BOX	HS 22.0	HS 33.0
	'ARCH' ON FOOTING	HS 20.0	HS 30.0
PRECAST CONCRETE (See Note Below)	BOX	HS 24.0	HS 36.0
	'ARCH' ON FOOTING	HS 20.0	HS 30.0
	ROUND PIPE	HS 24.0	HS 36.0
	ARCH PIPE	HS 22.0	HS 33.0

NOTE: For LOA…
HS 25 De…

MATERIAL			
ALUMINUM			
METAL			
TIMBER			
MASONRY	'ARCH' ON FOOTING	HS 18.0	HS 27.0

The Physical Inspection of this structure indicates no structural distress and is considered safe for all legal loads under current traffic conditions, therefore the above ratings are considered appropriate.

OR

The Physical Inspection of this structure indicate possible distress;
I.E.. METAL - deflections of 2% of the span or rise or >= 5".
CONCRETE - any cracking greater than .01"
TIMBER - cracking, rotting or other defects.
I therefore recommend the following reduced ratings on my judgment.

INVENTORY RATING ________ OPERATING RATING ________
(Enter appropriate ratings in spaces provided)

Rated by: ____________ Date: ________
(Engineer's Name)

NEW

Form 90
Revised: Dec. 11

Culvert Rating Form

Bridge Number:	Year Built:	Year Remodeled:
County:	Bridge Owner:	
Route:	Feature Crossed:	
Culvert Type:		
Structure Type Code:	Culvert Dimensions:	
No. of Barrels:	Barrel Length:	

Rating Guidelines

Material	Culvert Type	Structure Type Code	Inventory Load Rating	Operating Load Rating
✱ Cast-in-place Concrete	Box	113	HS 22.0	HS 33.0
	Type W Box (1930 era)	113	HS 16.0	HS 24.0
	Footing Supported Arch	112	HS 20.0	HS 30.0
✱, ✱✱ Precast Concrete	Box	513	HS 24.0	HS 36.0
	Footing Supported Arch	512	HS 20.0	HS 30.0
	Round Pipe	514	HS 24.0	HS 36.0
	Pipe-Arch	515	HS 22.0	HS 33.0
			14.0	HS 21.0
			12.0	HS 18.0
			16.0	HS 24.0
			16.0	HS 24.0
			16.0	HS 24.0
			14.0	HS 21.0
			18.0	HS 27.0
			25.0	**HS 42.0**
			F=1.0	**RF=1.3**

The above table may be used as a guideline to the culvert rating.

Inventory Rating		Operating Rating	

NBI Condition Rating: Culvert ______
If the culvert condition rating is 4 or less, do not use this form.
Instead, rate by Physical Inspection Rating (Form_PIR).

(Typed or Printed) Name: ____________ Date: ________
(Typed or Printed) Title: ____________
(Typed or Printed) Employed by (Agency / Firm): ____________

NBI Condition Rating: Culvert ________
If the culvert condition rating is 4 or less, do not use this form.
Instead, rate by Physical Inspection Rating (Form_PIR).

MINNESOTA DEPARTMENT OF TRANSPORTATION

Physical Inspection Rating (PIR)

Old

FORM V

PHYSICAL INSPECTION RATING

FOR STRUCTURES WITH

'POOR' CONDITION OF A SUPPORT ELEMENT

IDENTIFICATION DATA

County ____________ Bridge Number ____________

Year Built ________ Route System/Number ____________

Feature Crossed ____________

Structure Type ____________ Length ________

Describe ITEM DEFICIENCY ____________

Due to the POOR condition of the ________ (element) of this structure,

I recommend the structure be restricted in LOAD CARRYING CAPACITY.

Based on my engineering judgement,

the GROSS LOADING CAPACITY for this structure

should be ________ TONS

OR

________ TONS SINGLE VEHICLE and ________ TONS SEMI-TRAILER.

RECOMMENDED BY: ____________ (Signature) Date: ________

New

FORM RC-CL
Revised Jan. 2012

MnDOT BRIDGE RATING AND LOAD POSTING REPORT
FOR COUNTY AND LOCAL AGENCIES

Bridge Location and Description

Hwy. No. ________ Over ☐ Under ☐ ________ Bridge No. ________

Year Built ________ Year Remodeled ________ Replaces Br. ________

Type ________ County ________ Ref. Pt. ________

Description ________

Location ________

Data for Basis of Report (Check all that apply)

- ☐ Bridge Inventory File
- ☐ Previous Bridge Rating and Load Posting Report
- ☐ Bridge Plans
  - ☐ New ☐ Overlay
  - ☐ Repair/Reconstruction ________
  - ☐ Other Dead Load Modifications ________
- ☐ Bridge Inspected by ________ Date ________
  - ☐ Damaged Component ________
  - ☐ Deteriorated Component ________

Types of Analysis:
☐ Manual ☐ Computer* ☐ BARS ☐ Virtis, V.____ ☐ Other*
*

NBI Condition Ratings
Deck ________
Superstructure ________
Substructure ________
ADTT ________

Method of Rating (Check appropriate box)

- ☐ Load Factor (LF) ☐ Assigned Load Ratings
- ☐ Allowable Stress (AS)
- ☐ Load & Resistance Factor (LRFR)
- ☐ Load Testing
- ☐ No Rating Computations performed

Design Load ________

Design Method ________

Summary of Rating and Load Posting Analysis

Load Posting: Required ☐ Not Required ☐

Sign	TONS		
R12-1A ☐			
R12-5a ☐			
R12-5 ☐	M3	M3S2	M3-3
R12-X11 ☐		45	

Bridge Rating

Inventory	Operating
HS ☐ RF ☐ ________	HS ☐ RF ☐ ________

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Signature: ________ Date: ________

(Typed or Printed) Name: ________ License No. ________

(Typed or Printed) Employed by (☐Agency/☐Firm): ________

My signature below indicates that I have read and fully agreed with the load rating report.

Program Administrator's Signature: ________ Date: ________

FORM PIR
Revised Mar 06

MINNESOTA DEPARTMENT OF TRANSPORTATION
PHYSICAL INSPECTION RATING
(Per AASHTO 7.4.1 - Manual for Condition Evaluation of Bridges)

Bridge Location and Description

Hwy. No. ________ over/under ________ Bridge No. ________

Year Built ________ Year Remodeled ________ Replaces Br. ________

Type ________ County ________ ADT ________

Problem leading to this physical inspection rating: ________

Describe bridge; Spans, lengths, widths, depths, deck, wearing course, etc. ________

Describe Bridge Condition: ________

Other Remarks: ________

Bridge Sketch

Questions?

Rating Unit List

Yihong Gao at 651-366-4492

Moises Dimaculangan at 651-366-4522

Jim Pierce at 651-366-4555

Steel Girders

Nick Haltvick

Jessica Wahl Duncan

Bridge Design Engineers

Presentation Navigation

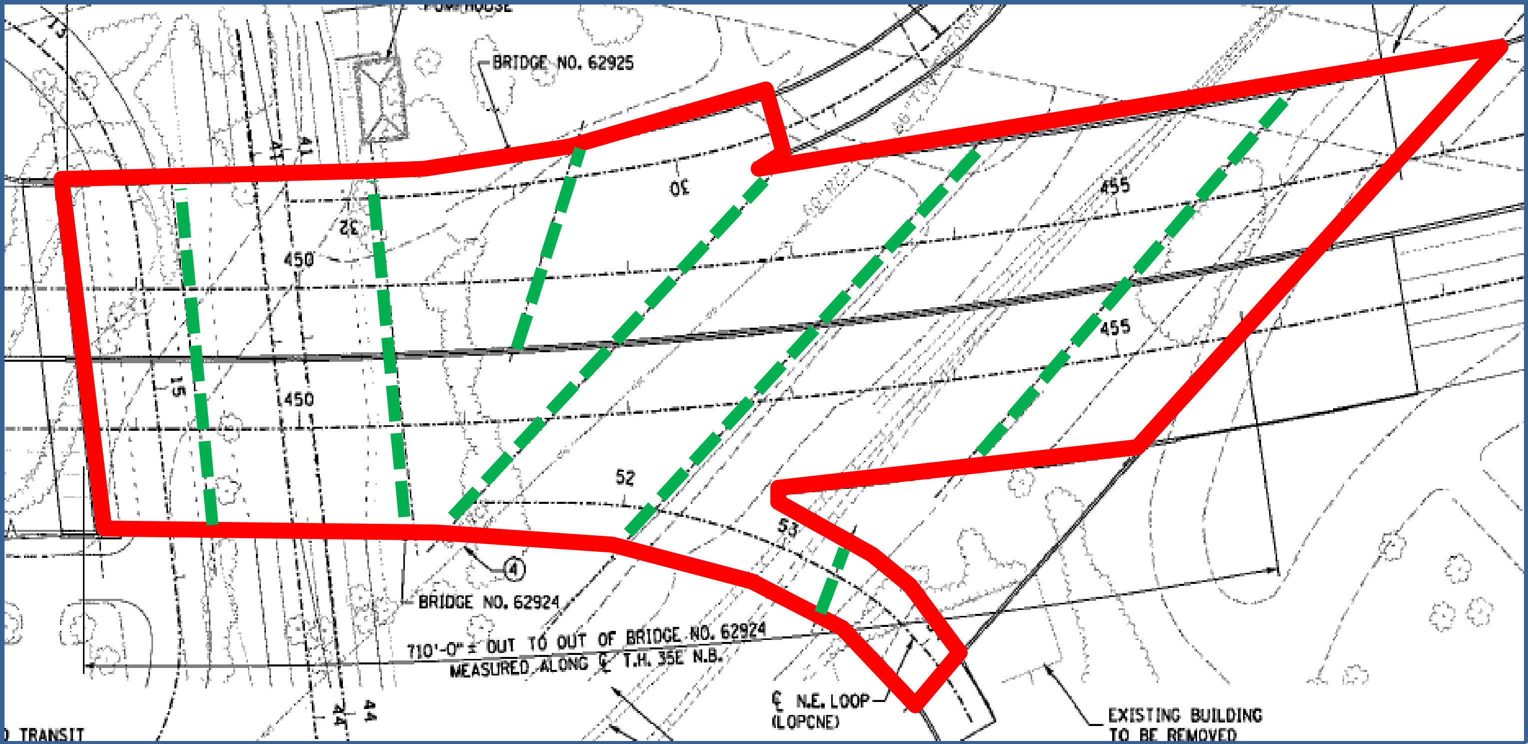
- Introduction, Design Aids, References, Misc.
- Design Topics
- Fabrication
- Constructability
- Deck Placement Sequences
- Software Issues
- Drafting & Detailing
- Review Submittals

Why use Steel Girders?

- In MN, the preference is concrete due to the harsh environment.
- However, steel can be a more economical solution when:
  - Need shallower or lighter beams
  - Very long spans
  - Curved alignment
  - Specialty structures (i.e. Lafayette Bridge)
- NSBA *Selecting the Right Bridge Type*

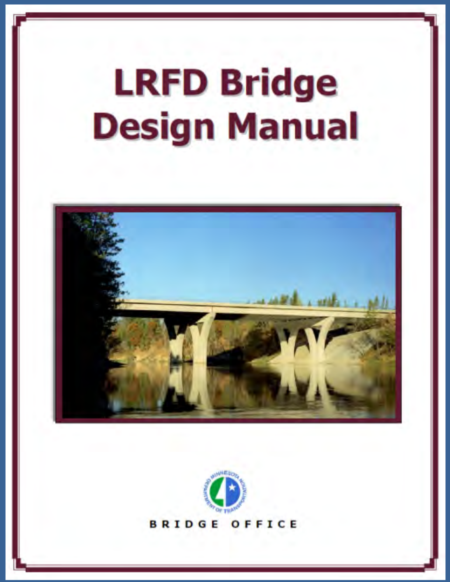
Why use Steel Girders?

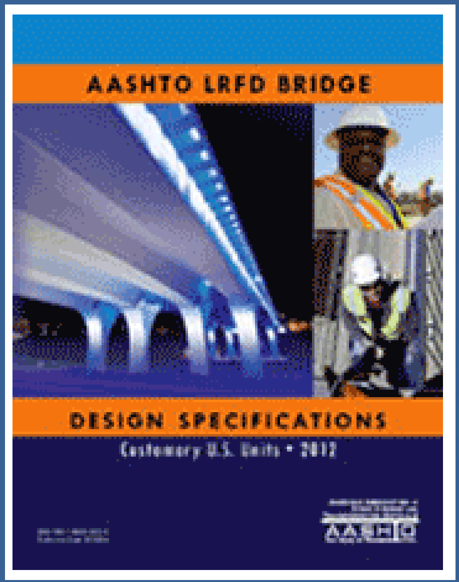
- Limited right-of-way available
- Tight geometric constraints
- Challenging roadway design



Design Requirements & Aids

- AASHTO & MnDOT LRFD Bridge Design Manual
- AASHTO/NSBA Steel Bridge Collaboration Documents (www.steelbridges.org)
- NHI Courses





Design Requirements & Aids

- With the MnDOT Project Manager, please coordinate ***any deviations*** from the AASHTO or MnDOT Bridge Design Manual ***prior*** to implementation.

