

# Superstructure Construction Inspection

## Session 4



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## Session 4 – Learning Outcomes

Upon completion of this session participants will be able to:

- Identify the critical elements of superstructure construction.
- Perform basic plan and layout checks on critical bridge superstructure elements.
- Identify the equipment used for superstructure construction.
- Perform girder inspection.
- Perform bar steel reinforcement inspection.
- Perform concrete placement inspection.



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## Superstructure Definition

- The main superstructure component is considered that which spans between and bears on the substructure units
  - Girder (Steel or Prestressed Concrete)
    - Substructure supports girders
    - Girders support the deck
    - Deck supports traffic
  - Slab
    - Slab bears on the substructure supporting itself and traffic
  - Truss
    - Bottom chord bears on substructure
    - Floor system supports deck and transfers load
  - Arch
    - Similar to truss



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## Superstructure Elements

### General

- Bearings/Bearing Pads
- Girders
- Concrete Diaphragms (at substructure units)
- Steel Diaphragms
- Shear Studs/Shear Reinforcement/Stirrups
- Deck/Slab
- Sidewalk/Median
- Parapet/Railing



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## Slab Span Bridges Components

### General

- No Girders
- Slab Supports Itself when complete
- Small spans
- Sidewalks/Median
- Railing/Parapet



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## Installing Polyethylene Sheeting

Allows for slab movement while abutment remains fixed



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## Forming the Slab



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## Steel Girder Superstructure

Typical Evaluation Elements

- Steel Girders
  - Bearings
  - High Strength Bolts
  - Shear Studs
- Diaphragms
- Deck
- Railing/Parapet



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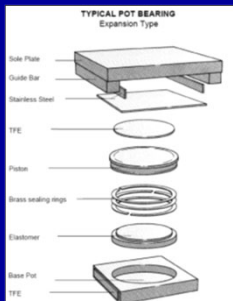
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## Steel Girder - Pot Bearings



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### Steel Girder – Rocker Bearing



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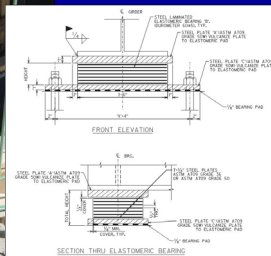
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### Steel Girder – Laminated Elastomeric Bearing

Used for expansion



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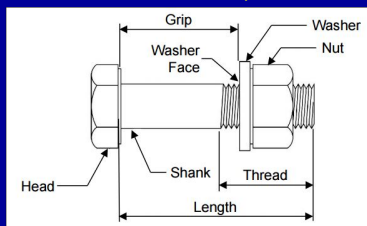
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### Fasteners

Verify bolt type and diameter. Must conform to ASTM F3125

- Structural Bolts
  - A325 (120 ksi yield)
    - Most commonly used
    - Hot dip galvanized (A153)
  - A490 (150 ksi yield)
    - Heat treated
    - Typically not allowed
- Washers
  - ASTM F436
  - Flat washers
- Nuts
  - ASTM A563

Bolt Assembly



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## High Strength Bolt Training

- Do not do any testing or inspection on bolts unless you have been properly trained or work with someone who has.
- Definitely a specialty knowledge area
- Classes are put on every few years



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## Bolting - Rotational Capacity Tests

Rotational Capacity Tests to be performed on each size of bolt/washer/nut used

Ensure nuts and bolts are lubricated and stored in a sealed container in the shade

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## Ro-Cap Testing Form

DT2113

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### Pre-Installation Verification Test of High Strength Bolts Form

DT2114 – To verify method used to install bolts can obtain proper tension.

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### Bolt Installation Methods

- Turn of the Nut
  - Snug-tight: Impact or spud wrench
  - Once snug-tight the Bolt/Nut/Washer are marked, nut then turned predetermined number of "flats" to obtain necessary tension for bolt diameter/length
- Direct Tension Indicator
  - Washer with specifically designed protrusions on one side
  - Placed under bolt head
  - Nut turned until protrusions flattened to specified gap. Feeler gauge is used to help determined the gap.
- Contractor will test min. 10% of each connection (2 min.)

Further information available in CMM section 5-20.6 and spec 506.3.12.3.

