Stone Arch Bridges of Washington County, MD

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Washington County Division of Public Works
Overview

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- Bridge Inspection Program
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Introduction

- Washington County goes to great efforts to preserve and maintain its infrastructure, including our stone arch bridges.
  - To ensure the maximum useful life of our structures.
  - To provide acceptable service to the public.
Washington County Bridges

• Major Structures - Culverts or bridges with spans of 20’+
• Minor Structures - Culverts or bridges with spans 6’-20’

• 90 Major Structures owned and maintained by County
  – 14 Stone Arch Bridges
• 185 Minor Structures owned and maintained by County
  – 12 Stone Arch Bridges

• 179 Major Structures owned and maintained by SHA
  – 7 Stone Arch Bridges
• 215 Minor Structures owned and maintained by SHA
  – 7 Stone Arch Bridges

• Approx. 580,000 major bridges in U.S.
Bridge Inspection Program

  – National Bridge Inspection Standards (NBIS)

• Primary purpose is to locate and evaluate existing bridge deficiencies to ensure the safety of the traveling public.
  – Stone arch bridges were not built to carry the vehicles of today.
  – Provide a thorough bridge inspection. Document and monitor the deficiencies until appropriate repairs can be made.
    • In turn, we can adequately preserve and maintain our historic structures.
Bridge Inspection Program

- NBIS require major structures to be inspected at least every 2 years.
  - Set national standards for proper safety inspection and evaluation of bridges
  - Bridge inspection reports

- Local jurisdictions determine the inspection cycle for minor structures. Every 4 years in Washington County.
Bridge Inspection Program

- From the Inspection Reports, the County evaluates:

  > Structure Inventory & Appraisal (SI&A) Ratings,
  > Bridge Sufficiency Ratings (BSR),
  > and PONTIS Ratings

- Based on the numbers, our stone arch bridges are at the top of the priority list for repairs.

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Bridge Inspection Program

- Structural Inventory and Appraisal (SI&A) Ratings
  - Each component of a bridge gets a rating value from 0 to 9.
Bridge Inspection Program

- A bridge is considered structurally deficient if:

- Deck, Superstructure, Substructure, or Culvert are rated a 4 or less (poor or worse condition).
  - Some of our stone arch bridges needing repairs are considered structurally deficient.
Bridge Inspection Program

- Each bridge has a bridge sufficiency rating (BSR).
  - 0-100 (100 is new bridge)

- FHWA tracks each major bridge in the U.S. by this number.
Bridge Inspection Program

- If a bridge has a BSR of less than 50 and has a bridge component rated 4 or less, the bridge qualifies for replacement funding.

- If the bridge has a BSR from 50 to 80 and has a bridge component rated 4 or less, the bridge qualifies for rehabilitation funding.
  - 9 stone arch bridges qualify for rehabilitation funding.
Bridge Inspection Program

- Washington County spends $300,000 on major bridge inspections and $90,000 on minor bridge inspections.
  - Visual (hands-on) inspection and underwater inspection.
  - Written inspection report with documented conditions and photographs.
  - Approx. $40,000 major arches
  - Approx. $5,000 minor arches
Funding

- Funding is limited.

- Washington County spends app. $2.5 million per year on maintaining, repairing, rehabilitating, replacing bridges.

- Average rehabilitation cost for a three span stone arch bridge is app. $1,000,000 dollars.
Funding

- Prioritize funding.
- Capital Improvement Plan (CIP).
  - 6 major stone arch bridges are scheduled for rehabilitation in the next 10 years.
  - 4 stone arch bridges were rehabilitated since 2000.
Decision Making

- Due to the aging infrastructure and the lack of funding available, Washington County typically follows a “Worst-First” evaluation.

- “Worst-First” - Structures with the lowest ratings are grouped together for review.
  - If a structure is eligible for federal aid funding, it goes to the top of the list for rehabilitation or replacement.
  - Most of our stone arches fall under worst-first criteria.

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Decision Making

- **Capital Projects Engineering**
  - Maintains inventory, develops priority list and cost estimates for review

- **Director of Public Works and CIP Budget Committee Review**
  - Evaluates list and prioritizes against other project needs (Buildings, Roads, Parks, etc.)

- **Washington County Commissioners**
  - Continue to invest in repairing and rehabilitating our stone arch bridges.
Design

- Our stone arch bridges are identified as historic.
  - Eligible for listing in the National Register of Historic Places.

- Must comply with Section 106
  - Afforded a degree of protection under historic preservation laws.

- Must adhere to Secretary of the Interior’s Standards for the Treatment of Historic Properties
  - To provide an acceptable rehabilitation or repair.
Design
Design

• Major rehabilitation projects are designed by a consultant hired by the County through SHA’s open-ended consultant process.
  – $150,000 design cost per bridge
    • Using Federal Aid Funding and SHA Review Process
  – Design and load rating based on finite element analysis modeling of reinforced lightweight fill concrete and stresses on the stone masonry arch.