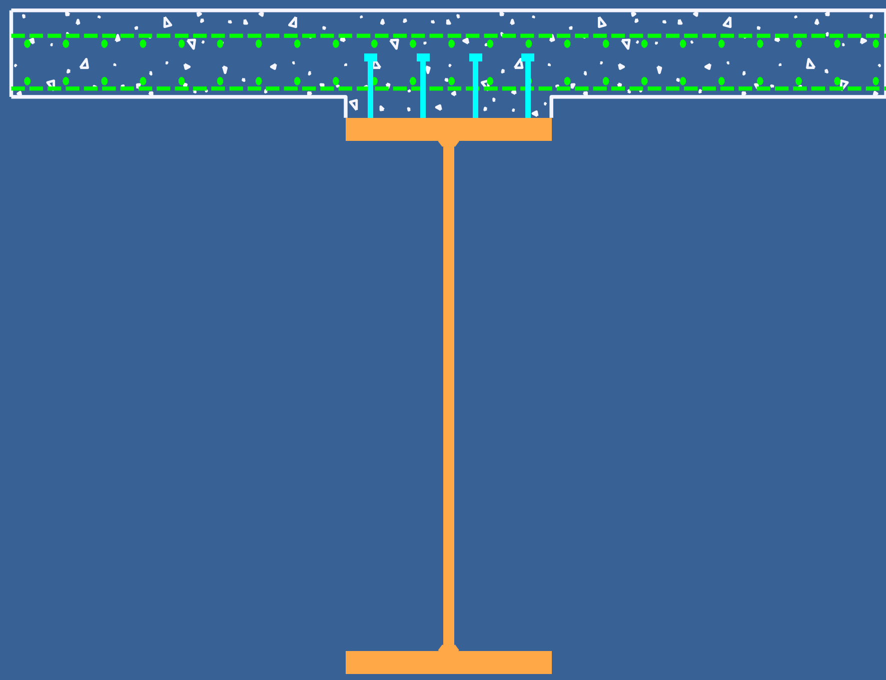
Design – General Procedure

- Common Misconception (aka “Rules of Thumb”)
  - Lightest Girder = Cheapest Girder

- Reality (Currently)
  - Least Labor ≈ Least Cost
  - Use simple custom details

Design – General Procedure

- Select baseline element sizes based on final condition



- Modular ratio
  - Non-composite Dead Load = n
  - Live Load = n
  - Composite Dead Load = 3n

Design – General Procedure

- Consider constructability requirements
  - Erection of girders
  - Stability
  - Deck placement sequence
- Only increase from baseline plate sizes

Design – Plate Sizing

- Span Lengths & Arrangements
- Global Need of Large Projects
- MnDOT LRFD 6.5

CHANGE IN SLIDE ORDER

Design – Plate Sizing

ELEMENT	STRAIGHT	CURVED
WEB	$D \geq {}^{L}/_{30}$	$D \geq {}^{L}/_{25}$
	${}^{D}/_{t_w} \leq n$ *n = 150 w/o long. stiff.* *n = 300 w/ long. stiff.*	
	Uniform Depth	
	Min. ½” thick	

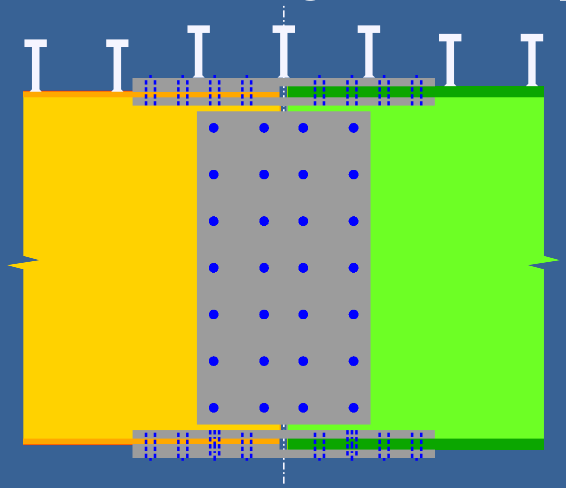
CHANGE IN TEXT

Design – Plate Sizing

ELEMENT	STRAIGHT	CURVED
FLANGES	$b_{fc} \geq L/85$	$b_{fc} + (2" \text{ to } 3") \geq L/85$
	$b_f/2t_f \leq 12$	
	$b_f \geq D/6$	
	$t_f \geq 1.1t_w$	
	$0.1 \leq I_{yc}/I_{yt} \leq 10$	
	Min. ¾” x 14”	

Design – Flange Sizing

- Max of three thickness changes per field section
- Constant top flange width within field sections
  - –Bottom flange width over entire length of bridge
- Welded Shop Splices
  - –Reduce by < ½ of the area of the thicker plate
  - –Many pieces cut from single wide plate

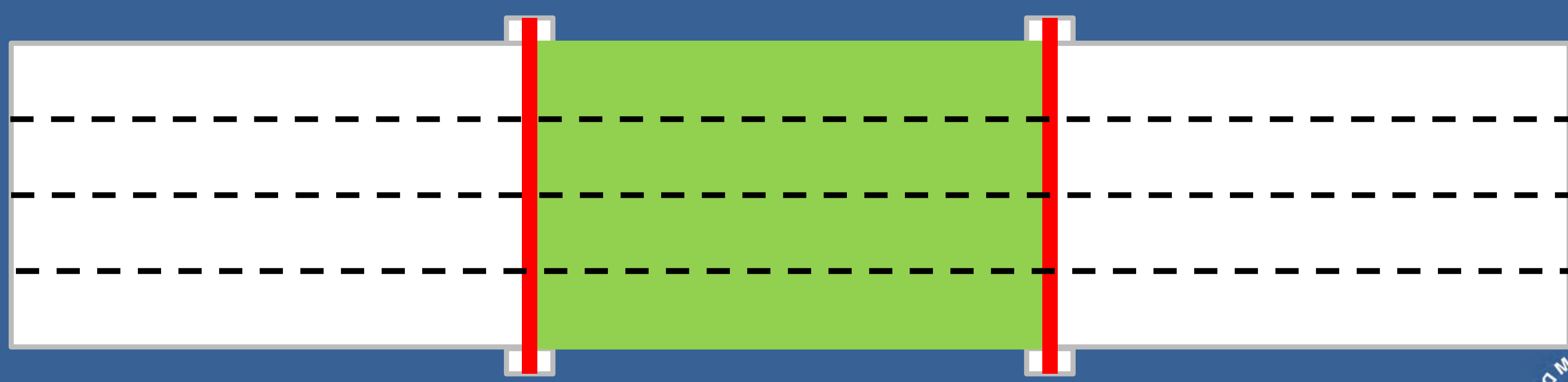


Design – Plate Sizing

- Consider Fabrication Methods

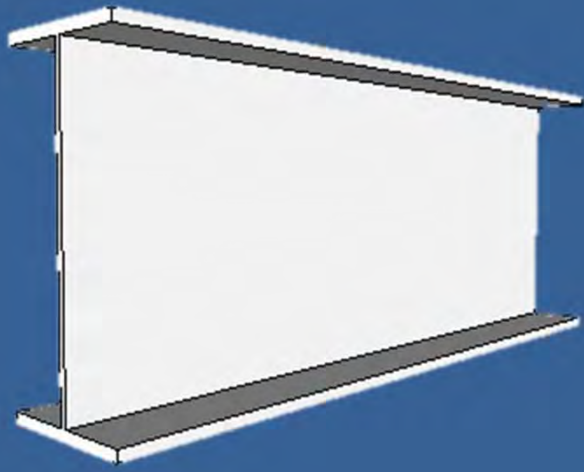
  - Single Piece Splice

  - Slab Welding (Multiple Pieces)



Design – Structural Steel

- MnDOT LRFD 6.1
- Weathering Steel
- Spec
  - 3309 = Grade 50W
  - 3316 = HPS Grade 50W
  - 3317 = HPS Grade 70W
- Toughness requirement for Zone 3



Design – High Performance Steel (HPS)

- MnDOT Spec 3317 (HPS 70W)
- Can be economical when used as:
  - Bottom flange in positive moment regions
  - Both flanges in negative moment regions
- Cost of material
  - Comparable by weight for thickness < 2"
  - Limited plate lengths available (50' to 55')
- Before use, check with
  - MnDOT Project Manager
  - NSBA or Fabricators

Design – High Performance Steel

- Goal = Logical use of 70 ksi steel
  - Why:
    - Fabrication requirements
    - Availability
    - Cost
- Minimize number of plate thickness
- Consider transition at field splices
  - Metallurgical issues
  - CJP welds limited

Design – Fracture Critical

- Non-redundant structures only
- Limits
  - Fabricators certified
  - Available shifts due to inspector
- Increases cost

- Specify on unique structures?
  - Not preferred!
  - Belief = Stricter material testing results in an "elite material"
  - Reality = Elite material is HPS

Design – Area 'A'

- Composite design for full length of bridge.
- MnDOT LRFD 6.2

CHANGE IN TABLE TEXT

Design – Diaphragms

Straight & Slightly Curved

- MnDOT LRFD 6.2
- Secondary Members
- Detail B407
- Unbraced compression flange

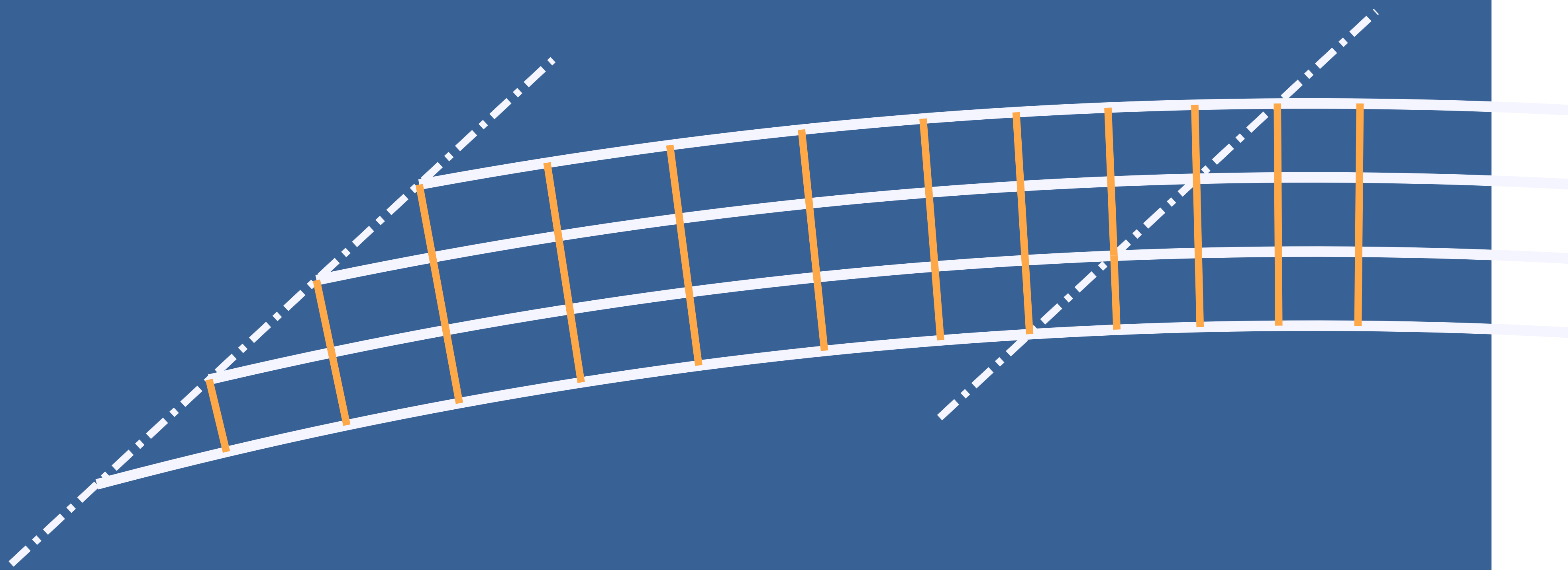
Complex & Curved

- MnDOT LRFD 6.6
- Primary load members
- Detail B408 or B402
- Lateral flange bending and structure stiffness

MAX SPACING	
(+M) ≈ 25' to 30' (-M) ≈ 15' to 20'	Lesser of: Radius/10 25' (MnDOT)

