CENTRAL OF GEORGIA RAILWAY VIADUCT ASSESSMENT

Inspection Date: April 14, 2020
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Prepared for:

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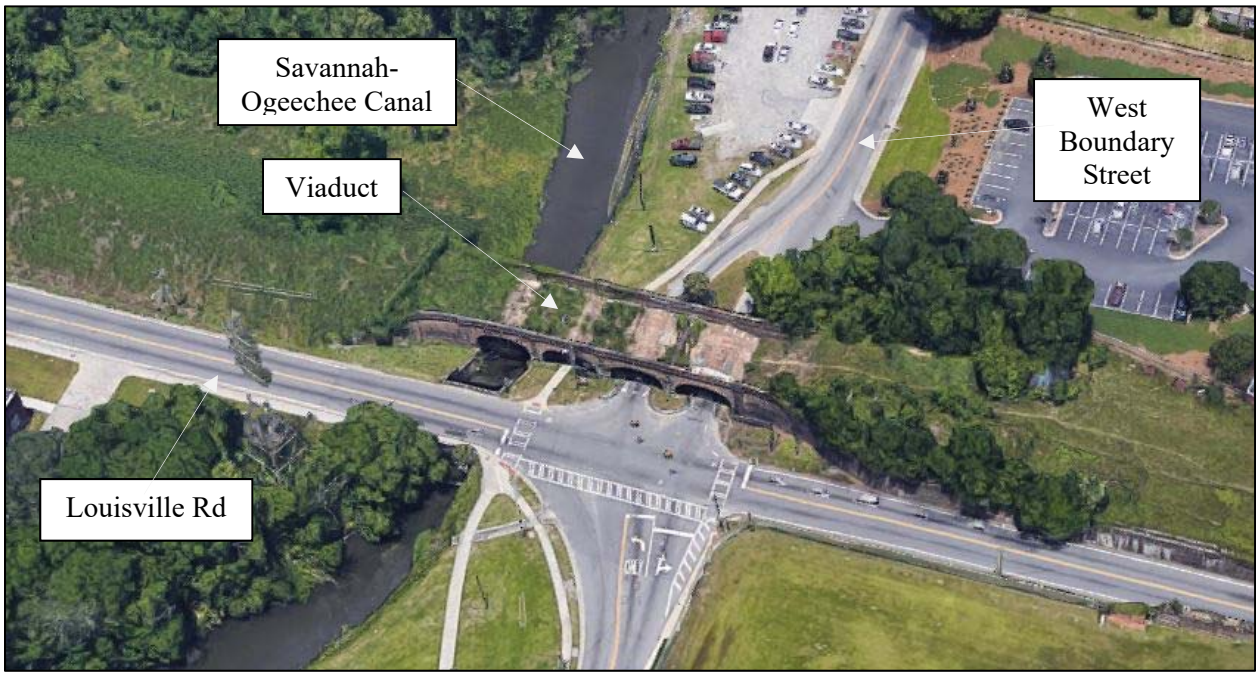

Location Map

1.0 INTRODUCTION

1.1 Purpose and Scope

Collins Engineers, Inc. (Collins) was engaged by CHA Consulting, Inc. (CHA) to assess the condition of the existing brick masonry viaduct that crosses over West Boundary Street and the Savannah-Ogeechee Canal along Louisville Road in Savannah, Georgia. The purpose of the assessment was to review the existing condition of the viaduct and determine if it can safely support pedestrian and light vehicular loads for a proposed trail.

The following report summarizes the results of Collins' assessment; this includes a description of the structure, the existing site conditions, and observed deficiencies, a condition evaluation and general structural assessment, a scope of work for conceptual repairs, an opinion on whether the viaduct can safely support pedestrian and light vehicular traffic, and an order-of-magnitude cost estimate for the proposed repair scope of work.

