Deck Construction
Section 14

Pour Sequence
Case Study

• 3 span steel plate girder bridge. Plans call for pouring the 3 spans at the same time.

• Contractor requests to pour span 1 first followed by span 2 two weeks later and span 3 a week after span 2. Closure pours after the other pours are all completed.

• Is this reasonable? What issues would you be concerned with? What do you do?
Structure in Question
Deck Construction Section 14.1

Deck Cracking

Loose Block
Since span 3 was placed last, how does it look?

Looks Good
Occasional Crack

Pour Sequence

- Follow per plans
- Changes must be approved by the Engineer of Record.
- Improper pour sequence can lead to significant cracking and premature failure of a structure.
Pour Sequence

• It’s not just a deck issue.

• Loads can be built into structural members that they were not designed for.
Case Study

- Simple span, concrete bulb-I girders resting on pilecaps. Plans call for pouring the “E” beams as a separate pour after the deck pour.
- Contractor pours the “E” beams prior to the deck pour.
- What issues does this raise?

Construction Material Storage
I-35 Bridge in Minneapolis

I-35 Bridge Gusset Plates

A CRUCIAL, UNDETECTED DESIGN FLAW

Federal investigators have proposed key gusset plates in the center portion of the Interstate 35W bridge that were undetected and interfering. There are meeting today for a two-day public hearing with the National Transportation Safety Board into its determination of what led to the I-35W Bridge collapse 15 months ago in Minneapolis. The main cause of failure has been on the north and west gusset plates.

GUSSET PLATES EXPLAINED

Gusset plates are flat pieces of steel used to connect adjacent truss members such as beam and “I” beams. They are either riveted or bolted into place. Gusset plates were used in large numbers throughout the truss structure. The NTSB says that due to its design flaw, the south 35W east and west gusset plates were only one half inch thicker than the 1-inch thickness that the NTSB says would have been safe.

This image is a representation of the I-35 Bridge Gusset Plates.
I-35 Material Storage

Milling concrete on bridge

Previously stored material on ramps and approaches

Inspector allowed storage on main span without review by bridge design

Cracking of Bridge Decks
Why does concrete crack?

It cracks when it is stressed beyond its structural capacity.

What causes stress in concrete?

- Shrinkage
- Dead Loads
- Live Loads
Shrinkage Cracks

Shrinkage Cracks Are Caused By:

- Autogenous Deformation
- Plastic Shrinkage
- Thermal Shrinkage
- Drying Shrinkage
Autogenous Deformation

The change in volume taking place of the concrete mixture as the hydration process chemically changes the material and it becomes a solid mass.

Plastic Shrinkage

Results from surface evaporation prior to the cure being put on.
Thermal Shrinkage

- Shrinkage caused by temperature differences
- PADOT Study
  
  Temperature difference induces 5.5 microstrains per 1 degree F.

  228 microstrains of thermal shrinkage would initiate cracking.

Drying Shrinkage

- Short term (several days)
- Long term (about 1 year).
- It results from the process of the deck drying out.
Concrete Cracks

When total stress in the concrete exceeds the modulus of rupture of the concrete

400+/- microstrains of total stress?

Other Factors Affecting Shrinkage Cracking

- W/C Ratio
- Aggregate Absorption
- Aggregate Size
- Cement Type & Source
- Timely & Proper Cure
Deck Grades

Include camber and crush
### Deck Grade Example

<table>
<thead>
<tr>
<th>Location</th>
<th>FG</th>
<th>Camber</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.1</td>
<td>100.00</td>
<td>0.05</td>
</tr>
<tr>
<td>0.2</td>
<td>100.00</td>
<td>0.09</td>
</tr>
<tr>
<td>0.3</td>
<td>100.00</td>
<td>0.13</td>
</tr>
<tr>
<td>0.4</td>
<td>100.00</td>
<td>0.15</td>
</tr>
<tr>
<td>0.5</td>
<td>100.00</td>
<td>0.17</td>
</tr>
<tr>
<td>0.6</td>
<td>100.00</td>
<td>0.15</td>
</tr>
<tr>
<td>0.7</td>
<td>100.00</td>
<td>0.13</td>
</tr>
<tr>
<td>0.8</td>
<td>100.00</td>
<td>0.09</td>
</tr>
<tr>
<td>0.9</td>
<td>100.00</td>
<td>0.05</td>
</tr>
<tr>
<td>1.0</td>
<td>100.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Deck Grade Example Key