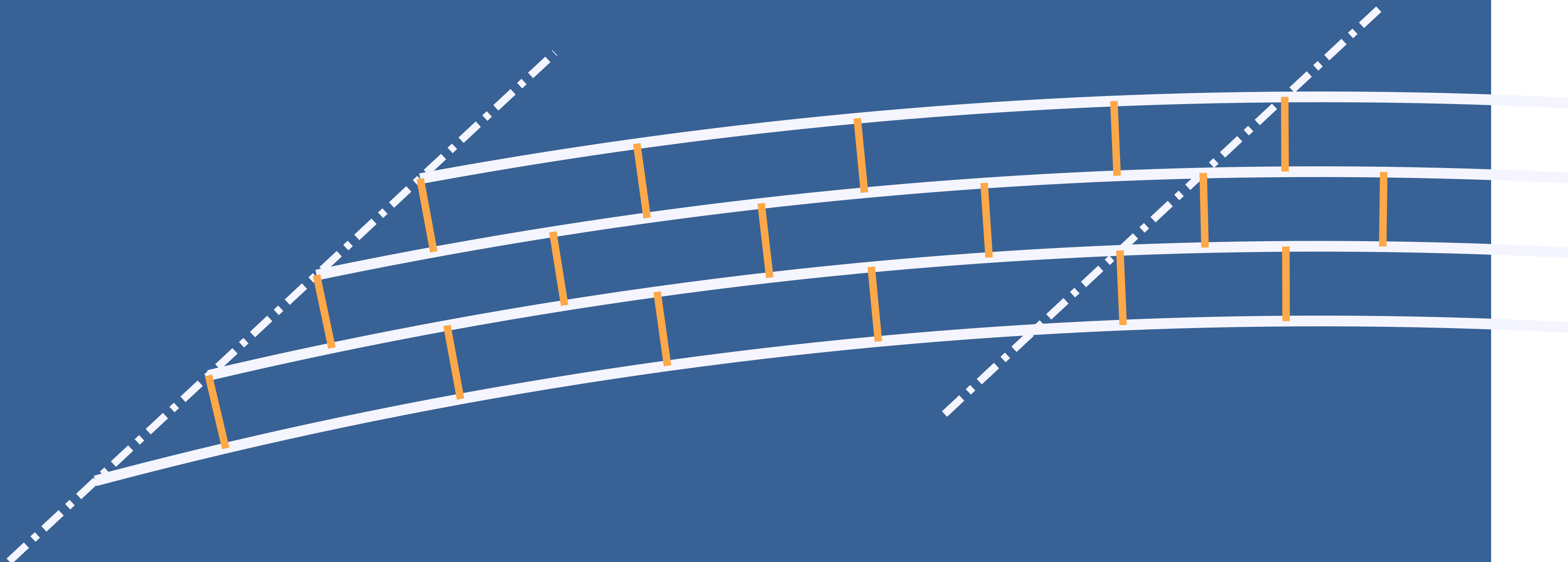
Design – Diaphragms

Continuous Framing Arrangement



Design – Diaphragms

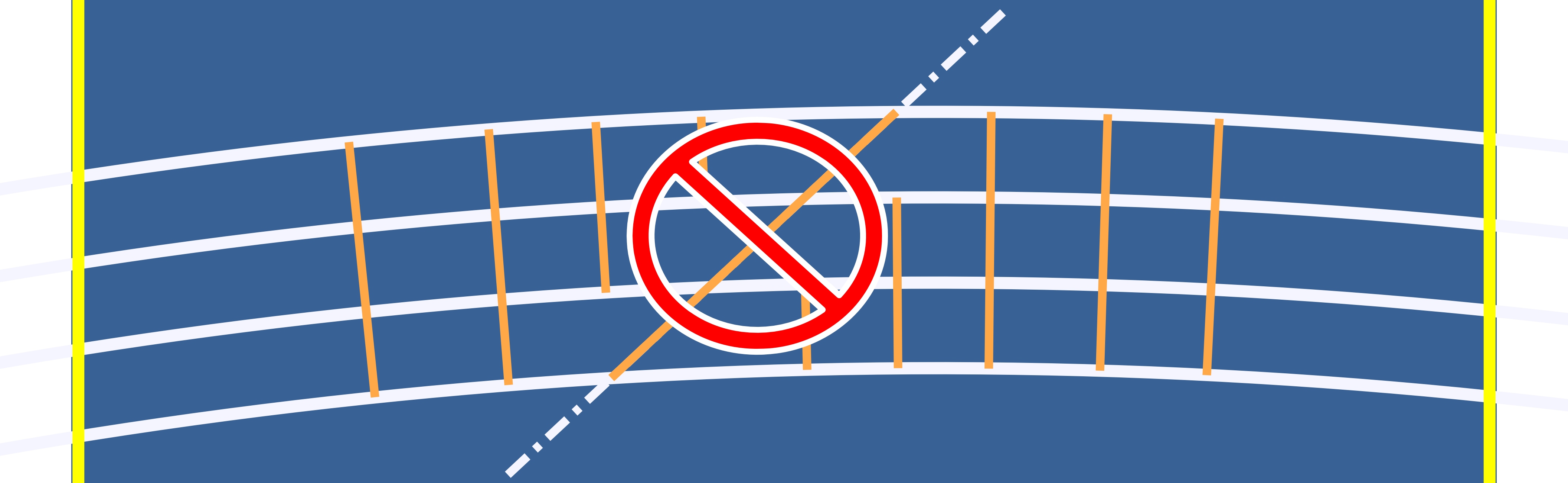
Discontinuous Framing Arrangement



CHANGE IN SLIDE ORDER

Design – Diaphragms

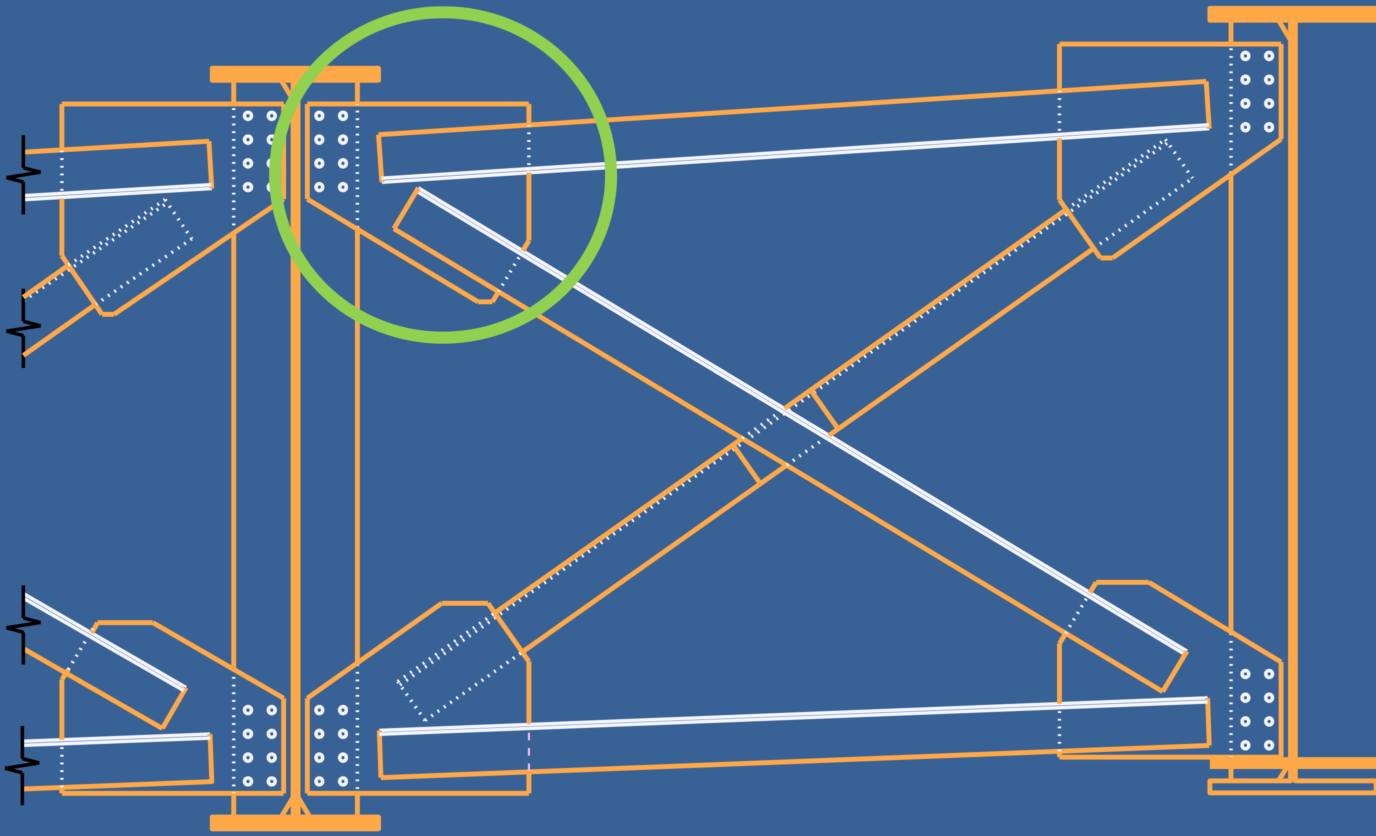
Not skewed over piers with θ > 20°



CHANGE IN SLIDE TEXT & IMAGE

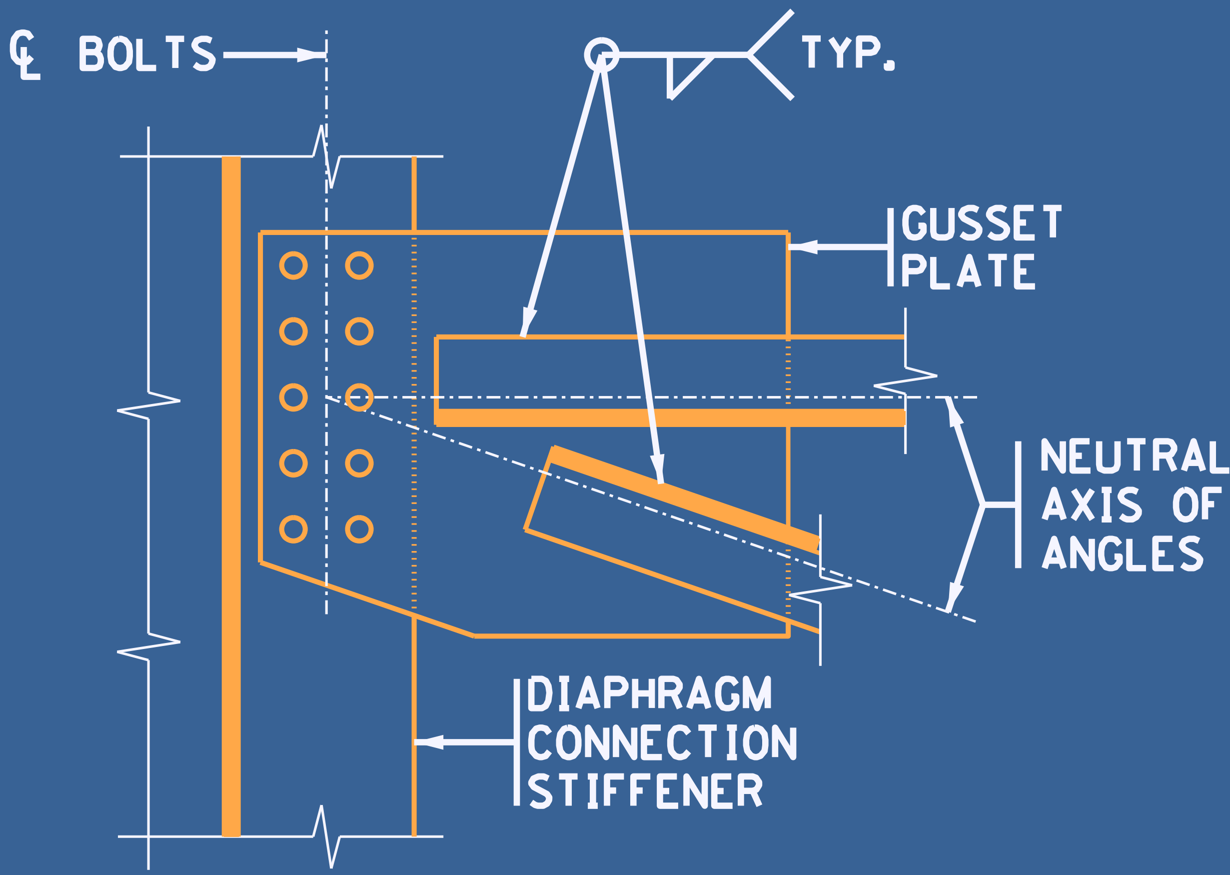
Design – Diaphragms

- Detail to accommodate cross-slope
- Connections

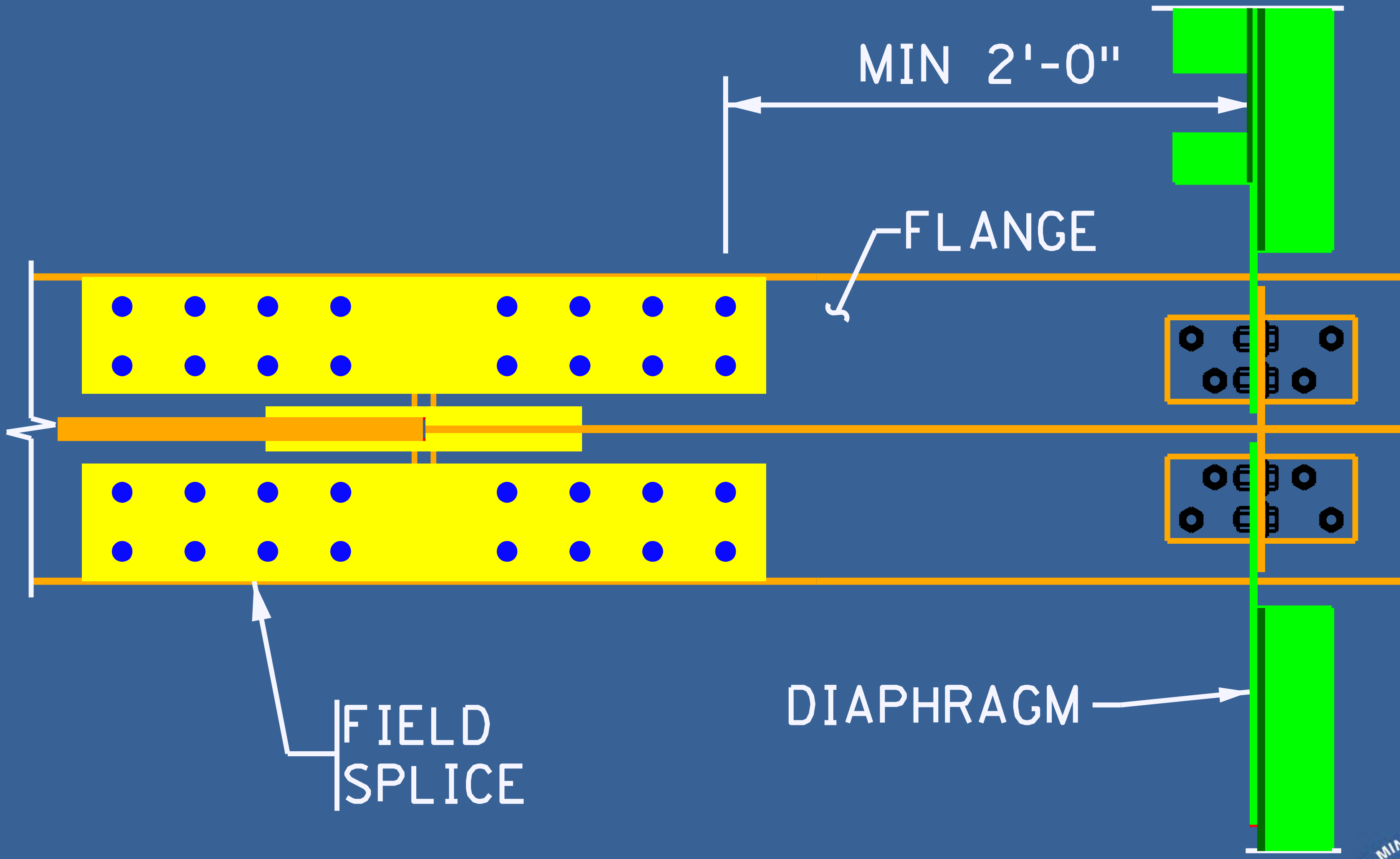


Design – Diaphragms

- Welded connections – All around welds
- Bolted connections – Gusset to Stiffener