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### Steel Girder Delivery

Check girder/hardware marking vs. shop drawings, check for shipping damage

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### Steel Girder Fit-up

- 25 % temp pins placed to align connection
- Bolts should drop into holes (no hammering)
- Slip Critical Connection
  - Design bolts to pinch plates to the girders
  - Strength from friction between faces of plates and girders
- All burrs must be removed with light grinding
  - Repainting is required
  - No reaming holes without designer approval



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### Steel Girder Fit-up

Bad fit up procedures and reaming of holes



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### Steel Girder - Splices

Use a calibrated torque wrench to inspect 10% (2 min.) of bolts at every connection/ initial and date each splice when it is acceptable



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### Steel Girder Erection

Note use of the spreader beam used to distribute the loading and provide balance for the pick




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### Steel Girder Erection

Install diaphragms continuously to provide stability




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### Steel Girder – Shear Studs

Be sure to inspect the contractor's location marks of studs prior to beginning installation/ Note the use of ceramic welding shields

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### Steel Girder – Shear Stud Installation

- SS 506.3.19.1 - Approved annual welding plan
  - Submit DT2320 each day to inspector
- Top flange cleaned to allow proper base material
- Zinc-primer on top flange is weldable
- Any bare steel should be painted with zinc primer
  - Studs are not painted




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### Steel Girder – Shear Stud Inspection

Use 3-5 lb hammer/ Listen to sound while striking/  
Dull thud indicates improper weld




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### Prestressed Girder Superstructure

Typical Elements

- Concrete Girders with Shear Reinforcement
- Diaphragms
- Deck
- Railing/Parapet



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**Checking Concrete Bearing Area**  
 Check during concrete placement, recheck before girders are installed



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**Elastomeric Bearing Pads**  
 Note filler material in front of bearing



09/22/2010 09:04 PM

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**Assembling Safety Posts to Girder**



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### Diaphragm Angle Clips Assembled

Depending on site conditions, this may be done after girders placed



10/04/2010 07:48 AM



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### Girders Lifted from Delivery Truck



09/28/2010 10:31 AM



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### Girder Launcher Used




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### Rechecking Bearing Pad Location



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### Prestressed Girders In Place

Lateral support installed/ Typically diaphragms are installed after setting



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### Install Diaphragms or Other Lateral Bracing



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**Placing Steel Diaphragms**  
 Install diaphragms as soon as possible/ Tighten bolts to snug-tight condition




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**Girders and Diaphragms Set**




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**Survey Top of Girder Elevations**  
 Note where the surveyor is taking the shots

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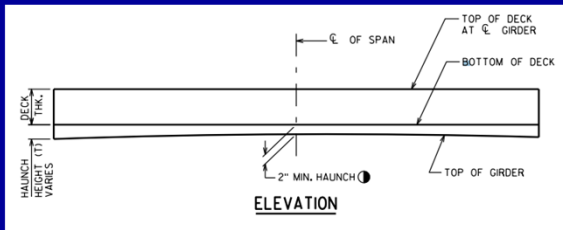
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### Slab Haunch Detail Concept

Bridge Manual Standard Drawing 19.32



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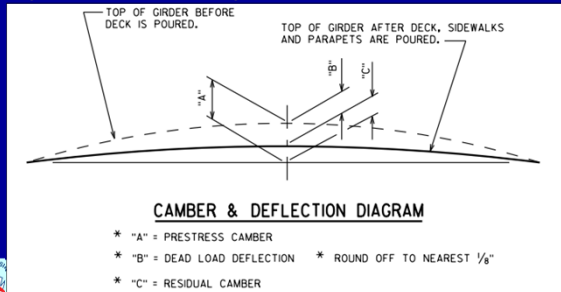
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### Slab Haunch Detail Concept

Bridge Manual Standard Drawing 19.32



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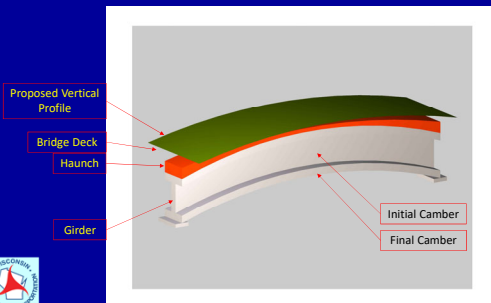
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### Slab Haunch Detail Concept – Cont.