<table>
<thead>
<tr>
<th>Location</th>
<th>FG</th>
<th>Camber</th>
<th>DG</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>100.00+</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>0.1</td>
<td>100.00+</td>
<td>0.05</td>
<td>100.05</td>
</tr>
<tr>
<td>0.2</td>
<td>100.00+</td>
<td>0.09</td>
<td>100.09</td>
</tr>
<tr>
<td>0.3</td>
<td>100.00+</td>
<td>0.13</td>
<td>100.13</td>
</tr>
<tr>
<td>0.4</td>
<td>100.00+</td>
<td>0.15</td>
<td>100.15</td>
</tr>
<tr>
<td>0.5</td>
<td>100.00+</td>
<td>0.17</td>
<td>100.17</td>
</tr>
<tr>
<td>0.6</td>
<td>100.00+</td>
<td>0.15</td>
<td>100.15</td>
</tr>
<tr>
<td>0.7</td>
<td>100.00+</td>
<td>0.13</td>
<td>100.13</td>
</tr>
<tr>
<td>0.8</td>
<td>100.00+</td>
<td>0.09</td>
<td>100.09</td>
</tr>
<tr>
<td>0.9</td>
<td>100.00+</td>
<td>0.05</td>
<td>100.05</td>
</tr>
<tr>
<td>1.0</td>
<td>100.00+</td>
<td>0.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Excess Camber?

Deck Pre-Placement Conferences
Deck Pre-Placement Conferences 00540.02

A pre-pour conference should be held 3 weeks ahead of placing concrete. This conference is to discuss all phases of the deck pour and the responsibilities of all parties involved.

Any problems that arise should then be resolved well ahead of the day of concrete placement.

Deck Pre-Placement Conferences Cont’d

A second pre-pour conference should be held at the job site one-half hour before the placement begins to discuss placement duties and procedures with the contractor’s entire placement crew and the Engineer.
Preparations for Concrete

Before the contractor orders any concrete for delivery and placement at the site, you should:

- Insure that an approved mix design is on file with the Material Section.

Preparations for Concrete Cont’d

Make sure the contractor has adequate resources for the pour:

- A steady supply of mix.
- Adequate labor and equipment.
- Back-up equipment at the jobsite.
Screed Rails

• Place outside the finished area.
• Rail supports are at about every 3 feet
• Ensure all rail supports are checked. If every other support is shot in then stringline in between.

Screed Rails Cont’d

• Removable to at least 2 inches below surface, if within deck limits.
• The rail and supports extend far enough beyond the end of the deck to provide all equipment with full access to the deck.
Detour so close, machine rails set on beam

What is so bad about machine rails in the deck?
Possible Voids from Footprints

Deck Finish Machine (00540.24)

- Capable of finishing the entire surface.
- Self-propelled with positive control in both forward and reverse directions.
- Capable of raising rolls or screed to clear the screeded surface.
- Equipped with augers.
Deck Finish Machine Cont’d

- Equipped with rollers or a vibrating screed.
- Run on the skew of the bridge.

Deck Machine Dry Run

- Run machine over the entire deck to ensure proper deck thickness and clearances prior to the deck pour.
- Past the end bulkheads to ensure all areas have been checked.
- Do not allow adjustments in machine crown or leg heights after clearances checked and approved.
- Note: The drum will usually float up about 1/8 inch on the concrete mix.
Pouring Deck

Typical Deck Machine
Typical Deck Machine

- Like to see small ball of mix in front of screed roll
- Keep mix about halfway up auger

Texas Screed Type Equipment for Narrow Pours
Prevent Splatter

Length of vibration
Void at chair

Poor Vibration
Poor Vibration

Unconsolidated Concrete in Sidewalk Area
Footprints in Sidewalk Area?