Design – Diaphragms

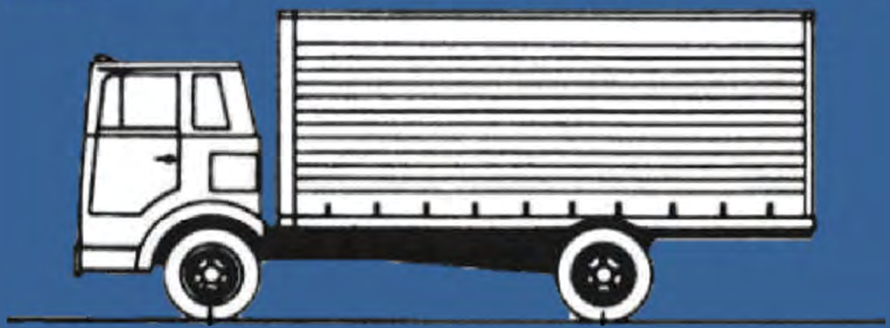


Design – Dead Loads

- Steel Weight Estimates
  - 15% for Prelim. Design Only (MnDOT LRFD 6.3)
    - Estimates “all” accessories
  - 1.5% for Quantities Only (MnDOT LRFD 6.2)
    - Beam only => To account for welds & bolts
  - 2% to 5% for Rating Only
    - Welds, splices, bolts, connection plates, etc…
  - Components (MnDOT LRFD 6.2)
  - Distribution

Design – Live Loads

- MnDOT LRFD 4.2.2.1
  - Skew effects distribution of live load
  - MnDOT deviates from AASHTO 4.6.2.2.2e
    - Do not reduce Moment
  - MnDOT adheres to AASHTO 4.6.2.2.3c
    - Magnify Shears and Reactions



Design – Live Loads

- Memo To Designers 2005-01
  - For continuous spans
  - Deviation for moment from AASHTO 3.6.1.3.1
  - Increase HL-93 double truck effect from when longest span:
    - $L_{span} < 100ft$ — See AASHTO (90%)
    - $100ft \leq L_{span} \leq 200ft$ — $[90 + (L_{span} - 100) \times 0.2]\%$
    - $200ft < L_{span}$ — 110%
  - Applies to Moment and Reaction
  - Purpose – Ensures load ratings are acceptable

Design – Load Modifiers

- Load Modifiers (η)
  - MnDOT LRFD Table 3.2.1
  - Multiple criteria
  - Applies to *entire* superstructure design

Design – Analysis

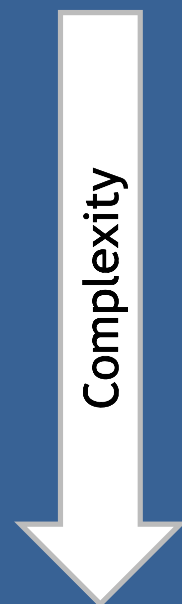
- What level is needed?
  - Straight
  - Skews
  - Curves
  - Bifurcations or Splays

- Downstream Consequences?
  - Line (aka Special) vs. Full Assembly
  - Differential Deflections
  - Erection Issues
  - Rating Issues

Design – Analysis

- MnDOT & AASHTO Bridge Design Manual

- Methods of Analysis
  - NCHRP 12-79
  - Line Girder
  - 2D
    - Grillage
    - Plate & Eccentric Beam
    - V-Load *(Gut-Check)*
  - 3D Finite Element Analysis



Design – Analysis

- Neglect of Curvature
- AASHTO 4.6.1.2.4
  - ☑ Eccentricity of segment between nodes < 2.5% of segment length
  - ☑ Concentric girders
  - ☑ Skews from radial ≤ 10°
  - ☑ Similar girder stiffnesses
  - ☑ $\frac{Arc\ Length}{Girder\ Radius} < 0.06\ radians$
    - See AASTHO for arc length definition

Fabrication

- Common Misconception (aka “Rules of Thumb”)
  – Lightest Girder = Cheapest Girder

- Reality (Currently)
  – Least Labor ≈ Least Cost
  – Use simple details

http://www.koike.com

Fabrication – Camber

- MnDOT LRFD 6.3.4
  - Match profile grade
  - Offset dead load deflections
- Residual Camber
  - For architectural reasons
  - Straight Girders
  - Curved Girders – no longer required

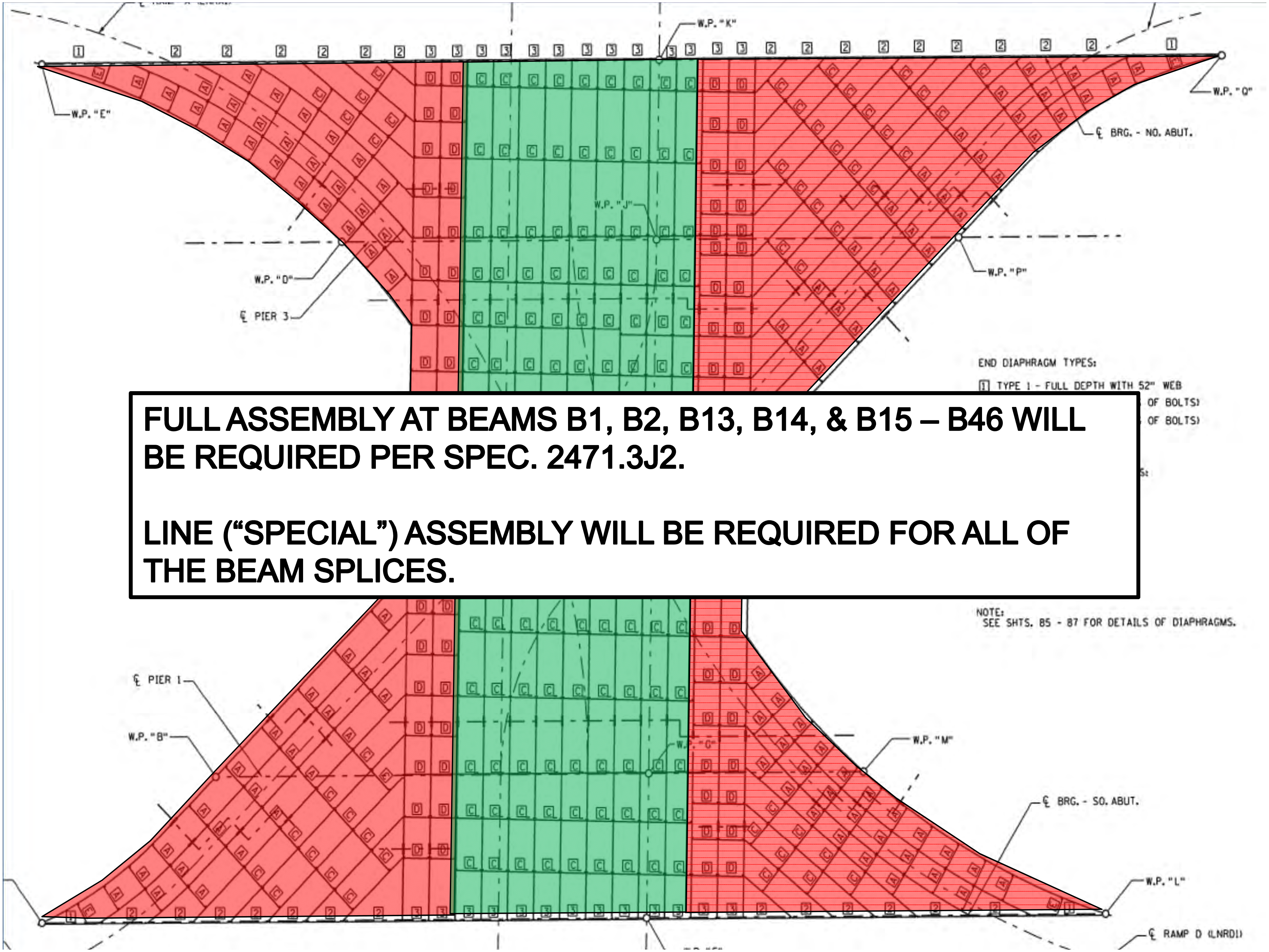
Fabrication – Assembly

Line Assembly (2471.3J1)

- aka "Special" Assembly
- Oversized bolt holes
- Detail diaphragms for cross-slope

Full Assembly (2471.3J2)

- Standard bolt holes
- Girders drilled in "No-Load Condition"
- Limit area required when possible
- Beam rollover



FULL ASSEMBLY AT BEAMS B1, B2, B13, B14, & B15 – B46 WILL BE REQUIRED PER SPEC. 2471.3J2.

LINE ("SPECIAL") ASSEMBLY WILL BE REQUIRED FOR ALL OF THE BEAM SPLICES.

CHANGE IN SLIDE ORDER

Constructability

- Construction Assumptions

CHANGE IN TEXT

Constructability

ELEMENT	STRAIGHT	CURVED	
CHORD LENGTH	L ≤ 145ft	L ≤ 100ft	L ≤ 145ft
CHORD MIDORDINATE	n/a	3ft ≤ M ≤ 6ft	< 3ft
FLANGE WIDTH	$b_{fc} \geq {}^{L}/_{85}$	$b_{fc} + (2\text{"} \text{ to } 3\text{"}) \geq {}^{L}/_{85}$	
SHIPPING HEIGHT	≤ 13'-6"		

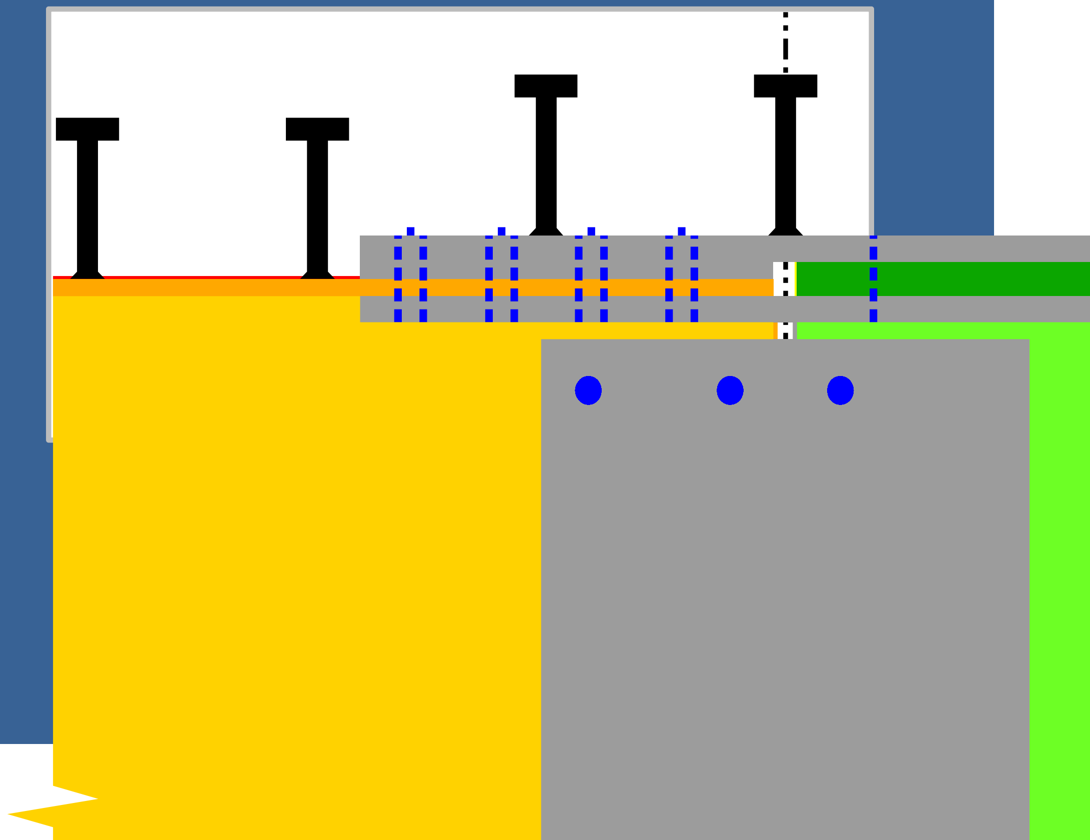
Constructability

Stool Heights

- Min. Stool = 1.5”