Bridge Manual Standard Drawing 19.32



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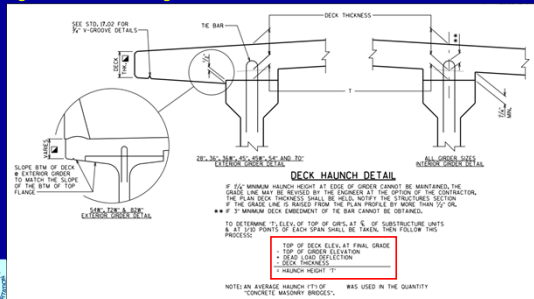
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## Slab Haunch Detail

Bridge Standard Drawing 19.32



## Calculate T's/Haunches/Fillets

Spreadsheet available in Pantry Software

PROJECT NO. 1012-10-79		SPAN NUMBER 1		GIRDER NUMBER 1											
		0	1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10			
CONST. GRADE (ft.)	0-plan	686.20	686.18	686.15	686.12	686.10	686.07	686.05	686.00	685.97	685.95	685.90			
D/L DEFLECTION (in.)	0-plan	0.00	0.50	1.00	1.38	1.50	1.63	1.50	1.38	1.00	0.50	0.00			
CONCRETE GRADE (ft.)	0-comp (1-HA/10/12)	686.20	686.22	686.23	686.23	686.23	686.21	686.18	686.11	686.00	685.97	685.90			
DECK THICKNESS (in.)	0-plan	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00			
POSITIONAL G/L (ft.)	0-comp (1-HA/10/12)	686.20	686.22	686.23	686.23	686.23	686.21	686.18	686.11	686.00	685.97	685.90			
TOP OF GIRDER G/L (ft.)	0-haunch	685.20	685.23	685.27	685.31	685.31	685.28	685.25	685.19	685.11	684.99	684.91			
CUT OR FILL (ft.)	0-comp (1-HA/10/12)	0.25	0.24	0.23	0.18	0.18	0.18	0.18	0.18	0.18	0.23	0.25			

### Notes:

- Note the units of measurement for each row.
- Fillets should be calculated at 1/10 points of span.
- Fillets for wide flange girders to be calculated on each side of girder.

## Small or Negative Haunch

- What does it mean?
  - Improper entry in Pantry sheet
  - Top flange will be close or embedded in underside deck
  - Girder was manufactured outside the tolerances of the plan
    - Girders manufactured far in advance of use can gain camber over time.
- Corrective actions
  - Contractor may use alternative decking methods (\$\$\$)
    - Standard Borg hangers minimum calculated haunch should be ~0.1' (1.25"). Anything less may require alternative decking
  - Raise vertical profile of roadway across structure uniformly
    - Caveat: Any elevation raise greater than 0.04' (1/2") must be approved by BOS
- Send out DIN to the designer
  - May be a design error

### Placing Poly Sheeting, Filler, and Cork



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### Forming Concrete Abutment (End) Diaphragms



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### Forming Concrete End Diaphragms



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### Diaphragm Reinforcement in Shear Key



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### Reinforcement/Girder at End Diaphragm



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### End Diaphragm Forming at Wing



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### End Diaphragm Reinforcement Complete



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### Forming of Concrete End Diaphragms



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### Pier Diaphragm Forming and Reinforcement



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## Deck Joist Installation



A photograph showing the underside of a bridge deck during construction. Large steel joists are visible, supporting the deck structure. The image illustrates the installation of the deck joists.

## Deck Form Supports

Inspector should periodically check the haunches as joists are set to elevation



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### Completed Haunches/ T's /Fillets

Final check of haunches and stirrups / Cut off pick points




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### Deck Overhang Falsework

Check that the top of the top flange will be embedded within the bottom of the overhang




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### Overhang Brackets on Girders

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### Adjusting Overhang Supports



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### Edge of Deck Formwork

Note the chamfer for drip groove



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### Transverse Bottom Deck Steel

Check Chairs to Ensure Proper Cover per Plans



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### Transverse Bottom Deck Steel



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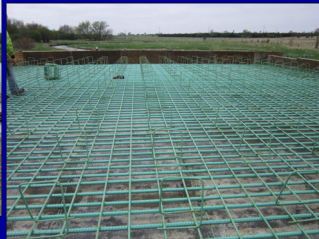
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### Placing Bottom Mat Slab Reinforcement

Note the spacing of the continuous and individual bar chairs



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### Placing Top Mat Slab Reinforcement

Slab Span



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### Percentage Tied Reinforcement

- Reinforcement spaced  $<12"$  on center
  - 50% tied
- Reinforcement spaced  $\geq 12"$  on center
  - 100% tied
- Once tied "kick the deck"
  - The intent of tying the reinforcement is to ensure the steel does not shift while walking over it and during concrete placement
  - Bars that easily move should be tied down



