Geotechnical Evaluation of Bridge Foundations for Reuse

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Why?

- Existing infrastructure is over capacity and reaching its design life

- Large capital costs with removal and installation of new foundations
- Limited space, particularly in Urban Environments
- Environmental and permitting constraints

- All of these were that case for the Crowchild Bridge project in Calgary

- But that project is not the only one….

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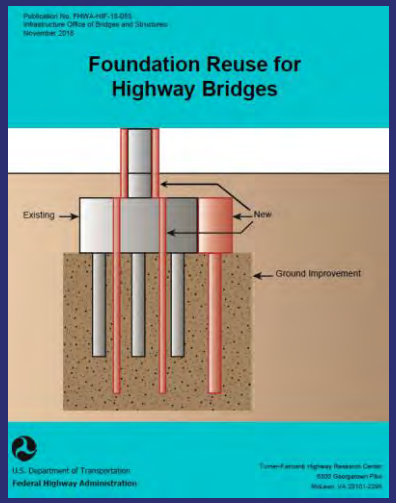
Current References

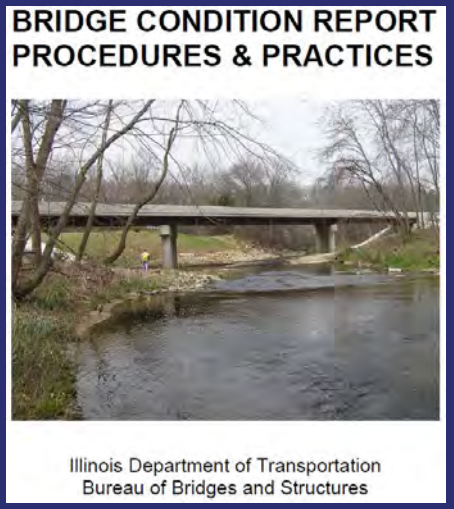
2018 FHWA Publication

Foundation Reuse for Highway Bridges



Illinois Department of Transportation (IDOT)