Part of Deck Poured at Wrong Grade
Deck Removal Damaged Bulb-T

Pan Decking on Temporary Structure
Form Collapse During Deck Pour

Float Finishing

- Floats at least 4 feet wide.
- Used in overlapping passes.
Straightedge Checks

• With 12 foot straightedge.
• Both parallel and perpendicular to roadway centerline.
  – At lane lines
  – At bridge ends
  – In gutters
Straightedge Checks Cont’d

• Must be within 1/8 inch per 12 feet.
• In timely manner to allow for contractor to correct deficiencies while the mix is still workable.
Depth Checking

Handwork

Some hand-finishing is needed in areas that cannot be reached by the mechanical screeding equipment.

These are the areas where you will tend to see problems.
Standing Water on Both Sides of Inlet

End Dropoff?
What happened to the rail stirrups?

Deck Roadway Texturing

- Saw cut after cure is complete.
- 1/8” – 3/16” deep
- Randomly spaced
- 16” Smooth @ Gutters
Deck Roadway Texturing Cont’d

- Transverse to centerline
- Avoid overlaps
- 6” From joints

Edge of Deck Treatment
Edge of Deck Treatment (1 ¼"")

- 6-#4 longit. bars. Stop 2" clear at all joints.
- 10" R.
- 3"
- 2-#4 longit.
- 1 ½" - 2-#4 longit. x Varied @ 7 ½" (epoxy coated).
- ½" V-Groove.
- Longit. deck steel.

TYPICAL SECTION
(FIXED FORMS)
No Scale
Deck Construction

Rail Flush with Deck?

Rail / Deck Transition
Rail Overhangs Deck?

Checking Edge of Deck Location on Curve
Drips on Edge of Deck

Joints
Construction Joint

- Only at planned/approved locations.
- Surface retarder required (00540.43)
- “Roughened-surface” or “shear-key” type per plans.
- Pre-wet for next pour.

Roughened Surface

Surface retarder required 00540.43
Shear Key in 30” Deep Deck

Shear Key in 30” Deep Deck
Construction Joints Cont’d

• Use extra care to vibrate adequately against the existing surface. Increase the number of insertion points.

• If bonding agent is used, it must not be dry when the concrete is placed or it will do the opposite and create a bond breaker.

Open gaps at closure pour?
Voids Behind Stay-in-Place Form

Stay-in-place joint forms are not allowed in bridge deck construction joints. 00540.43(a)
Voids Behind Stay-in-Place Form

Transverse Joint with Stay-in-Place Form Material?
Shear Key Blockout

Shear Key
Expansion Joints

Protect Edges
Joint Edges?

Joint Wanders

Repaired Joint Edge

Repaired with Kwikbond Polymer PPC Easy Patch Fine Mix
**Repaired Joint Edge**

Repaired with Propoxy 2500

**Expansion Joints**

**Common Joint Types:**

- Sawcut
- Preformed Joint Material
- Poured Joint
- Asphalt Plug Joint
- Compression Seal
- Strip Seal
- Segmental Joint
- Finger Joint
- Modular Joint
Panel End Detail

- Sawcut 1 1/2"
- Fill With Traffic Loop Sealant

Preformed Joint Material
Preformed Joint Material

BR165
PREFORMED EXPANSION JOINT FILLER

• Remove 1 1/2" Deep
• Fill With Traffic Loop Sealant

Poured Joint
Asphalt Plug Joint

BR157
Temporary Asphalt Plug Joint
Asphalt Plug Joint
Pothole in Asphalt Plug Joint
Compression Seal

BR139
Compression Seal with Armor

For movement up to 1 1/2"

Compression Seal without Armor
Compression Seal End in Rail

Compression Seal End
Compression Joint Repair

N Fk Quartz Cr
Strip Seal
Strip Seal

For movement up to 4"

Adjust for Temperature Variations

Install extrusions to manufacturer’s recommended installation width. Check detail drawings. Adjust as required for variations in structure temperature as shown on project plans.
Coefficient of Expansion

- Steel \(6.5 \times 10^{-6} / ^\circ F\)
- Concrete \(5.5 \times 10^{-6} / ^\circ F\)
- Aluminum \(13.1 \times 10^{-6} / ^\circ F\)

Thermal Movement Example

- 100 ft steel girder bridge
- How much movement would you expect from a 15°F temperature change?

\[
(0.0000065 / ^\circ F)(100 \text{ ft})(15 \ ^\circ F) = 0.01 \text{ ft}
\]

0.01 ft = 1/8”
Thermal Movement Exercise

• 600 ft steel girder bridge with joints at both ends.

