WORKSHOP

DG8 – ROCK RIPRAPP AT PIERS AND ABUTMENTS
LEARNING OUTCOMES

• Describe the background of riprap for protecting piers and abutments
• Describe the methods for designing riprap at piers and abutments
• Size riprap for piers and abutments
RIPRAPH AT PIERS

- Little verification for protection at piers
- Turbulence and velocities around piers can move the riprap over time
- Schoharie Creek case study
SCHOHARIE CREEK BRIDGE PROFILE

LONGITUDINAL GEOLOGIC SECTION
(Looking North)

GENERAL STRATA DESCRIPTIONS

Legend

- F Fill
- Ice contact stratified drift
- Bedrock
- Silt
- Varved clay
- Alluvium
- Basal till

E - Expansion End Bearing
F - Fixed End Bearing
GUIDELINES FOR PIERS

• Riprap is not a countermeasure for new bridge piers

• Riprap at piers of existing bridges requires monitoring and inspection during and after periods high flows

• Riprap at piers of existing bridges should be considered as a means to reduce the risk from scour
MEDIAN STONE SIZE

\[ D_{50} = \frac{0.692 (KV)^2}{(S_s - 1) 2g} \]
OTHER CRITERIA

- $D_{\text{max}} = 2D_{50}$
- Mat thickness $\geq 3D_{50}$
- Mat should extend at least 2 pier widths from the face of the pier or the extent of the scour hole
- Bottom of mat at or below computed contraction scour
- Use a granular or geotextile filter
DESIGN EXAMPLE

• Size riprap at an existing circular pier
• Sketch the horizontal extent and depth
EXAMPLE SUMMARY

• Answers
• Other design constraints
• Further steps in the design process
• Questions
RIPRAP AT ABUTMENTS

- Two FHWA laboratory studies
- 1\textsuperscript{ST} Study: vertical and spill through abutments with 28-56\% encroachment of floodplain
- 2\textsuperscript{ND} Study: spill through abutment with 56-100\% encroachment adjacent to channel
- Resulting failure zone was different for the two types of abutments
SCHEMATIC OF FLUME USED IN SECOND STUDY
OBSERVED FAILURE ZONE
GUIDELINES FOR ABUTMENTS

• Method of placement is important
• Protect face of embankment and abutment
• Extend riprap horizontally from toe or provide toe trench
• Use graded rock riprap
• Provide filter as necessary
MEDIAN STONE SIZE

\[ \frac{D_{50}}{y} = \frac{K}{(S_s - 1)} \left( \frac{V^2}{g y} \right) \]

for \( F_r \leq 0.8 \)
MEDIAN STONE SIZE

\[
\frac{D_{50}}{y} = \frac{K}{(S_s - 1)} \left( \frac{v^2}{gy} \right)^{0.14}
\]

for Fr > 0.8
CHARACTERISTIC
AVERAGE VELOCITY

\[ V = \frac{Q}{A} \]

\[ SBR = \frac{\text{Setback Distance}}{\text{Average Channel Flow Depth}} \]
OTHER CRITERIA

• Mat thickness \( \geq \) either 1.5\(D_{50}\) or \(D_{100}\)

• Increase thickness by 50% when placed in water

• Extend riprap the lesser of 2 flow depths or 7.5 m (25 ft) out from toe

• Provide 0.6 m (2 ft) of vertical freeboard above high water
### Riprap Gradation

<table>
<thead>
<tr>
<th>Stone Size Range (m)</th>
<th>Stone Weight Range (Kg)</th>
<th>Percent Smaller Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.5D_{50}$ to $1.7D_{50}$</td>
<td>$3.0W_{50}$ to $5.0W_{50}$</td>
<td>100</td>
</tr>
<tr>
<td>$1.2D_{50}$ to $1.4D_{50}$</td>
<td>$2.0W_{50}$ to $2.75W_{50}$</td>
<td>85</td>
</tr>
<tr>
<td>$1.0D_{50}$ to $1.15D_{50}$</td>
<td>$1.0W_{50}$ to $1.5W_{50}$</td>
<td>50</td>
</tr>
<tr>
<td>$0.4D_{50}$ to $0.6D_{50}$</td>
<td>$0.1W_{50}$ to $0.2W_{50}$</td>
<td>15</td>
</tr>
</tbody>
</table>
GRANULAR FILTER

\[
\frac{D_{15} \text{(coarser layer)}}{D_{85} \text{(finer layer)}} < 5 < \frac{D_{15} \text{(coarser layer)}}{D_{15} \text{(finer layer)}} < 40
\]

Note: See HEC-11 geotextile design criteria
DESIGN EXAMPLE

- Size riprap at a floodplain abutment of an existing bridge
- Determine the extent and layout
EXAMPLE SUMMARY

• Answers
• Other design constraints
• Further steps in the design process
• Questions