Bridge Condition Report
Procedures & Practices



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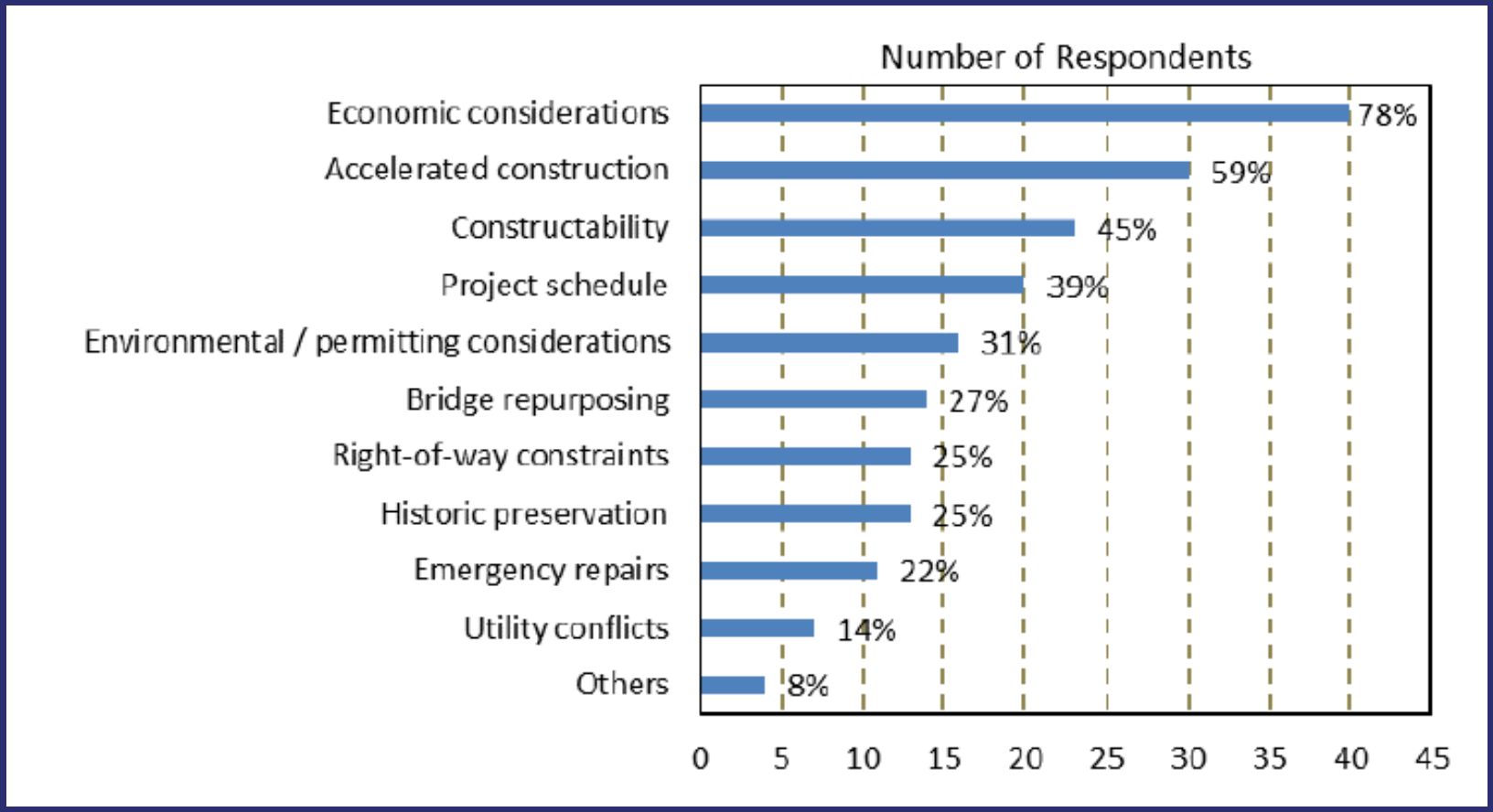
WHAT ARE THE BENEFITS OF FOUNDATION REUSE?



2017 survey of current practices on the reuse of bridge foundations

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WHAT CAN WE DO WHEN IT IS TIME TO UPGRADE?

Four Basic Options

- Install new foundation on a new alignment
  - Reuse or replace the existing bridge, add a new bridge to increase capacity
- Install new foundation on an existing alignment
  - Demolish the existing bridge and foundation and build a new bridge
- Re-evaluation and reuse of existing foundation
- Reuse existing foundation by strengthening it

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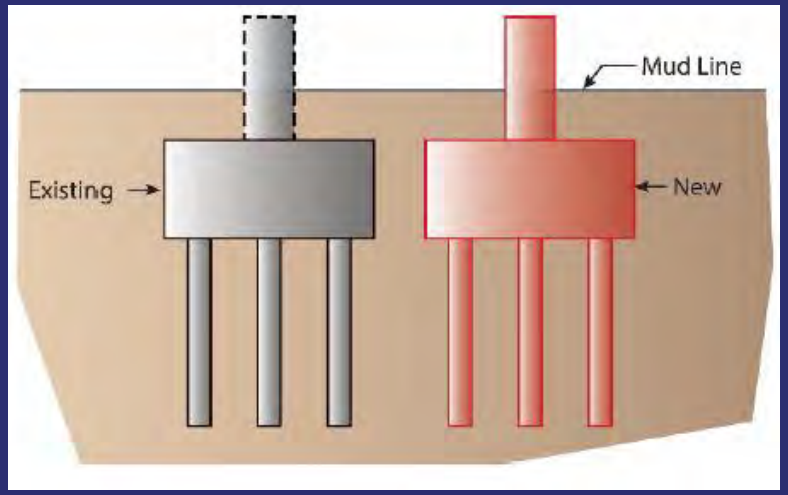
OPTION 1