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### Top Deck Steel/Deck Waler

Note the lack of separation between top and bottom mat of steel at end of deck



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### Rebar Mat Rigidity

Check ends and edges where bars terminate – Should flex very little under weight



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### Prepping for Bidwell



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### Checking Clearance During Dry Run

Typically every bay (between girders) at every 10<sup>th</sup> point is checked and recorded



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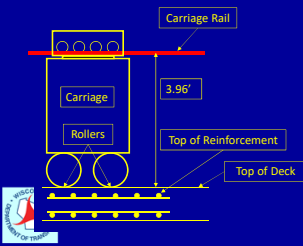
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### Dry Run Clearance Check

- Deck Thickness = 8" (0.67')
- Top of Reinforcement Clear Cover = 2.5" (0.21')
- Rail to Bottom Roller = 3.96'



Girder	1/10 Pt.	Rail to Deck	Rail to Top	Deck Thickness	Clear Cover
		4.65'	4.13'	0.66'	0.23'
		4.64'	4.18'	0.66'	0.22'
		4.63'	4.18'	0.67'	0.22'
		4.63'	4.17'	0.67'	0.21'
		4.64'	4.17'	0.66'	0.21'
		4.62'	4.17'	0.66'	0.21'
		4.61'	4.17'	0.65'	0.21'
		4.61'	4.16'	0.65'	0.20'
		4.60'	4.14'	0.64'	0.18'
		4.59'	4.14'	0.63'	0.18'
		4.60'	4.14'	0.64'	0.18'



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### Checking Clearance During Dry Run

It is preferred to allow 1/8" to 1/4" of clearance for snow plows



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### Adjusting Bidwell After Dry Run

Leg adjustment and check rails and forms for deflection



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### Deck Placement

Prior to placement, what does the inspector need?

- Deck Pre-Pour Meeting (Schedule within 1 week of pour)
  - Establish the logistics of the deck pour
    - Truck Rate/ Concrete Placement/ # Workers
- Evaporation Rate
  - Contractor provided (engineer should verify)
  - Rate dependent on Temperature, Humidity and Wind Speed
  - Should be less than 0.2 lbs water/SF deck/hour (formula in CMM)
- Contractor temperature control plan
- Ensure fogging equipment is present and working
  - Compressor and water supply
- Know the concrete mix design and when QC/QV tests will be taken
  - Ask QC tester for random numbers
- Prepare spreadsheet/notes for taking deck depth checks
- Issue Deck Pour Authorization per Section 501.3.8.2



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### Weather Protection

Temperature plan must be submitted and approved by engineer

- **Cold Weather Protection. Standard spec 502.3.9**
  - Prevent freezing of the concrete until it develops opening strength
  - Keep steel and forms above 40 degrees during pour (may need to preheat)
  - Contractor may need to use heated water, aggregates, or both
  - Temp of deck concrete cannot exceed 120 degrees or fall below 40 during protection period
    - Blankets, plastic, etc are commonly used.
  - No pouring a deck under 32 degrees (ambient) within 24 hours of the pour
    - Must house and heat underside of deck if 20 or less degrees during protection period.



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### Weather Protection

Temperature plan must be submitted and approved by engineer

- **Hot Weather Protection. Standard spec 501.3.8.2**
  - Contractor must act if concrete temp exceeds 80 degrees
    - Possible remedy's are night pours, watering aggregate piles, using cool water, etc
  - Contractor must follow approved temp plan
  - Cannot place if concrete exceeds 90 degrees.
  - Department pays for ice if plan is followed and concrete temps still exceed 85 degrees. Target temp is 80 degrees.
  - Ice is paid at \$0.75/LB. Ice is a last resort.