1.2 General Description of the Structure

Constructed circa 1853, the viaduct extends approximately 200-ft in the east-west direction with a typical width of 45-ft in the north-south direction. The viaduct was reportedly designed by Martin P. Muller and Augustus Schwaab and constructed by Benjamin F. Armstrong for the Central of Georgia Railway. It was constructed with brick masonry and is comprised of four *anse de panier* arches; the arches are approximately 30-ft wide and vary in height above grade. The arches were labeled in the field from west to east as follows: Arch 1 spans over the Savannah-Ogeechee Canal with a clearance of approximately 26-ft above the water; Arch 2 spans over a pedestrian sidewalk with a clearance of approximately 15.7-ft; Arch 3 spans over West Boundary Street southbound traffic with a clearance of approximately 14.9-ft; and Arch 4 spans over West Boundary Street northbound traffic with a clearance of approximately 14.9-ft. The intermediate piers were constructed with brick masonry with a minimum width of 5-ft along the length of the viaduct; each pier was constructed with an approximately 22-in wide by 24-in high arch-shaped opening that extends through the full width of the viaduct; the openings appear to have been constructed to facilitate drainage.

Brick masonry wingwalls were constructed to retain soil at the northwest and southwest corners of the structure; the wingwalls extend approximately 40-ft and step down four times along their length; the maximum height of each wingwall is approximately 18-ft above grade. Brick masonry railing was constructed along the north and south fascias of the viaduct; the top of the railing was approximately 25-ft above grade. Refer to Appendix A for photographs of general conditions and observed deficiencies.

Original construction documents were not provided to Collins for review, however, documentation from a 1975 survey conducted by the Historic American Engineering Record (survey HAER GA-3) was accessed from the Library of Congress; this information is provided in Appendix B of this report.

1.3 Method of Investigation

A team comprised of two engineers, one of whom is a licensed Professional Engineer and a Federal Highway Administration (FHWA) certified bridge inspection team-leader, conducted the assessment on April 14th, 2020. The assessment consisted of a visual and tactile examination of the accessible portions of the structure, with particular attention given to any observed areas of deterioration and apparent distress. No material sampling or destructive testing was performed. All dimensions are approximate and must be field verified by a Contractor prior to beginning any repair work. A 3-D finite element structural analysis of the structure was not included in the scope of this investigation. All dimensions noted in the assessment findings below are approximate.

2.0 ASSESSMENT FINDINGS

2.1 Topside

Following are Collins' observations at the topside of the viaduct:

- The portions of Arches 3 and 4 which were exposed during previous fill removal were covered with mortar; up to 8-ft long by 3-ft wide sections of mortar were missing, exposing the brick masonry below. Light-to-moderate mortar loss and vegetation growth was observed at the exposed masonry. (Photograph 15)

- Portions of the open drainage arches up to 6-ft long by the full width and height were collapsed at Piers 1 and 2. (Photographs 16, 17, and 18)

- Bowing up to 2-in high was observed along a 4-ft portion of the open drainage arch at Pier 3; the mortar joints were open and filled with debris. (Photograph 19)

- It appears that up to 6-ft of fill has been removed from the top of the viaduct; the fill was reportedly removed as part of a previous repair program. (Photograph 20)

- Heavy vegetation growth was observed throughout the top of the viaduct. (Photograph 21)

- Graffiti was observed throughout the exposed brick masonry. (Photograph 22)

- A vagrant shelter was observed above Arch 4. (Photograph 23)

- The west approach of the viaduct was blocked by a chain link fence; the fence was covered with heavy vegetation growth. (Photograph 24)

2.2 North Elevation

Following are Collins' observations along the north elevation of the viaduct:

- A crack up to 3/4-in wide initiated from the buildout west of Arch 1 and propagated into the arch; see Section 2.4 for additional information. Approximately fifteen damaged bricks were observed at the buildout. (Photograph 25)

- An approximately 3-ft long portion of brick has separated up to 1-in from the base of the northwest corner of Pier 1. The brick appears to have displaced due to vegetation growth. (Photograph 26)

- A crack up to 1/8-in wide by 24-in long was observed between the second and third major courses of the masonry arch ring at the southeast corner of Arch 4. (Photograph 27)

- A crack up to 1/8-in wide by 22-in long with three damaged/cracked bricks was observed at the northeast corner of Pier 1. (Photograph 28)

- A crack up to 1/8-in wide by 36-long with five damaged/cracked bricks was observed at Pier 2. (Photograph 29)

- Up to fifteen bricks in the arch ring appear to be cracked/damaged at Arch 3. It appears that mortar repairs were performed to the arch ring as part of a previous repair program.