• Repair plans are prepared in-house.
• Repairs to the bridges in the late 1970’s and early 1980’s provided a concrete cap over the arches and drainage pipes within the existing soil-gravel fill.
  – Not replacing the soil-gravel infill with lightweight concrete has been proven to be an issue with the development of bulging spandrel walls and severe deterioration of mortar joints.
Design

- The concrete cap over the arch has proven to be effective in protecting the arch and has assisted in ensuring the arches remain in tact during construction.
Design

- We use an effective technique for rehabilitation that strengthens the bridge and does not alter its visual appearance.
  - Replacing the soil-gravel fill with reinforced lightweight concrete and reconstructing the stone masonry spandrel and parapet walls.
- The fill of the bridge is not considered a character defining element.
Design

- This type of design follows the Secretary of Interior Standards
  - Deteriorated historic features will be repaired rather than replaced.
  - Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and where possible materials.
  - Replacement of missing features will be substantiated by documentary and physical evidence.
Design

and

- is considered “no adverse effect” by the Maryland Historical Trust.
  - Reconstruction of stone spandrel and parapet walls utilize existing salvaged stone or new stone that matches the existing stone as closely as possible.
  - The mortar used for repointing and reconstruction matches MHT’s recommendations.
Rehabilitation

• Most major stone arches need to be fully rehabilitated by a Contractor with sufficient resources.
  – $300,000 - $1,500,000 per project
    • $300,000 - $700,000 for two span arch
    • $700,000 - $1,100,000 for three span arch
    • $1,100,000 - $1,500,000 for four span arch
  – 4 - 8 months per project
Rehabilitation

General Work Items associated with most bridge rehabilitation projects:

- Excavate soil-gravel fill and replace with lightweight concrete.
  - Temporary shoring
- Reconstruct and/or re-point stone spandrel walls and parapet walls.
  - Scaffolding and stream diversion.
- Construct concrete collars around the pier/abutment.
- Replace concrete parapet cap.
Rehabilitation

- Excavate soil and gravel fill

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Rehabilitation

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Rehabilitation

- Place epoxy-coated reinforcing
Rehabilitation

• Replace with lightweight fill
Rehabilitation

• Reconstruct and/or re-point spandrel walls
Rehabilitation

• Reconstruct and/or re-point parapet walls
Rehabilitation

- Reconstruct pier noses
Rehabilitation

- **Types of Mortar Used in Current Construction**
  - **Lime Mortar (Lime, sand, and water)**
    - Used on stone arches in the early 1800’s.
    - No longer used because of durability and strength issues.
  - **Mason’s Hydrated Lime (Cement mortar, lime, sand, and water)**
    - Used on stone arches today.
    - Better durability and strength.
  - **Masonry Cement Mortar (Portland cement, hydrated lime, plasticizers, air entraining agents, sand, water)**
    - Types: M, S, N, O, K
    - Durability, strength, and workability are much better.
    - Type S (1,800 psi).
Rehabilitation

• Mortars
  – White masonry cement
  – Flamingo brand of masonry cement using the color C224 (formerly C280).
  – Mason’s hydrated lime
    • 1 part white masonry mortar mix.
    • 3 to 3 ½ parts of washed, sharp bank sand.
    • ¼ part of mason’s hydrated lime.
  – Masonry cement mortar - Type S

• Joint Styles
  – Shallow inverted tooled smooth “V” joint or flat joint.
Rehabilitation

• Repointing stone masonry mortar joints
Rehabilitation

• Access and scaffolding
  – Different methods are used depending on size of bridge.
  – Stream bed make-up effects anchoring of scaffolding.
  – Forklifts with aluminum picks for one and two span arches.
  – Scaffolding for three and four span arches.
    - System (engineered)
    - Buck (traditional)
    - Swing-stage
Rehabilitation

• Stone reconstruction
  – Stones are removed in an orderly fashion and placed back in an area similar to their original position.
  – Weight considerations of staged material.
Rehabilitation

- Pier nose stones are numbered and photographed to ensure original placement.
Rehabilitation

- Install stream diversion around pier and abutments.
Rehabilitation

- Construct concrete collars around the piers and/or abutments.
Rehabilitation

- Concrete pier caps.

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Rehabilitation

• Completed Bridge Rehabilitation Projects

• Roxbury Mills Bridge W-5371
  • Rehabilitated in 2002
Rehabilitation

• Prys Mill Bridge W-5652
  • Rehabilitated in 2003

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Rehabilitation

• Completed Bridge Rehabilitation Projects

• Broadfording Road Bridge W-0821
  • Rehabilitated in 2005
Rehabilitation

- Funkstown Bridge (No. 2) W-4001
- Rehabilitated in 2008

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Costs

- **Excavation**
  - $100 per CY
- **Lightweight Concrete**
  - $300 per CY
- **Stone Masonry Reconstruction**
  - $1,200 per CY
- **Repointing Masonry Joints**
  - $30 per SF
- **Replace Concrete Parapet Cap**
  - $2,500 per CY
- **Concrete Collar**
  - $1,000 per CY
Repairs

• Flooding damaged pier nose.
  – Stones recovered from the stream were taken to our Highway Department for storage until bridge can be rehabilitated. A temporary concrete pier nose was constructed in its place.
Repairs

• Underwater inspection discovered undermined pier.
  – New concrete collar was constructed to stabilize the foundation.
Repairs

• Vehicle Damage to parapet wall.
  – Stones from the damaged wall were taken to our Highway Department for storage until the bridge can be rehabilitated. A temporary concrete wall was constructed in its place.
Repairs

• Vehicle Damage to parapet and spandrel wall.
  – Stones were recovered from the stream bank by our Highway Department and reconstructed to closely match their original position.
Closing

- To effectively maintain and preserve our stone arch bridges, we need to continually:
  - Assess our inventory
  - Identify and address our needs
  - Invest in one of our county’s greatest treasures.

- An effective method of rehabilitation, continued federal funding availability, and strong commitment to preservation is key.
Questions

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