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### Clean Deck and Rebar



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### Snorkel Truck Pumping Concrete



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### Double pump trucks

Note that a second pump is in place to pick up where the first pump can not reach



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### Concrete Conveyor Truck



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### Concrete Belts



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### Multiple Concrete Belts



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### Tasks During Deck Placement

- Depth Checks
- Watering Deck Before Concrete Placement
- Concrete Consolidation
  - Observe technique and verify all concrete is properly consolidated
- Finishing Texture and Profile
  - Use a 4-6' level to verify the gutterlines are pitched and flowing in the correct direction
- Tracking Timing of Burlap Placement and Fogging
  - HPC in particular requires to be covered and wetted as soon as possible
- Concrete Truck Timing (Checking Batch Tickets/ Mix)
  - Collect truck tickets, and check the batch times and mix
  - Trucks getting backed up may need to be sent off due to time expiration



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### Tasks During Deck Placement

- QC/QV Testing and Results
- Is ambient air and concrete temperature similar to the evaporation rate used?
- Anchor rod projection



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### Deck Finishing with Bidwell



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### Depth Checks

- Layout with 1/10 points taken for dry run (between girders)
- Note depths to within 1/8"
  - Compare results with dry run numbers
    - Depth changes +/- 1/4" should be discussed with contractor
    - Severity of issue will depend on steel cover and trends
    - Recommend using electrical tape to mark proper depth on the rod
- Tools
  - Tape/Stick measure
  - Chaining pin (8" decks)
  - Steel rod (slabs)
  - Rubber overshoes



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### Depth Checks




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### Deck Pour Video



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### QV/QC Testing During Deck Placement

- QC (Contractor) start up test taken before pour can begin
  - Pumps require pre-start up correlation test for air loss
- QC takes air, slump, temp, and cylinders within each subplot (50 CY)
  - Grade E: 6.0% +/-1%; <2 Inch
  - Other Grades: 6.0% +/-1.5%; 1-4 Inch
  - Temp should be within range set by evaporation rate
- QV (Department) will take 1 test every 5 QC tests or at least 1 every lot (500 CY)
- Inspector should record both QC/QV results
- Get concrete sample at point of placement
- If results are non-conforming; Stop placing concrete until results are conforming



HTCP PCC Tech-1 certified tester only can take these tests

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### What Could Possibly Go Wrong?

Be Ever-Vigilant During a Pour

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### Deck Finishing




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### Longitudinal Grooving

Completed at a later date




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**Deck Finishing with Bidwell**  
Wetted burlap is placed as soon as possible to provide for proper curing

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**Deck Finishing with Bidwell**  
Fogging employed to continually wet burlap during deck placement and before soakers can be laid on the deck

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**Deck Curing Period**  
7-day wet cure required for normal concrete  
14-day wet cure required for HPC decks

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### Deck Wet Curing Period & Strength

- 502.3.5.4 May form and place parapets & sidewalks 48 hours after deck placement but no heavy equipment and it properly cures the adjacent deck
- 502.3.10.1.2.1 No construction/public traffic, until wet cure period is complete
- 502.3.10.1.2.3 Except, after concrete cures sufficiently (may be < 3500 psi) light loads may be allowed by the engineer (i.e. parapet construction)
  - Need opening strength to operate hauling equipment to perform subsequent pours
- 502.3.10.1.3 Opening Strength (3500 psi)
  - Cylinders
  - Maturity method (uses sensors placed in the concrete to determine concrete strength)



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### Deck Wet Curing Period & Strength

- Wet cure and opening strength are separate timelines.
- Most likely get strength before wet cure period is complete but wet cure is required for entire 7 or 14 days.
- The basic idea is to keep heavy equipment off the bridge deck during the wet cure.
  - This is possible on most bridge decks. However, when multiple deck pours are needed they are allowed to haul after strength is achieved
  - But the wet cure is ongoing, which can become a mess hauling on top of the wet burlap.
  - Hauling equipment across the bridge for other operations (i.e. earthwork or paving) during wet cure is not allowed



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### Things to Look For

- Monitor burlap to make sure it does not dry out during cure period
- May need plastic on top of burlap to hold moisture
- Deck water run off can cause washouts near the abutment. Contractor needs to have a plan for handling it.
- Decks over traffic may need signage to alert traffic of falling water. "Watch for Falling Water"
- All this should be discussed in pre-pour meeting



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### Railing Anchors

Reinforcement layout through anchoring systems must be inspected carefully




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### Finishing Sidewalk with Straightedge

Check cross slope. Must be  $\leq 1.5\%$




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### Stripping Deck Forms





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### Finished Sidewalk



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### Railing Posts Installed



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### Railing Posts Installed



- Tighten to a snug tight fit and given an additional  $\frac{1}{4}$ " turn
- Nut must have full engagement with anchor rod
- Galvanized shims maybe used under the base plates for alignment



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**Railing Posts Installed**  
 Non-bituminous joint sealer. Check painting requirements for nuts and bolts.