- A damaged mortar joint was observed between the second and third major courses of the arch ring at Arch 3. (Photograph 30)

- A crack up to 1/8-in wide by 36-in long was observed at the top of Arch 2; up to fifteen bricks were cracked/damaged. (Photograph 31)

- Heavy vegetation growth was typically observed at the weep drains. (Photograph 32)

- A previous mortar repair was observed at the north end of Pier 2. Portions of the repair have failed, exposing the brick masonry; the masonry exhibited mortar loss and missing bricks up to 4-ft high by 12-in wide by 12-in long.

- Multiple areas of damaged or missing brick up to 2-ft long by 1-ft wide by 8-in high were observed along the outside edge of the arches. (Photograph 33)

- Approximately twenty bricks were missing at the northeast corner of Pier 1. (Photograph 34)

- An area of missing brick up to 48-in high by 8-in wide by 8-in long was observed at the northwest corner of Pier 2. (Photograph 35)

- Light-to-moderate vegetation growth was observed throughout the north elevation. (Photographs 36, 37, and 38)

- One broken brick was observed east of Arch 4. (Photograph 39)

- A crack gauge was previously installed at Arch 4. (Photograph 40)

- Impact damage was observed at the guard rail protecting Pier 3. (Photograph 41)

- Four stainless steel bolts were installed during a previous repair program above Arch 4. (Photographs 42 and 43)

- "L" shaped stainless steel brackets up to 1/2-in thick by 6-in high by 33-in long were installed at the northeast corner of Arch 4 during a previous repair program. (Photograph 44)

2.3 South Elevation

Following are Collins' observations along the south elevation of the viaduct:

- A diagonal crack up to 1/4-in wide by 17-ft high with sixteen damaged/cracked bricks was observed in the brick masonry west of Arch 1; the crack propagates through the south face into the pier build-out. (Photographs 45 through 49)

- A mortar parging was applied at the lower west portion of Arch 1 during a previous repair program. The parging has cracked up to 5/8-in. wide and spalled up to 16-in high by 4-in wide. Four missing bricks and six damaged/cracked bricks were observed at this area. (Photograph 50)

- A crack up to 1/2-in wide by 4-ft high was observed at the east face of the buildout west of Arch 1; differential displacement up to ¾-in. was observed along the crack. (Photographs 51 and 52)

- Approximately ten damaged, cracked, or missing bricks were observed at the lower east portion of Arch 1. (Photograph 53)

- A 48-in high by 16-in wide by 16-in long portion of masonry was displaced due to a crack at the base of the southwest corner of Pier 3; differential displacement up to 1/2-in was observed along the crack. (Photogrpah 54)

- Multiple areas of damaged or missing brick up to 3-ft long by 1-ft wide by 8-in high were observed along the outside edge of the arches. (Photographs 55, 56, and 57)

- Moderate vegetation growth and staining was observed at the weep hole at the base of Pier 3. (Photograph 58)

- An approximately 4-in wide by 4-in high weep hole was observed at Pier 1; staining was observed on the brick masonry below the weep. (Photogrpah 59)

- Light vegetation growth was observed throughout the south elevation. (Photograph 60).

- Open mortar joints were observed throughout the brick masonry. (Photograph 61)

- Four bricks were missing at the west end of the viaduct. (Photograph 62)

- Three bricks were missing east of Arch 4. (Photograph 63)

- Two bricks were missing at the top of Pier 2. (Photograph 64)

- A crack gauge was previously installed across the mortar joint between the arch ring and wall above Arch 3. (Photograph 65)

- The guard rail at the lower west portion of Arch 1 was disconnected from its attachment to the arch. (Photograph 66)

- The vertical portion of the guardrail that connects the lower horizontal member to the concrete curb was missing in front of the lower east portion of Arch 1. (Photograph 67)

- Cracking up to 1/8-in was observed in the concrete in the vicinity of the rail connection at the southeast corner of Arch 1. (Photograph 68)

2.4 Underside of Arch 1

Following are Collins' observations at the underside of Arch 1:

- A crack up to 1/2-in wide propagates across the full underside of the barrel of the arch. The crack initiates at the buildout at each side of the opening at the north face approximately 2-ft from the south end of the archway. The crack connects to the crack in the west buildout mentioned in Section 2.2. (Photographs 69 and 70)

