Yellowstone River at Huntley, MT
Bridge Scour Countermeasure Failure Investigation
Russell Brewer, P.E.
Old US Highway 312 Crossing the Yellowstone River at Huntley, MT

Located approximately 11.5 miles NE of Billings, MT
Old US Highway 312 Crossing the Yellowstone River at Huntley, MT

Initial Scour Analysis Completed April 10, 1998

- Total pier scour estimated at 18.2-feet
- Estimated Scour plots below the bottom of the footing elevations at piers 3, 6, and 7
- Footings “keyed” about 2-feet into Hard Blue Sandstone
- Structure placed on District Emergency Watch List (NBIS Item 113 Code 3)
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9-23-1998 UW Inspection

Pier 3 – Footing is exposed to a depth of 2.7-feet
Pier 6 – Footing is exposed to a depth of 4.5-feet
Pier 7 – Footing is exposed to a depth of 6.5-feet

Scour Countermeasures Recommended at piers 3, 6, and 7.
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Scour mitigation project completed December 2006
In 2011 the State of Montana and the Yellowstone River experienced significant flooding.

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Billings, MT - 50-yr RI
Indicates Counter Measures at pier 6 failed
Scour extends below bottom of footing elevation
What Happened?

MDT Scour Team

- Implement POA due to CM Failure
- Review Available Data
- Request Additional Data
- Determine what led to CM Failure
  - Design Features
  - Construction Techniques
  - Hydraulic Forces
  - Other Factors
Determine Mechanisms of failure:

- Design Features
  - Review Plans
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~68-ft

~35-ft

~7-ft
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Determine Mechanisms of failure:

- **Design Features**
  - Review Plans

- **Construction**
  - Method of Construction
  - Review Placement of ACB’s
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Challenges
- Site access
- Water depth at low flow = 9-feet
- How to isolate the work area?

Contractors Solution
- Earthen Cofferdams
- Pier 6
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- Excavate to Depth
Old US Highway 312 Crossing the Yellowstone River at Huntley, MT

- Block protrusion minimized?
- ACB Mattress “keyed” in around edges?
- ACB Mattress anchored US and DS?
- Place ACB Mattress
Determine Mechanisms of failure:

- **Design Features**
  - Review Plans

- **Construction Techniques**
  - Review Methods of Construction

- **Data Requested**
  - Bathymetric Survey
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Determine Mechanisms of failure:

- **Design Features**
  - Review Plans

- **Construction Techniques**
  - Review Methods of Construction

- **Data Requested**
  - Bathymetric Survey

- **Hydraulic Forces**
  - Flood Flow
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~ 15-yr RI ~ 50-yr RI

Duration of runoff

5-26-2011  60,700 cfs
~ 15-yr RI

7-2-2011  70,600 cfs
~ 50-yr RI
Determine Mechanisms of failure:

- **Design Features**
  - Review Plans

- **Construction Techniques**
  - Review Methods of Construction

- **Data Requested**
  - Bathymetric Survey

- **Hydraulic Forces**
  - Flood Flow
  - Hydraulic Modeling
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Hydraulic Modeling

- What do we want?
- Existing Modeling
- SRH-2D using SMS
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Assuming a projected block height of 2-in.
The safety factor for the ACB mattress is 1.2
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Scour hole extends beyond designed boundary of CM

Pier 6
Findings:

- Design
  - Initial Survey
  - Elevations not specified.
  - Mattress key depth
  - Mattress size not adjusted for angle of flow impingement

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Contractors Solution

- Earthen Cofferdams
- Excavate to Depth
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2011 Underwater Inspection report

Counter Measures were installed approximately 5-feet above footing at pier 3.

Counter Measures installed approximately 2-feet above the footing at pier 7.
ACB Mattress placement as intended?
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CASE I

FINISHED CHANNEL BOTTOM

*** GEOTEXTILE

EXISTING CHANNEL BOTTOM ABOVE FOOTING

EXCAVATE TO PROVIDE THE 1.0 M OF COVER BEFORE PLACING CABLE-TIED BLOCK.

* NOTE: Key the upstream and downstream edges and outside perimeter of the mattress in 600 mm (Typ.)

** GEOTEXTILE
(Typ. under all block mattresses)
(See Special Provisions)

*** INSTALL ANCHORS AROUND PERIMETER OF MATTRESS.
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Profile
Time Step: 02:00:00

Estimated ACB Elevation
Top of Footing Elevation 2994.8
Conclusion:

- ACB Failure combination of factors.
  - Minimal Survey
  - ACB Elevations not specified
  - Plan Interpretation
    - Contractor
    - Construction PM
    - Designer
  - ACB’s placed above channel thalweg.
  - Material beneath ACB mobile and likely washed away.
  - Experience
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- **Initial Site Survey/Evaluation**
  - Better description of what is going on underwater.
  - Aid in CM Selection process.
  - Allow for more detailed hydraulic modeling
  - Allow for better plan preparation

- **Design**
  - Define final elevations of countermeasures.
  - Extend depth of mattress “key” to minimum of exposed Footing Height.

- **Construction**
  - Technique and Experience
  - Plan Interpretation
  - Better communication
    - Construction Project manager
    - Design Engineer
    - Contractor.