Shear Connectors

- 2” above deck bottom
- 3” below top of deck



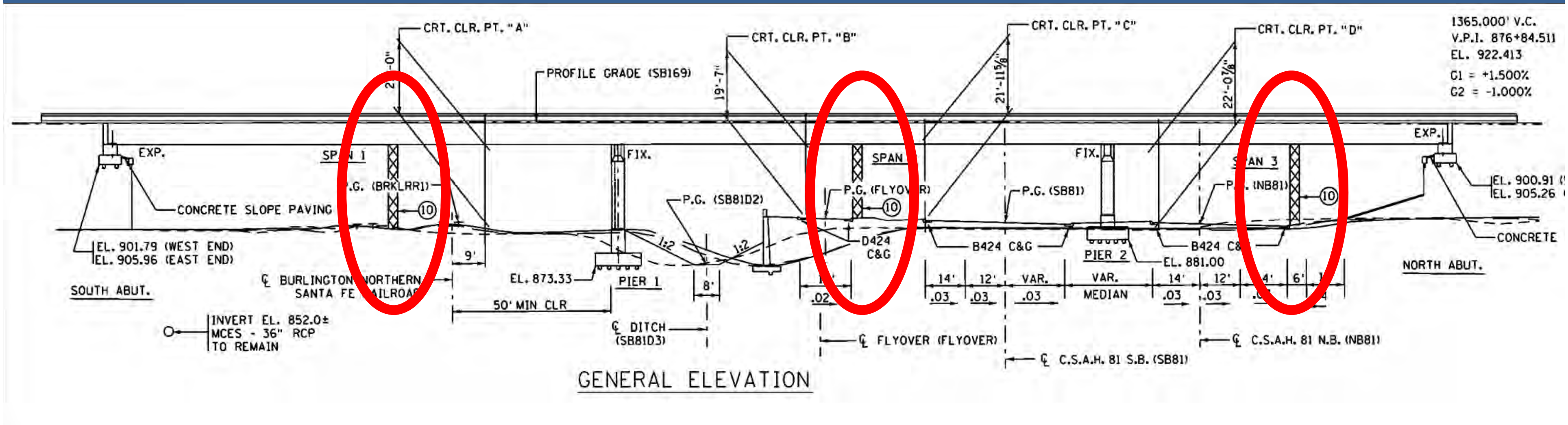
Constructability

Constructability

- Temporary Tie-Downs
  - Uplift at abutments
  - Global stability

Constructability

- Shoring Towers locations must be shown on GP&E plan sheets for MnDOT Projects



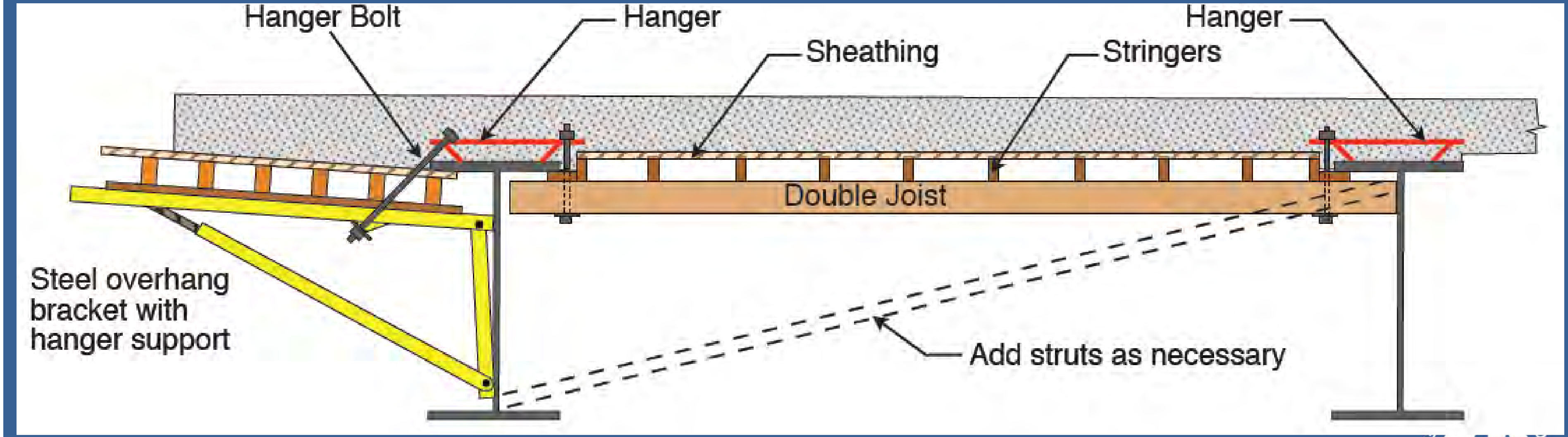
Constructability

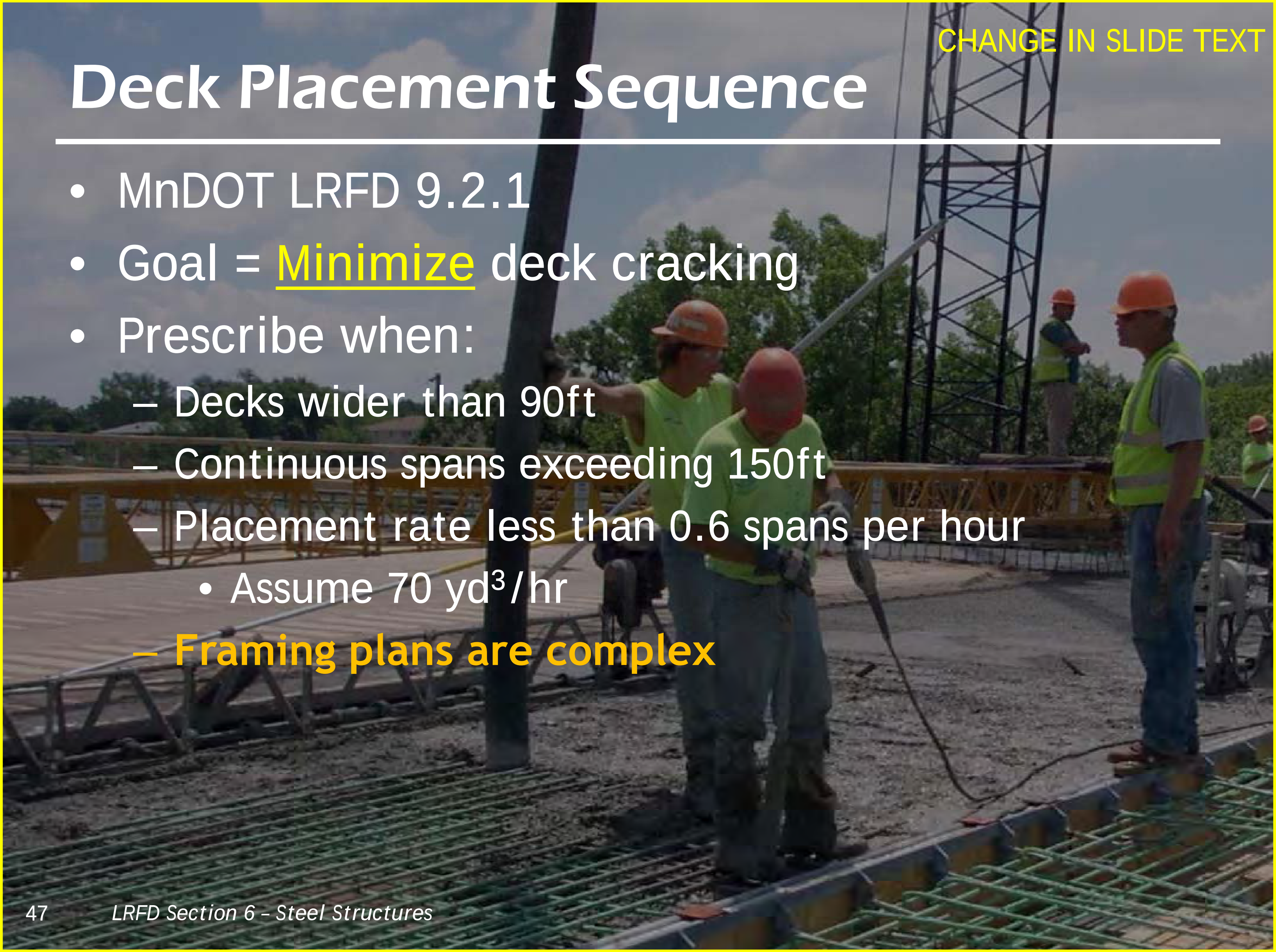
Constructability

- Shoring Towers required for:
  - *Stability*
    - Unless contractor's methods/calculations can prove otherwise
    - Minimizes locked-in stresses
  - *Geometry Control*
    - Ensures the quality of the final product

Constructability – Loads

- Dead loads
  - Formwork
  - Wet Concrete
  - Hardened Concrete
- Live loads
- Other Transient Loads
  - Wind
  - Water
  - ~~Seismic~~ <= Not in MN!
- Locked-In Stresses





CHANGE IN SLIDE TEXT

Deck Placement Sequence

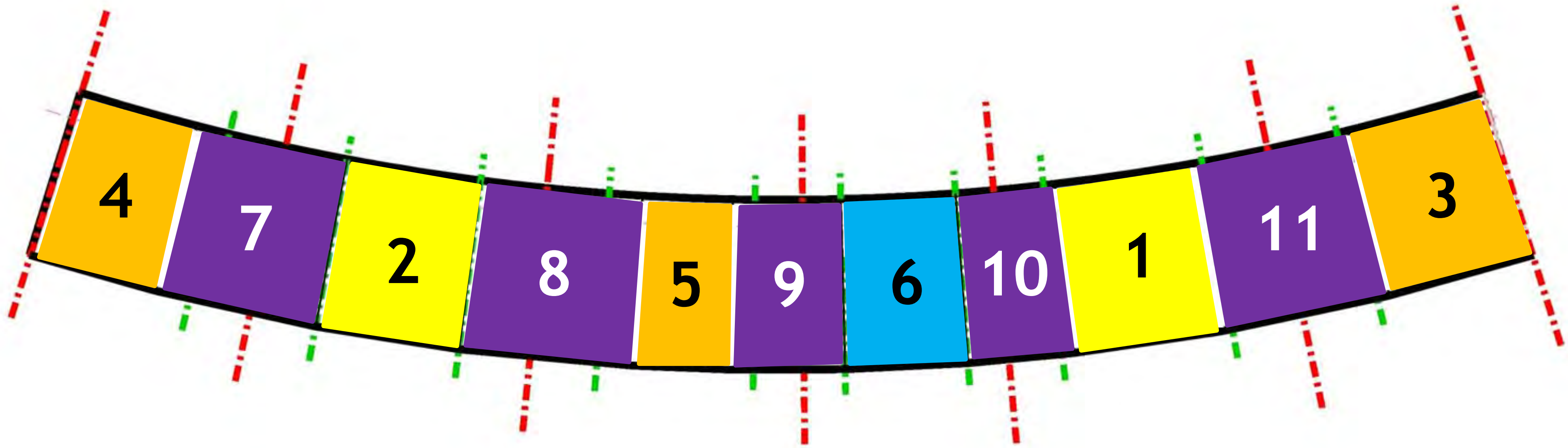
- MnDOT LRFD 9.2.1
- Goal = Minimize deck cracking
- Prescribe when:
  - Decks wider than 90ft
  - Continuous spans exceeding 150ft
  - Placement rate less than 0.6 spans per hour
    - Assume 70 yd^3/hr
  - **Framing plans are complex**

Deck Placement Sequence

- Dependent on length of spans
  - 150ft to 200ft Spans
  - Greater than 200ft
  - Unique Span Arrangement / Framing
- 72 hour waiting period between adjacent positive moment pours
- Min. Pour Rate

Deck Placement Sequence

- Positive Moments First
- End Spans & Short Positive Moment
- Negative Moments



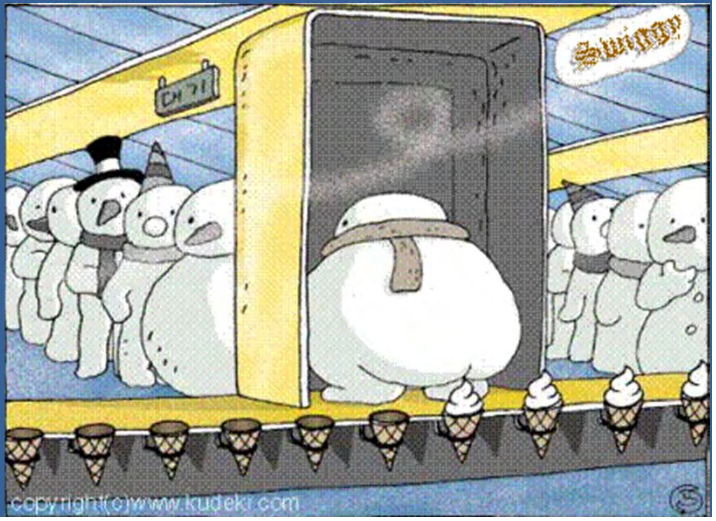
Deck Placement Sequence

- Beam Stresses
- Deck Stresses
- Uplift
- Deflection
- Camber

Software

Consider the geometry:

- Straight beam lines
- Concentric/non-concentric beam lines
- Large internal angles
- Changes in curvature mid-span
- Skewed abutments
- Bifurcation or splayed layout



Software

- Loads
  - Steel dead loads
  - Formwork and construction loads
  - Live load application
- Deck placement sequences
- Direction of global axis
- Fixity of beams and bearings
- User-defined commands
  - i.e. MDX includes “MnDOT Exceptions”

Detailing & Drafting

- Clear and concise details
- Dimension labels
- Significant figures
- Standard notes (MnDOT LRFD Appendix 2)
  - Assembly type
  - *Standard* vs. *Oversized* bolt holes
  - Well defined
  - Plan sheet location

STRUCTURAL STEEL NOTES

Detailing & Drafting

- Sole Plate
  - Include in girder quantities
- Galvanized Type III Weathering Steel Bolts
  - Field Painted Bridges
- Weld Symbols
- Temperature
  - Include on plan sheets

Reviews – Please include

- Plan Sheets
  - Framing Plan
  - Cross-sections
  - Structural Steel Details
    - Beams
    - Diaphragms
    - Splices
    - Camber
  - Pour Sequence (when applicable)

Reviews – Please include

- Design Calculations
  - Code References!
  - Software Runs (digital is best)
  - Load assumptions and computations
  - Description of methodology for determining element sizes
  - Other assumptions
  - Tabulated results of iterations effecting design
  - Notes related to incomplete portion of the design

Questions

- Top
- Design
  - General
  - Plates
  - Diaphragms
  - Loads
  - Analysis
- Fabrication
- Constructability
- Deck Placement
- Software
- Detailing
- Reviews

Thank you for
your participation!