Install new foundation on a new alignment

- Pros
  - Infrastructure meets modern standards
  - Known design life
  - Less impact on traffic
- Cons
  - Expensive
  - Requires more area



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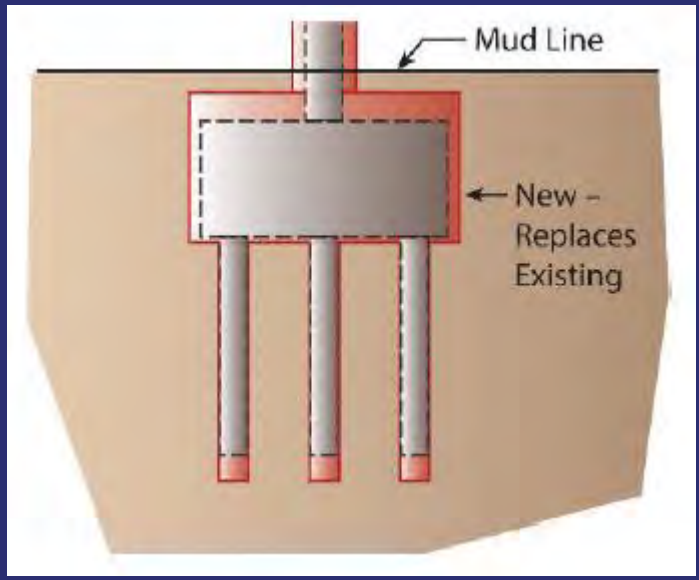
OPTION 2

Install new foundation on the existing alignment

- Pros
  - Potential to reuse architectural elements of existing infrastructure
  - Can re-use the existing alignment
  - Meets modern standards
- Cons
  - Difficult to remove the existing foundation
  - Where does the current traffic go?



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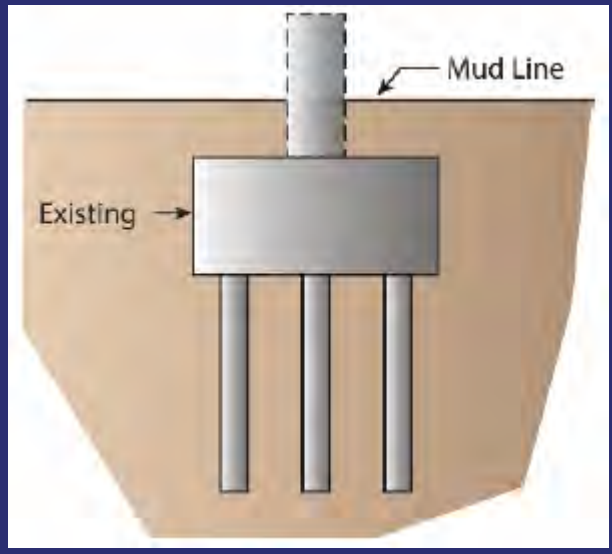
OPTION 3

Re-evaluation and reuse existing foundation

- Pros
  - Reduced costs and construction time
- Cons
  - Uncertain design life?
  - Use of new techniques or technologies can limit contractors and designers
  - Limited ability to increase capacity



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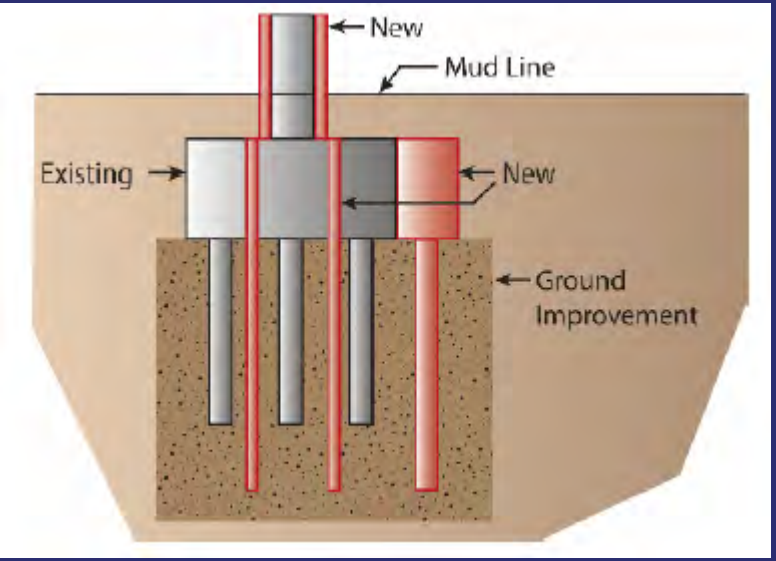
OPTION 4

