Introduction to Bridge Planning Tools

Bridge Planning Practitioners Workshop

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Alberta
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Government of Alberta
Transportation

Introduction

- Hydraulic tools (e.g. Channel Capacity Calculator, Flow Profile) developed to support the Department's practices for determining hydrotechnical parameters, (Q, V, Y)
- Geometric tools (e.g. BPG) developed to facilitate design

Hydraulic Modeling Approach

Recommended modeling approach

- Section averaged (1D), based on typical channel section
- Neglect overbank d/s flow component
- Account for GVF, RVF where appropriate
- Roughness, Slope – use Hydrotechnical Design Guide
- Results – HW EL (freeboard), V (rock sizing)

Hydraulic Modeling Approach

Accuracy

- Don’t confuse with precision
- Limited by geometry, hydraulics (n, K), other (drift, ice, sediment)
- +/- 20% acceptable for Y, V (confidence in parameters)
- Consider sensitivity of design
- Round Y to 10% (min 0.1 m)
- Round V to 10% (min 0.1 m/s, 0.01 m/s for fish passage)

Hydraulic Modeling Approach

Why not multi-section (HEC-RAS) or 2D?

- Boundary conditions – only 1D estimate anyway
- Mobile boundary – bedforms, scour, lateral erosion…
- Complex factors – drift, ice, sediment transport
- No ability to calibrate complex models
- Detailed output interpretation – lose impact
- No need for additional detail - accurate or not
- Unnecessary level of effort, resources

Hydraulic Modeling Approach

Why neglect overbank d/s flow component?

- Small percentage (<10%) of channel flow
  - Relatively shallow Y
  - Low V (high relative roughness)
- Small downstream component in floodplain
  - No defined, continuous channel in floodplain
  - Natural obstructions – trees, topography variation
  - Man-made obstructions – roads, development
  - Backwater from channel – cuts across floodplain
  - Most flow - lateral interaction with channel
- Consistent with flood observations

Ice

Potential structure impacts

- High Ice (Ice Jams) may govern min bottom flange elevation
  - Evidence in files or at site
  - Triggers: constrictions, tributary or slope change
- Ice Loads on Piers (CAN/CSA-S6-S06, Section 3.12)
  - Strength (situation)
  - Elevation (often from observation or past design)
  - Thickness
- Icing (Aufeis) may affect culvert operation
  - Opening partially blocked by ice
  - Mitigation: bridge, raise gradeline, 2nd culvert (higher), maintenance

Ice

Potential structure impacts

- Typical values based on past practice

Damage History	Small Stream (B < 50m)	Large Stream (B > 50m)
Minor	Sit. ‘a’ EL ~ 0.8 * Y t ~ 0.6m	Sit. ‘b’ EL ~ 0.6 * Y t ~ 0.8m
Major	Sit. ‘b’ EL ~ 0.6 * Y t ~ 0.8m	Sit. ‘c’ EL – observ. t ~ 1.0m

Drift

- Potential impact on structure
  - Opening partially blocked, reduced capacity
  - Culvert – overtopping, u/s flooding, uplift failure
  - Bridge – damage, pier scour, flow deflection against banks
- Prediction
  - Historic observations – flood conditions
  - Tree density adjacent to stream and tributaries
  - Low bank stability – provide large trees to stream
  - Beaver dams
  - Tree size – largest tree can start accumulation

Drift
Mitigation

- Culvert
  - Consider a bridge
  - Larger size (likely marginal impact)
  - Flared inlet (maintain flow with blockage)
  - Flow alignment piles
- Bridge
  - Increase minimum centre span
  - Maintenance

Scour

- Lowering of streambed
- Types:
  - Natural (passing of bed forms)
  - Constriction (across channel, increased V)
  - Bend (outside, secondary currents)
  - Pier (local, obstruction to flow)
- Impact:
  - Pier foundation design
  - RPW design
- Difficult to calculate, use practical design

Scour
Estimation Difficulties

- Changes in flow alignment
- Migrating bedforms
- Variable foundation materials
- Weathering of exposed rock
- Formation of natural armour layers
- Infilling during flood recession
- Compounding different scour types
- Time dependency
- Theoretical equations vs. practical observations

Scour

Mitigation

- Use deep piled foundations (BPG No. 7)
- River protection works (BPG No. 9)
  - Protect headslopes
  - Maintain flow alignment – guidebanks, spurs
- Practical design of launching apron length (~ 5^*D_{max})
- Pier Scour Inspection Program (existing structures)
- Pier Scour Rehabilitation

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