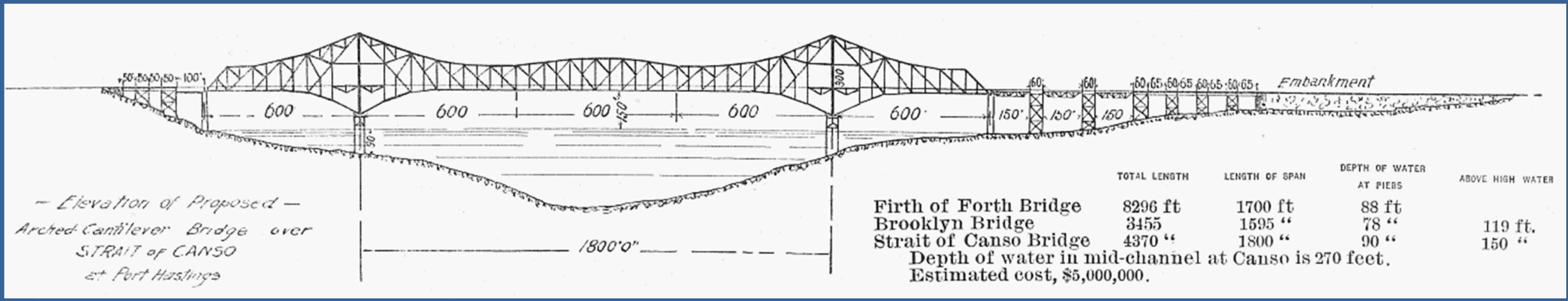
Preliminary Bridge Design Topics

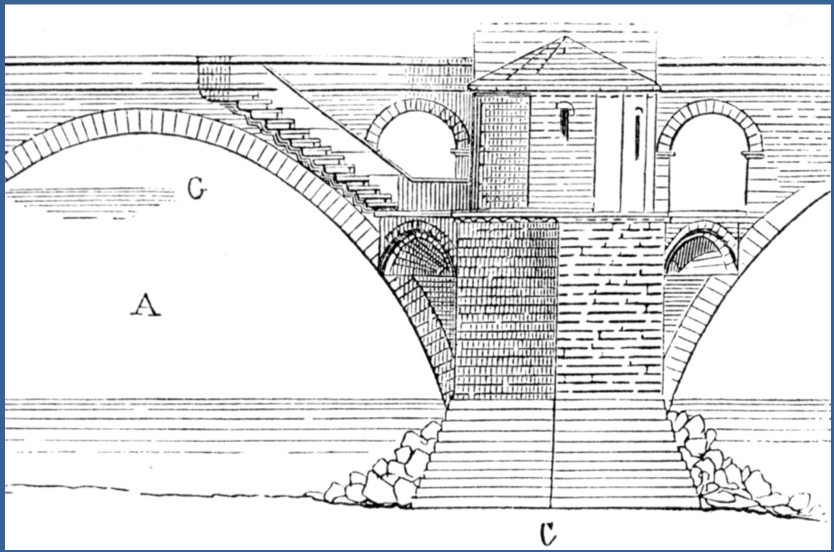
Keith Molnau
Preliminary Bridge Plans Engineer

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. . .





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

MINNESOTA DEPARTMENT OF TRANSPORTATION

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

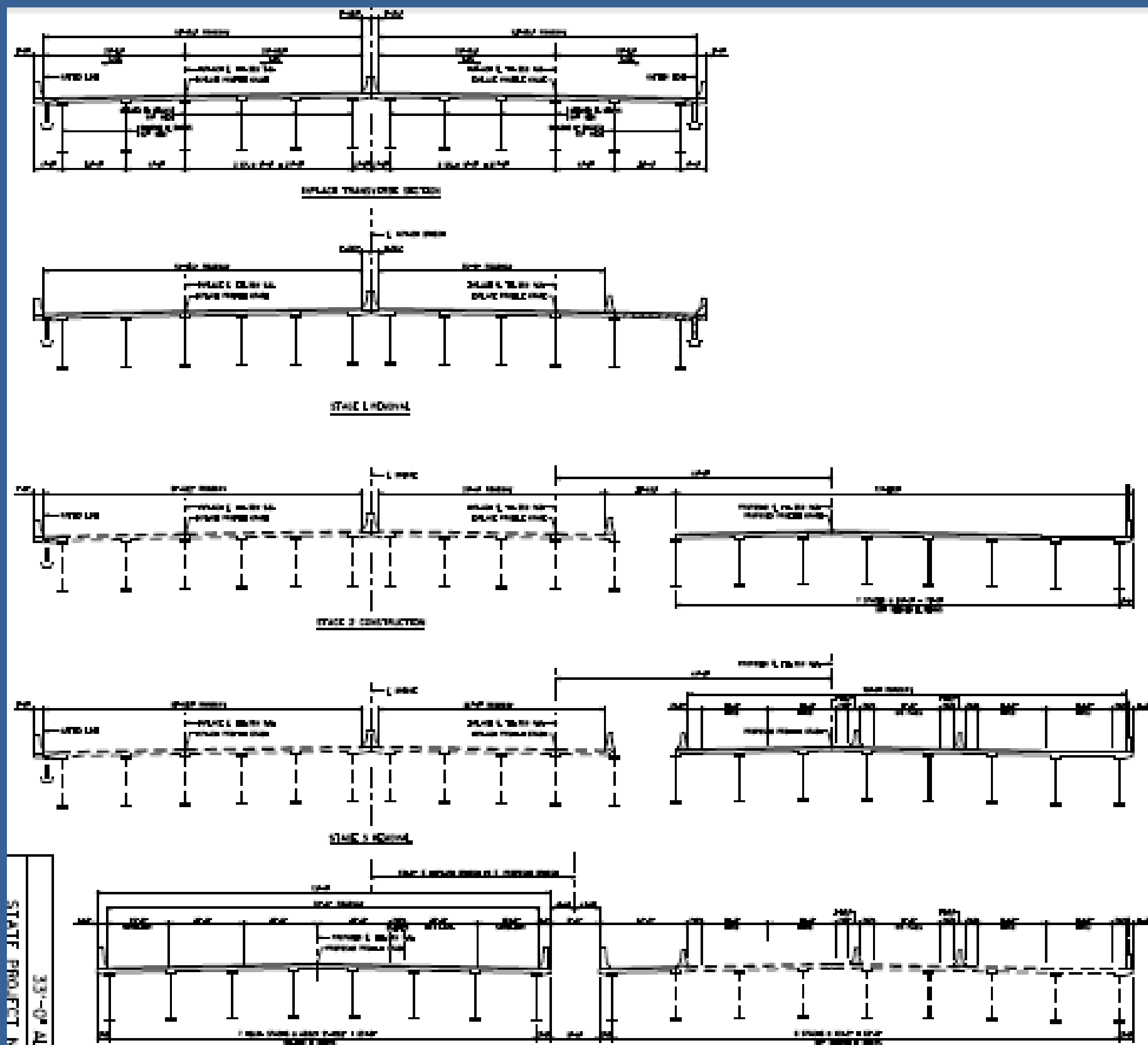
ONCE SUBSTRUCTURES ARE LOCATED, DRAFT PRELIMINARY BRIDGE PLAN ARE SUMBITTED TO MNDOT FOUNDATIONS UNIT FOR RECOMMENDATIONS.

Apply lessons learned: Are there any Artesian Conditions ?

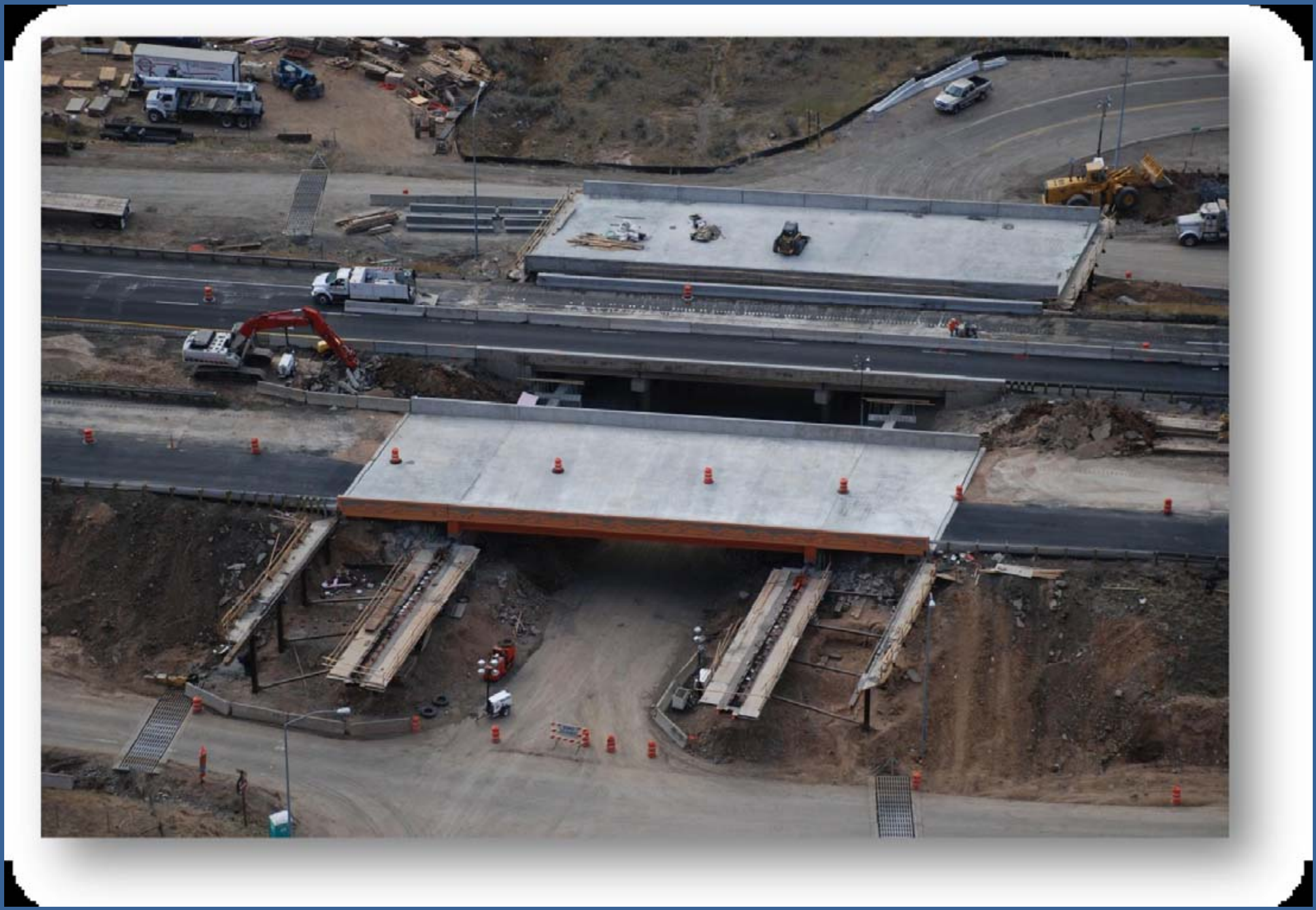
Other Foundations Considerations

- 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!

MINNESOTA DEPARTMENT OF TRANSPORTATION

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:

- <u>If we just can’t get 16’-4” of vertical clear…</u>

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

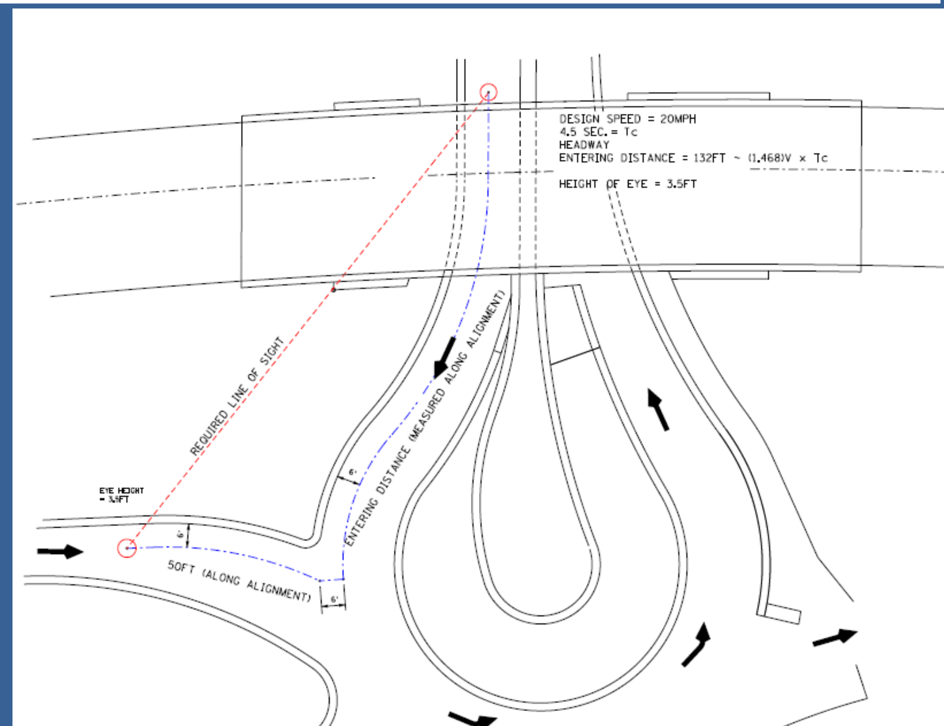
MnDOT LRFD Bridge Design Manual

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

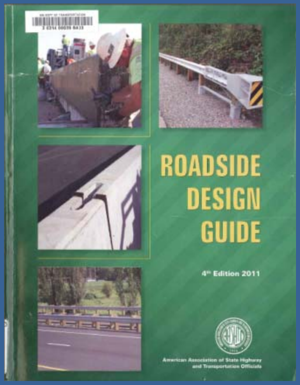
- Section 12-4.05.01 modifies it to values based on a t_c of 3.5 to 4.5 seconds

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 ….