Reuse existing foundation by strengthening it

- Pros
  - Can increase capacity
  - Update to modern standards
- Cons
  - Space constraints can lead to suboptimal design
  - Uncertain design life



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HOW CAN THE DECISION BE MADE?

- Requires reverse thinking
- Typically, the Structural Designer specifies loads and Geotechnical Engineer designs foundations to support them
- For reuse the Geotechnical Engineer assesses available capacity and the Structural Designer works within the constraints
- Needs close collaboration between the owner and the design team

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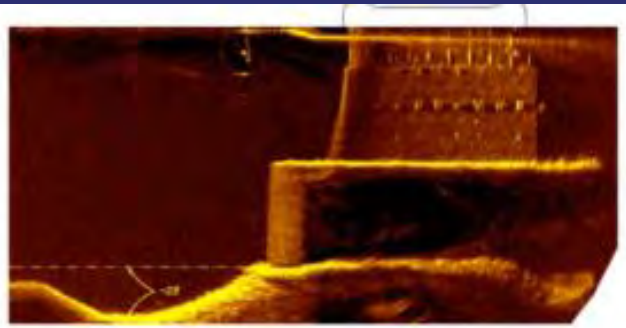
HOW MUCH CAPACITY IS THERE?

Starts with assembling information:

- Drawings and design reports
- Type of foundation (spread footings, piles)
- Soil conditions
- Foundation size and location (in-river, on shore)
- Accessibility for integrity testing and inspection



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RISKS

- There can be a big difference between as designed, as-built and as constructed
  - Can the foundation size and depth be assessed?
- What is the condition of the foundation?
  - Corrosion of steel
  - Concrete deterioration

- The feasibility of foundation reuse depends upon the design teams' ability to assess the capacity of the existing foundations

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ISSUES TO CONSIDER

- Concrete
  - Poor quality
  - Freeze thaw
  - Alkali-silica reactivity (ASR)
  - Leaching
  - Cracking
- Steel
  - Corrosion
  - Fatigue
- Water Table
  - Lots of issues where water table rises and falls

- Just because the bridge is still in service does not mean the foundation is performing as intended

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PROCESS

- Assess the geotechnical parameters of the soil
- Based on our knowledge of the foundation size and the effects of time, estimate the capacity of the foundation using modern building codes
- Structural design will make a similar assessment of the super structure
- Estimate the remaining service life
- Assess the risks and benefits

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CASE STUDY – CROWCHILD TRAIL

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CASE STUDY – CROWCHILD TRAIL

- Built in 1967
- Proximity to neighbourhoods and businesses made constructing a new bridge challenging
- Three candidates for re-use
  - In-river pier footings
  - Piled floodplain foundations
  - Bridge abutments (combination of piled and spread footings)

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CASE STUDY – CROWCHILD TRAIL

- In-river piers
  - Two separate bridges, with four pier lines in the river
  - Proposed widening would see two new girder lines on the outside of each bridge
  - Proposed load increase of 30%, higher than typical IDOT recommendations
  - Structural designer implemented an innovative solution to reduce the increase in moment by connecting the pier caps of the two bridges together
  - Concerns about the environmental impact of drilling and constructing in the river