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**Railing Issues**  
 Poorly Painted or Damaged Railing




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**Railing Issues**  
 Poor Railing Joints




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**Railing Issues**

Shipping Tabs Left In Place



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**Railing Issues**

Need full nut engagement with anchor rod



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**Railing Issues**

Need full nut engagement with anchor rod – Coupler Nuts



- May need to ream base plate holes
- Galvanize and/or paint repair needed
- These increase the thread engagement on the anchor rod



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### Installing Utility Conduit Through Parapet

Pull Box should be flush with formwork prior to placement




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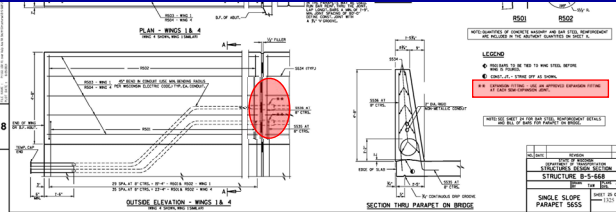

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### Installing Conduit Through an Expansion Joint

Ensure conduit expansion fitting used is proper for amount of bridge expansion expected and fitting is set at the ambient temperature immediately before pouring

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### Parapet Reinforcement Completed




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**Forming Parapet**



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**Forming Parapets**



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**Parapet Formwork Completed**  
Do not forget to install bridge name ID Plaque and benchmark cap



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**Curing Parapet**  
 Undergoes wet cure similar to deck but for shorter period of time  
 4 Days for most Concrete  
 7 Days for HPC



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**Sack Rub Finish**  
 Standard Spec 502.3.7

**BEFORE**



**AFTER**





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**Non-Structural Approach Slab Forming**  
 SDD 13b2-a Concrete Bridge Approach Slab




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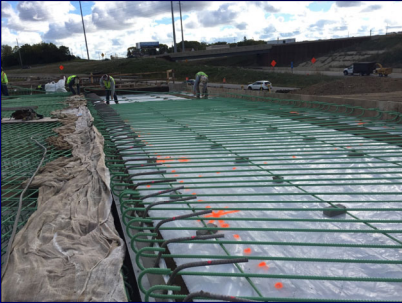
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### Structural Approach Slab

Plastic and Bottom Mat Placement





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### Structural Approach Slab

Note Approach Bears on Sleeper Slab





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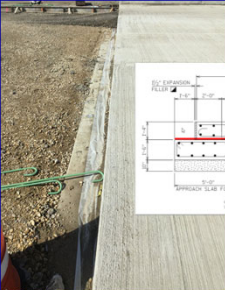
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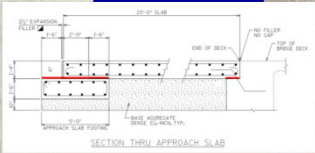
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### Structural Approach Slab

Paving notch and sleeper slabs must be free of aggregate





SECTION THRU APPROACH SLAB



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### Structural Approach Slab

Aggregate washes away and settlement occurs




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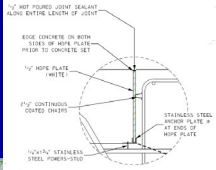



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### Combined Deck and Structural Approach Slab Pour

Deflection Plate Installed at Abutment (It is not an Expansion Joint)

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### Combined Deck and Structural Approach Slab Pour




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### Crack Survey – Deck Surface Only

Spec 502.3.13 & CMM 5-25.3

- Initial crack survey is to be performed within 7 days after end of wet cure.
- All cracks visible to the naked eye must be sealed with low viscosity crack sealer.
- Initial cracks are incidental to Concrete Masonry Bridges.
- Follow-up crack survey as late as possible before PST is applied. This is paid \$3/LF per spec.



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### Protective Surface Treatment

Spec 502.3.13 & CMM 5-25.3

- New decks shall be sealed after the follow-up crack survey
- Refer to the approved products list for applicable sealants



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### Pigmented Surface Sealer- Parapet

Commonly applied to inner face and top surface of parapet



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**Long Term Issues**  
Ponding (bird baths) on the bridge or leading up to bridge




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**Long Term Issues**  
Honeycombing due to improper concrete consolidation




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**Long Term Issues**  
Excessive deck cracking

- Start wet cure at proper time after deck pour
- Deck stays wet during cure period
- Loading of construction vehicles on deck – 502.3.10
  - Limit loading during wet cure period
- Staged bridges – traffic vibrations can cause cracking

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