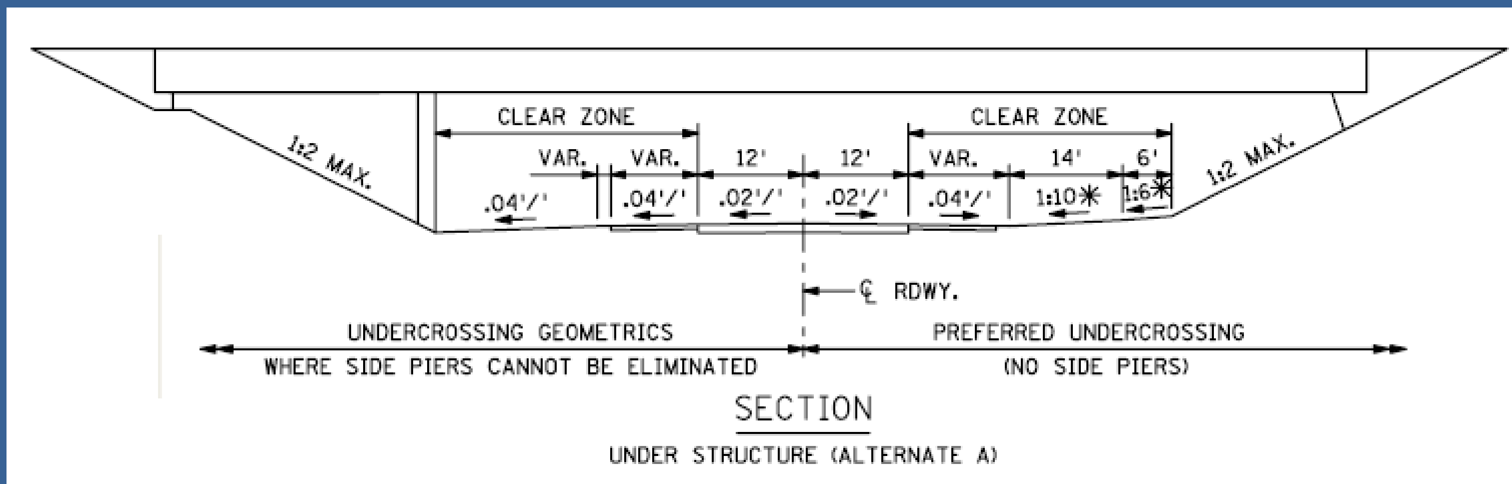
- Suggested Clear Zone Table 3-1 unchanged

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

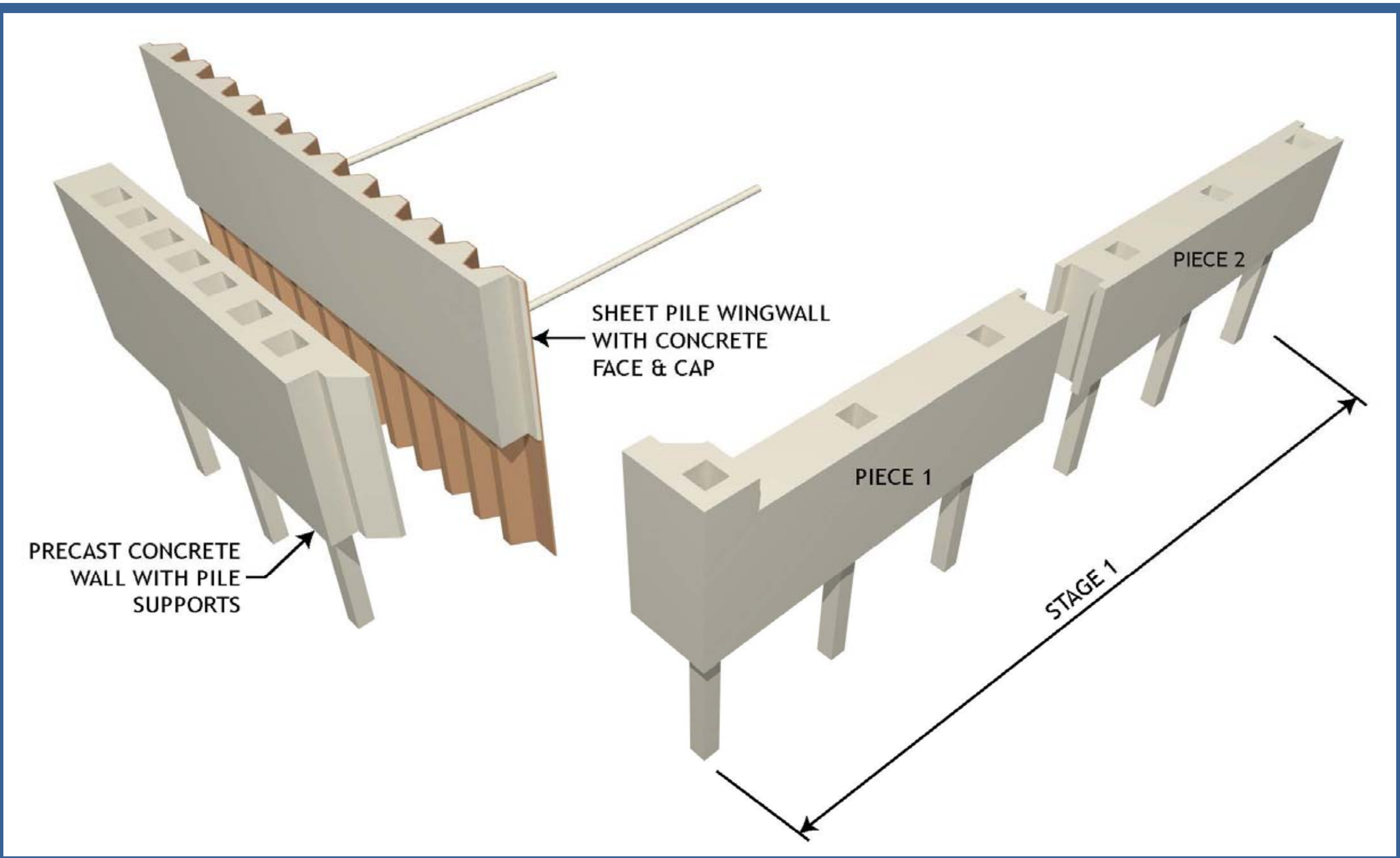
Integral Abutment – height exceeds standards, with Precast sub structure

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

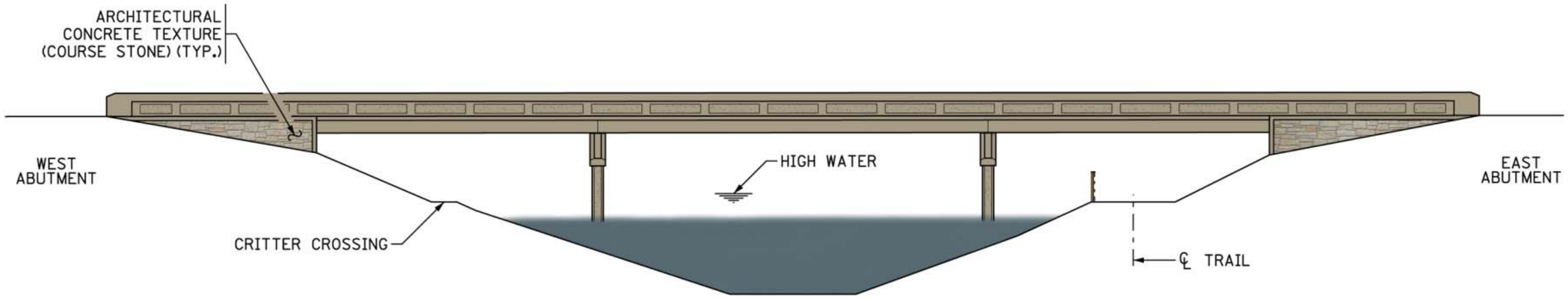
Boardwalk for trail to reduce the extent of retaining walls and minimize impact to wetlands

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

Precast Element Concepts

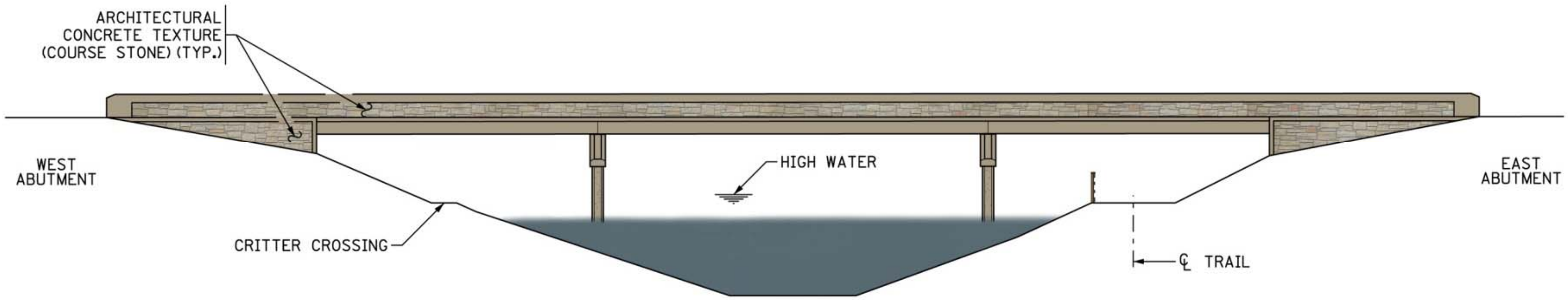


Aesthetics Concepts



CONCEPT 1

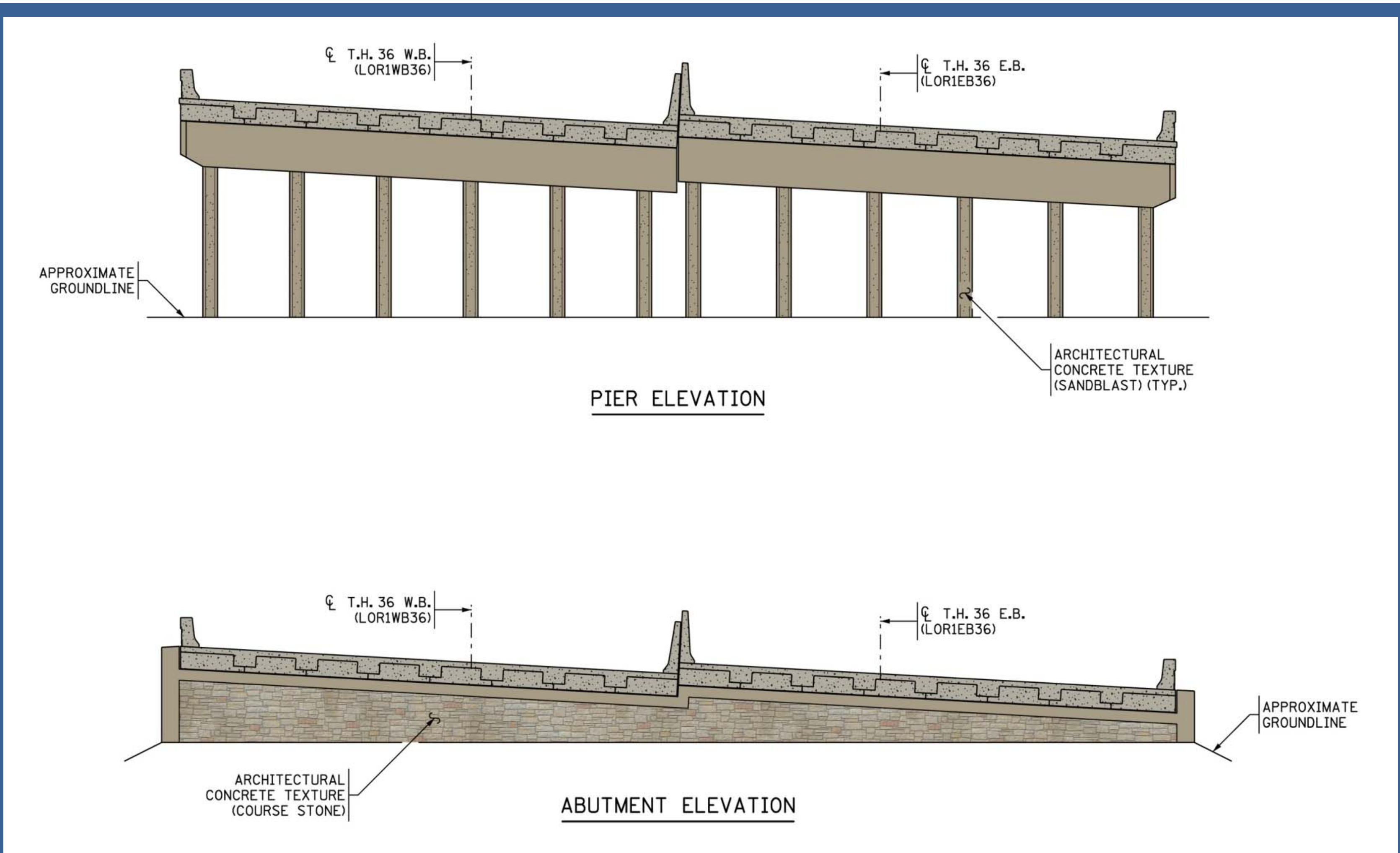
SOUTH ELEVATION



CONCEPT 2

SOUTH ELEVATION

Aesthetics Concepts



Questions

Miscellaneous Topics

Kevin Western
St. Croix Crossing Project
Design Manager

Outline

- Pedestrian Truss Bridges
- Pay Items / New Spec Book
- Design Build
- Memos to Designers
  - Plain Elastomeric Pads
  - Barrier Slope
  - Stainless Steel
  - Temporary Barriers

Outline

- Zone of Intrusion
- Adhesive Anchors
- Maintenance Issues
- Fixity / Bearings
- Future AASHTO Items

Pedestrian Truss Bridges

- "LRFD Guide Specifications for the Design of Pedestrian Bridges"
  - New in 2010
  - New special provision (Brian Homan contact)
  - Checking procedures for prefab truss

- What changed?
  - Loads (not really)
  - FC fabrication

Pay Items / New Spec Book

- New specification will be out later this year
  - HOPEFULLY!
  - Look for a transition plan with release
  - Change to active voice

- Pay Items
  - Please include draft list with 60% plans
  - Check of quantities is important and required

Design Build

- Quality process is important
  - We should see consistent approach from designers
- Changes from standards
  - Additional checking and review may be needed
  - Special provisions important
- Encourage ATC innovation
  - After selection change is Value Engineering item
    - We must see cost savings
    - 'Stretching' standard is not equal value

Memos to Designers - PEP

- Plain Elastomeric Pads
  - ‘Bulging’ of pads
  - Problems on several projects around the state
    - Mainly recent projects
  - AASHTO study is underway

- Possible Causes
  - Fab process
  - Materials
  - Stay tuned!