CASE STUDY – CROWCHILD TRAIL

- In-river piers
  - Had as-built drawings and historic in-river test hole information
  - Drilled test holes adjacent to the river
  - Reviewed scour records
  - During low water conducted a test pit to verify foundation dimensions and footing embedment into bedrock
  - Geotechnical assessment found that the piers would have sufficient capacity to support the additional loads
  - Settlement during construction was less than 5 mm

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CASE STUDY – GREENOCK CREEK

- Constructed in 1971
- Abutments are supported by steel piles
- Bridge would be replaced but there was a significant benefit in reusing the foundations

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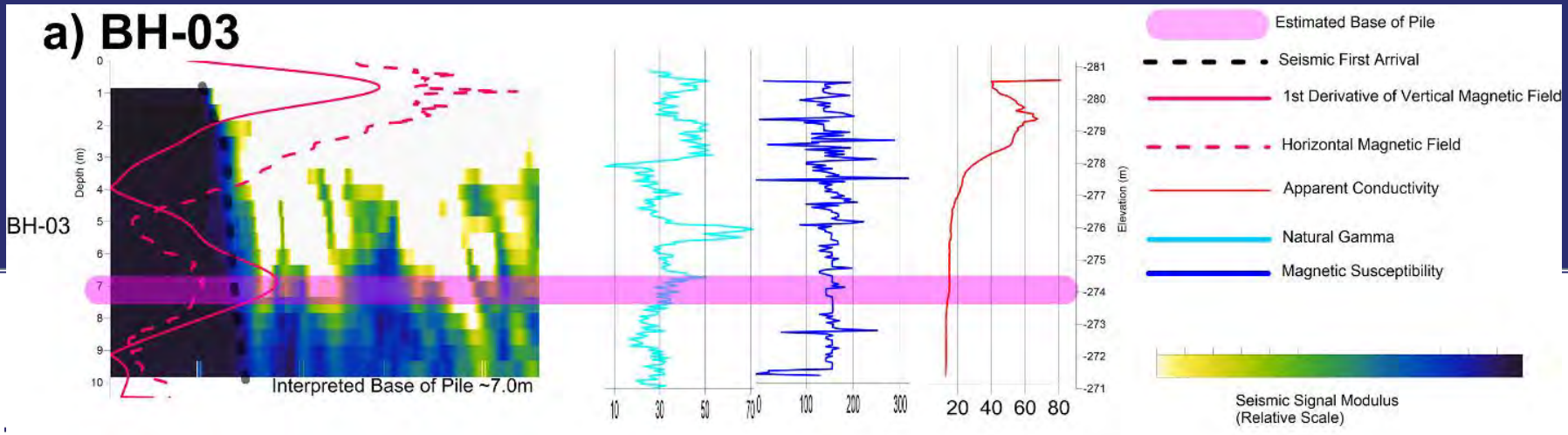
CASE STUDY – GREENOCK CREEK

- No as-built information available for the piles
  - Six test holes were conducted to collect samples and define the stratigraphy
  - Corrosivity assessment made of the soil and ground water
  - Downhole geophysics were conducted to estimate the pile length
    - Multiple methods were conducted with the parallel seismic and borehole magnetometer methods giving the best results
    - Challenges due to the pile batter



CASE STUDY – GREENOCK CREEK

- Estimate made of the section loss due to corrosion around the water table was made
- Updated capacity was estimated based on the new pile section and the test hole information
- Design life was estimated based on the corrosion rates
- Resulted in the piles being able to be reused which save significant construction time and reduced the overall project cost

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TAKEAWAYS

- Bridge foundation reuse can generate significant time and cost savings for a project
- No unified guidelines for bridge foundation reuse
- Not all foundations are suitable for reuse, each bridge requires careful evaluation
  - Each site is different and will likely require different techniques to make the assessment
  - Requires collaboration between the structural and geotechnical teams
- Risks need to be minimized and the owner must understand the residual risks

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REFERENCES

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