- A crack up to 1/2-in wide propagates across the full underside of the barrel of the arch. The crack initiates at the buildout at each side of the opening at the north face approximately 8-ft from the north end of the archway. Spalled mortar up to 3-ft long by 2-ft wide by 3-in deep was observed along the crack; a crack gauge was installed adjacent to the spall during a previous repair program. (Photographs 71 through 74)

- Three post-tensioning tie rods were installed across the full width of the arch; the rods appear to have been installed during a previous repair program and have subsequently failed. (Photographs 75, 76, and 77)

- The underside of the brick masonry arch was covered with mortar; map cracking was observed throughout. (Photograph 73)

2.5 Underside of Arch 2

Following are Collins' observations at the underside of Arch 2:

- A crack up to 1/2-in wide propagates across the full underside of the barrel of the arch approximately 6-ft from the north edge of the arch. (Photograph 78)

- Water was actively seeping from the mortar cracks at numerous locations at the underside of the arch. (Photograph 79)

- Spalled mortar up to 6-ft long by 4-ft wide was observed at the underside of the arch. (Photographs 80 and 81)

- The underside of the brick masonry arch was covered with mortar; map cracking was observed throughout. (Photograph 82)

2.6 Underside of Arch 3

Following are Collins' observations at the underside of Arch 3:

- An area of spalled mortar up to 30-ft long by 3-ft wide was observed along the apex of the arch. (Photographs 83 and 84)

- The underside of the brick masonry arch was covered with mortar; map cracking was observed throughout. (Photograph 85)

2.7 Underside of Arch 4

Following are Collins' observations at the underside of Arch 4:

- Longitudinal and transverse cracking up to 1/8-in wide was observed on the underside of the arch approximately 8-ft from the south edge. (Photograph 86)

- Water staining was observed along the lower 5-ft of the east wall. (Photograph 87)

- The underside of the arch was not covered with a mortar parging; it appears that the mortar may have been removed as part of a previous repair program, as previous brick repairs and re-pointed mortar joints were evident throughout. (Photographs 88 and 89)

2.8 Northwest Wingwall

Following are Collins' observations at the northwest wingwall:

- Heavy vegetation growth was observed throughout; the condition of the brick masonry could not be determined due to the vegetation. (Photograph 90)

2.9 Southwest Wingwall

Following are Collins' observations at the southwest wingwall:

- A diagonal crack up to 1/4-in wide by at least 166-in high was observed in the brick masonry below the transition from the third to fourth step; the extent of the crack and potentially damaged brick were obstructed by vegetation growth. The crack appears to be indicative of settlement. (Photograph 91)

- A diagonal crack up to 1/4-in wide by 146-in high with one damaged/cracked brick was observed in the brick masonry below the transition from the second to third step. The crack appears to be indicative of settlement. (Photographs 92 and 93)

- A vertical crack up to 1/8-in wide by 99-in high with one damaged/cracked brick was observed in the brick masonry below the transition from the second to third step. The crack appears to be indicative of settlement. (Photographs 94 and 95)

- A vertical crack up to 3/16-in wide by 72-in high with eight damaged/cracked bricks was observed in the brick masonry below the transition from the first to second step. The crack appears to be indicative of settlement. (Photographs 96 and 97)

- Mortar loss up to 3-in wide by 48-in high was observed along the construction joint between the wingwall and the viaduct. (Photograph 98)

- Deteriorated or missing mortar was observed throughout the brick masonry. (Photographs 99 and 100)

- Light-to-moderate vegetation growth was observed throughout; a section of chain link fence appears to have fallen and become entangled in the vegetation in front of the wall. (Photographs 101 and 102)

- One coping piece was dislodged from the top of the wall and was resting on grade at the base of the wall. (Photographs 103 and 104)

3.0 RECOMMENDATIONS AND EVALUATION

Based on Collins' observations, the viaduct does not appear to currently possess sufficient capacity to support the proposed pedestrian and light vehicular loads for the trail. The cracking evident at Arches 1 and 2 appears to be indicative of significant structural distress within the arch rings. Deterioration of the brick masonry and mortar joints was observed throughout. It is evident that the original drainage system has been damaged and it is need of cleaning and repair. Additionally, decades of unmaintained vegetation growth have compromised the integrity of the viaduct throughout.

In order to rehabilitate the viaduct to support the proposed trail loads, an extensive repair program would need to be undertaken. This would include stabilization of the arch rings, restoration of the deteriorated, cracked, or broken brick masonry and mortar, and reconstruction of the drainage system.