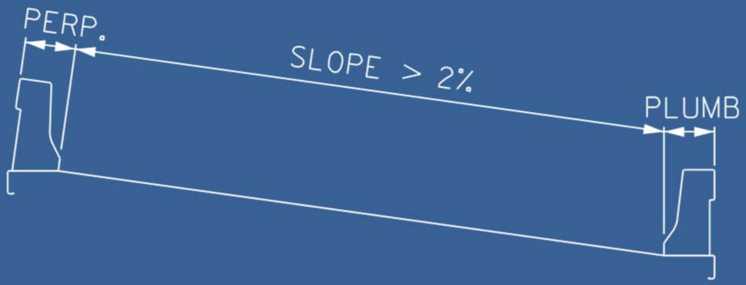
Memos to Designers - PEP

- Short term solution
  - Cotton Duck Pad
  - Has been used on RR structures
  - Great compressive capacity
  - Limited lateral movement

- Other option
  - Reinforced elastomeric pad
    - One ½ inch thick internal pad
  - Can still use PEP at integral abutments

Memos to Designers – Barrier Slope

- Sloped barrier requirement
  - Required on high side of superelevated bridge
  - 2% or greater slope



- Why needed?
  - Crash test concern
  - Recent experience with vehicle

Memos to Designers – Stainless Steel

- Stainless steel reinforcement
- Tech Memo on use
  - Complex Bridges
  - Large cost structures / major projects
  - Superstructure including barrier
  - Tied with HPC

- Potential design manual additions
  - Deck design example
  - Standard selection table
  - Consider non elastic-plastic yield strength

Memos to Designers – Temp Barriers

- Discontinuance of B920
  - Lack of testing, validation

- Interim policy based on:
  - Past practice
  - Draft research findings
  - Other state policies

Memos to Designers – Temp Barriers

Minimum Distance from Edge of Deck to Back (Non-Traffic) Side of Barrier on Bridges and Approach Panels			
Construction Posted Speed Limit	50 mph or greater or with significant geometric elements*	40-45 mph	35 mph or less
Anchored	4'-0"	2'-0"	6"
Unanchored	N/A	6'-0"	3'-0"

- Use more restrictive setback distance where:
  - Travel speeds significantly exceed the posted speed limit
  - Heavy truck traffic
  - Situations warrant increasing the dimensions in the chart

MINNESOTA DEPARTMENT OF TRANSPORTATION

Memos to Designers – Temp Barriers

- Anchor requirements:
  - Three, 1⅛” diameter anchor rods on traffic side only for each barrier segment
  - Bridge deck
    - 5½” minimum embedment and 6” maximum embedment
    - Maximum hole depth: 1½ inches less than the slab depth
  - Approach panels with top and bottom reinforcement
    - 5½” minimum embedment
    - Approach panels with no reinforcement or only a bottom mat of reinforcement 9” minimum embedment

Memos to Designers – Temp Barriers

- Anchors (cont):
  - Use only where concrete is in good condition
  - Through-deck anchoring may be utilized on existing bridge decks in poor condition.
  - Ultimate (nominal) strength of 14 kips
  - Proof tested to 7 kips
  - Include special provision for additional testing requirements
  - Minimum deployment length and anchorage requirements past the end of the bridge determined by the roadway designer and shown in the traffic control plans

Zone of Intrusion

- Why important?

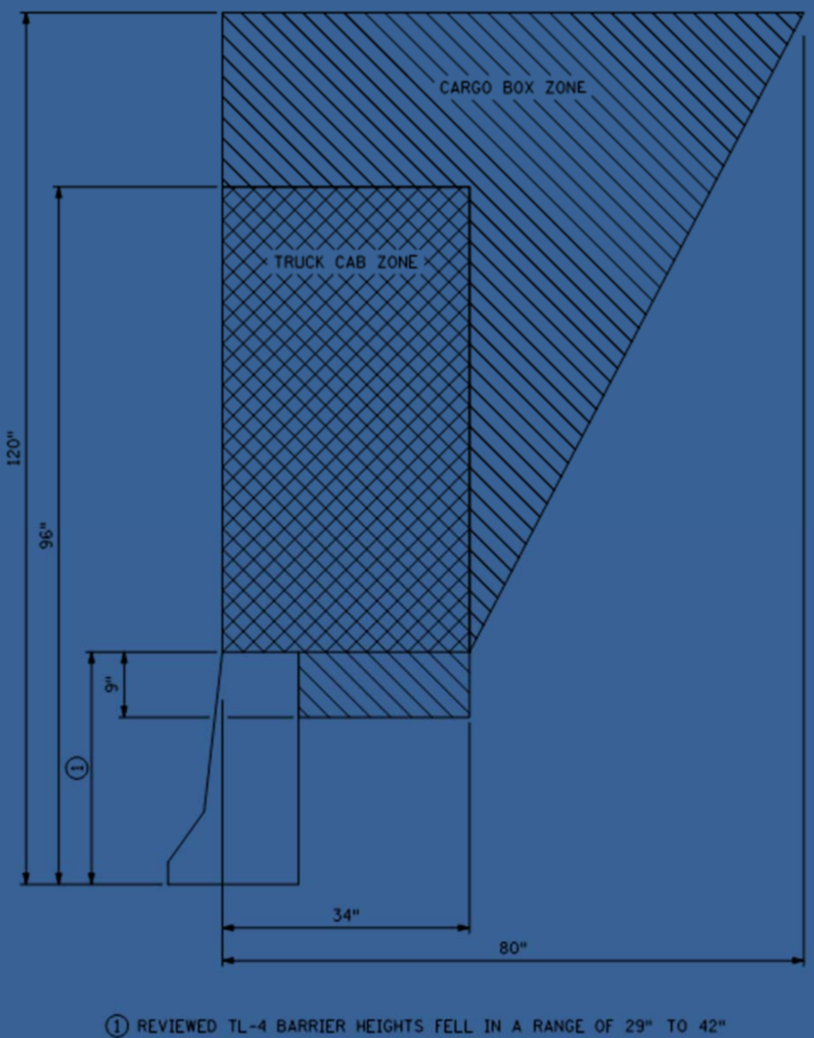
- Allow safety items only (i.e. lights, signs)
- Limit other items (i.e. pilasters)
- Protect by removing
  – Cables
  – Other critical structural elements

Zone of Intrusion

Reproduced from:

"Guidelines for Attachments to Bridge Rails and Median Barriers"

Midwest Roadside Safety Facility
February 26, 2003



Adhesive Anchors

- T-1 Rail Issue
  - Short anchors (hitting rebar)
  - Inadequate bond
  - Not enough capacity
- Retrofitted several T-1 rails
- Process change
  - Installer training and certification
  - Increased in-field testing
  - Key issues noted at inspector training
  - In future use only CIP anchorage with T1 rails
  - Still utilized on non-traffic rails

Maintenance Issues- Deck Cracking

Fixity and Bearings

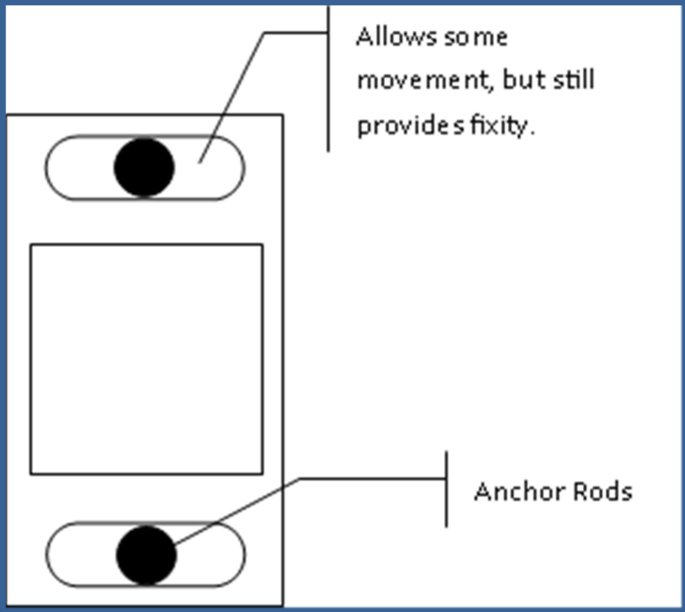
- Increased use of pot and disc bearings
  - Utilize AASHTO movement load factor
  - Vertical and lateral loads
  - List service and strength loads
- Modular joints
  - Historically only 20 year service life; want 100 years
  - New design and fabrication criteria – early 2000's
  - Fatigue is critical (14.5.6.9.7b)
    - Use infinite life for fatigue range
    - Average opening: consider creep, potential movements, 50 years as mid-life

Fixity and Bearings

- Requirement for two fixed piers
  - Stop end of bridge joints from closing/ripping
  - Better control of bridge movement
  - Increased thermal forces in piers
    - Utilize slotted anchor rod holes w/ exp. bearings

- Shear lugs to restrain lateral movement
  - Curved and skewed bridges
  - Concrete lug (preferred)
  - Steel lug allowed

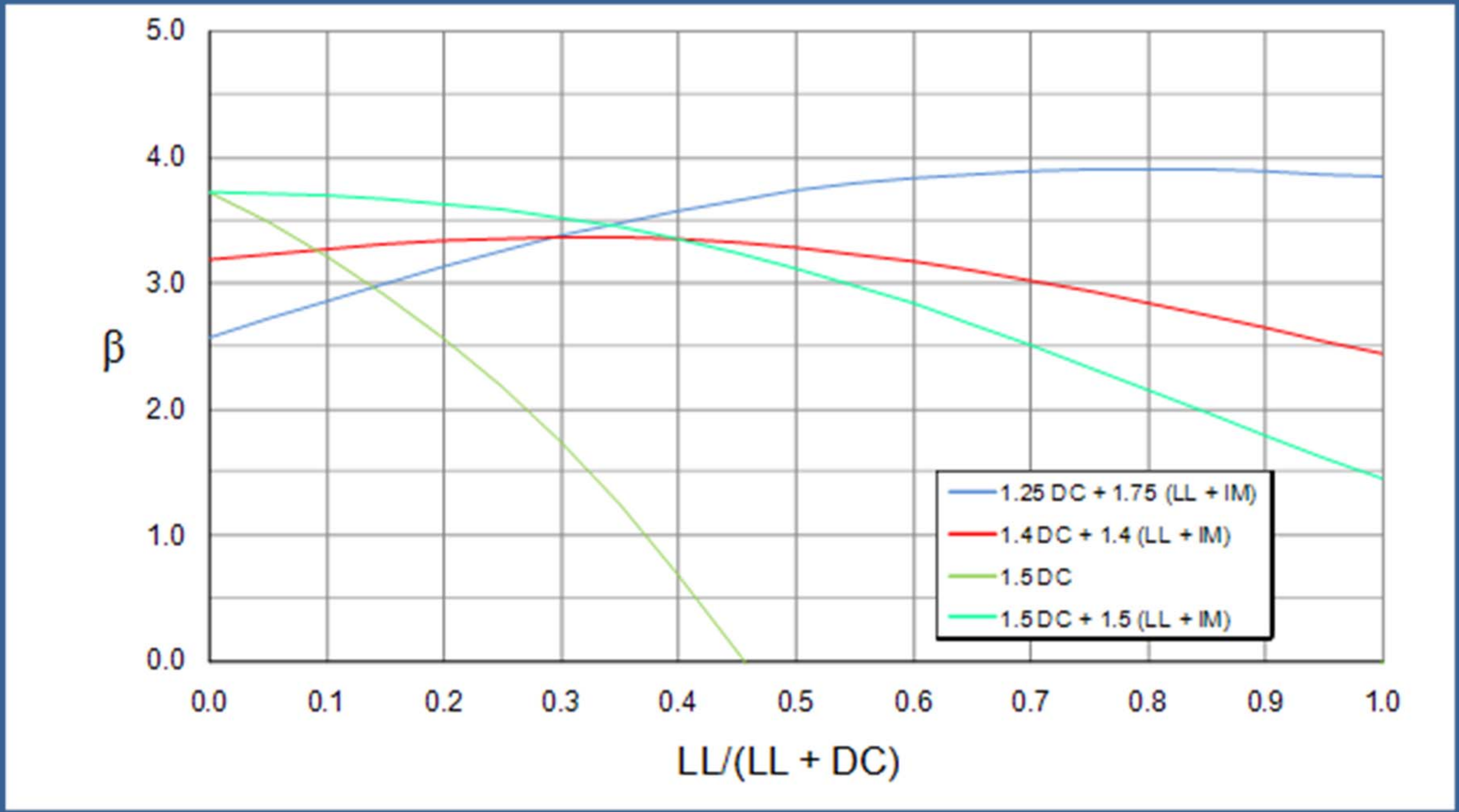
Fixity and Bearings



Shear lug

Future AASHTO Items

- Strength IV Load Combination
  - Possible change to 1.4 (DL+LL)



Future AASHTO Items

- Refined Analysis Section and Training
  - Explain 2D vs. 3D modeling
  - Analysis / resistance factor
  - NHI training being discussed

- Rewrite of Concrete Section
  - Clarify and REDUCE!

Questions