• If the average temperature for the area is 70°F, how much would you adjust the joint for a closure pour if the beam temperature is 40°F?

• Do you increase or decrease the joint opening?

Thermal Movement Exercise Key

\[
\frac{0.0000065}{\text{°F}} \times 600 \text{ ft} \times 30\text{°F} \div 2 \text{ joints} = 0.06 \text{ ft}
\]

\[
0.06 \text{ ft} = \frac{3}{4}''
\]

Beams are colder & shorter so joints are wider

or

\[
\frac{0.01}{100\text{ ft} \times 15\text{°}} \times 3 \times 2 = 0.06 \text{ ft} = \frac{3}{4}''
\]
Strip Seal

Strip Seal
Strip Seal

Strip Seal
Surface Not Level
Segmental Joint

4" (6mm)

Limits of sealant applied to base of blockout

5/8" cast in place anchor spaced @ 12" o.c.

 Allows for Movement Up to 4"
Segmental Joint

Finger Joint
Finger Joint

For movement up to 8”

Finger Joint

Allows for Movement Up to 8”
Finger Joint

Modular Joint
Modular Joint

Allows for Large Movements
Modular Joint

MC Overlay Preparation
Shotblasting
Hydroblast Surface
Standard Test Method for Measuring Pavement Stairsection Depth Using a Volumetric Technique

1. Scope

This test method covers the determination of stairsection depth of pavements by use of a volumetric technique. This method is applicable to pavements composed of asphalt mixtures, portland cement concrete, or other mixtures that are stairsectioned. The method is limited to pavement sections that are at least 10 cm (4 in.) in thickness and are stairsectioned to a depth of at least 2 cm (0.8 in.). The method is not applicable to pavement sections that are stairsectioned to a depth of less than 2 cm (0.8 in.).

2. Summary of Test Method

The test method involves the collection of pavement stairsection samples, the determination of the stairsection depth of the samples, and the calculation of the stairsection depth of the pavement. The samples are collected using a stairsectioning machine, and the stairsection depth of the samples is determined using a measuring device. The stairsection depth of the pavement is calculated using the measured stairsection depth of the samples and the thickness of the pavement.

3. Reference Citations


4. Interlaboratory

This test method is intended for use in interlaboratory studies. The method is designed to ensure that the results obtained by different laboratories are comparable.

5. Apparatus

The apparatus used in this test method includes a stairsectioning machine, a measuring device, and a balance.

6. Procedure

The procedure involves the collection of pavement stairsection samples, the determination of the stairsection depth of the samples, and the calculation of the stairsection depth of the pavement. The samples are collected using a stairsectioning machine, and the stairsection depth of the samples is determined using a measuring device. The stairsection depth of the pavement is calculated using the measured stairsection depth of the samples and the thickness of the pavement.

7. Precision and Bias

The precision and bias of this test method are not specified in the standard.
MC Overlay
00559

Deck Prep
Hydroblast Deck Prep

Surface After Hydroblast
Surface After Hydroblast

Class 2 Repair
Sealed Large Cracks

Soak Deck 8 Hours Prior To Pour
Plastic To Keep Deck Clean

Brooming Grout
Placing Mix

Deck Machine
Look For Clumps In Mix

Deck Machine
Cure Fabric

Deck Cure
Bond Test

Spray Waterproofing Membrane
SP00591
Bridge Preservation System
Methacrylate Prime Coat

Bond Test On Prime Coat
Polyurea Layer

2\textsuperscript{nd} Polyurea Layer (If required)
Rock Broadcast Before Set

Polycarb System
Bottom Layer of Epoxy
Polyurea Layer

Polyurea Layer
Top Layer of Epoxy

Rock To Refusal On Epoxy Layer
Hot Tack & Pave

Premixed Polymer Concrete Overlay (SP00557) (Polyester Polymer Concrete)
Methacrylate Layer

Slip Form Paver
PPC Placement

Hand Finishing End
Completed End

Angled Edge For Traffic
Spreading Sand On Top
Multi-layer Polymer Concrete Overlay (SP00556)
Shotblasted Surface

Spreading Flexolith
Blowing #8 Basalt On Top

Completed Lane
View FHWA Video

Bridge Deck Construction Review