Following are Collins' conceptual repair recommendations for rehabilitation of the viaduct:

1. All remaining fill should be removed from the top of the viaduct. Great care should be taken by the Contractor during removal operations to protect the integrity of the brick masonry and it is possible that hand removal of the fill may be required. The fill removal will facilitate the following repairs to the structure.

2. All vegetation growth should be removed, including all growth on the exposed portions of the brick masonry and within 10-ft of the structure. Additionally, the brick masonry should be cleaned with a non-abrasive, water-based method in general conformance with National Park Service Preservation Brief 1: Cleaning and Water-Repellent Treatments for Historic Masonry Buildings.
3. All mortar joints should be re-pointed with a mortar that matches the original (not mortar used during previous re-pointing programs) in historical composition, character, and color. A material analysis of a sample of the existing mortar should be performed by a testing agency with experience in the analysis of historic mortar. All work should be in general conformance with National Park Service Preservation Brief 2: Repointing Mortar Joints in Historic Masonry Buildings.

4. All cracked/damaged bricks should be removed and replaced with bricks that match the existing in character, size, appearance, color, and composition.

5. All displaced brick should be removed and re-set to re-establish the original shape, appearance, and architecture of the structure. Salvaged brick should be re-used wherever possible.

6. All missing bricks should be replaced with bricks that match the existing in character, size, appearance, color, and composition.

7. All graffiti should be removed. All work should be in general conformance with National Park Service Preservation Brief 38: Removing Graffiti from Historic Masonry.

8. The chain link fence at the west approach and the fallen fence section at the southwest wingwall should be removed.

9. All components of the existing drainage system should be exposed and cleaned. Following topside masonry repairs, the system should be rehabilitated as follows:

    - A waterproofing membrane should be installed atop each arch to facilitate drainage to the piers and protect the integrity of the masonry.
    - Drains that direct water to the existing weep holes should be installed along the full width of the piers.
    - Gravel/crushed stone should be installed as required to promote drainage.

10. All collapsed, damaged, or bowed portions of the open arches at the piers should be reconstructed to their original shape, appearance, and architecture.

11. The vagrant shelter above Arch 4 should be removed.

12. Following all topside repairs, fill should be installed to reestablish the grade and facilitate the trail path.

13. The mortar parging at the underside of the brick masonry at Arches 1, 2, and 3 should be removed.

14. Stainless steel post-tensioning through-bolts should be installed across the full width of Arches 1, 2, and 3; the bolts should be installed along the curvature of the arch ring at a maximum spacing of 36-in on-center. Circular stainless steel plates should be installed at the exterior face of each bolt. Following installation of the bolts, all components of the existing failed post-tensioning tie rods at Arch 1 should be removed.

15. All existing crack gauges should be removed.

16. All damaged guardrail should be removed and replaced.

17. Cracks in the brick masonry which do not exhibit differential displacement should be re-pointed. The repair mortar should match the existing in appearance, color, composition, and historic character. All damaged bricks in the vicinity of any crack should be removed and replaced with brick that matches the existing in appearance, color, size, composition, and historic character. A maximum joint width of 1/2-in should be provided when reconstructing areas of brick. Stainless steel helical "stitching" rods should be installed within the horizontal mortar joints across cracks as determined by the Engineer of Record.

18. Displaced sections of the pier buildouts should be removed and reconstructed.

19. All mortar installed during previous repair programs should be removed as part of the current repair program. The replacement mortar should match the existing in appearance, color, composition, and historic character.

20. The broken guardrail connection at the southwest corner of Arch 1 should be repaired.

21. The missing guardrail vertical at the southeast corner of Arch 1 should be replaced.

22. Cracks in the concrete in the vicinity of the guard rail connections should be repaired.

23. All broken, loose, or damaged mortar should be removed and replaced along the construction joints between the wingwalls and viaduct.

24. The fallen section of coping in front of the southwest wingwall should be re-installed atop the wall.

By implementing the conceptual repair recommendations provided above, it is Collins' opinion that the viaduct may be restored to its original capacity. Collins understands that the viaduct has previously been used to support railway traffic and should possess sufficient capacity to support the proposed trail.

4.0 ORDER-OF-MAGNITUDE COST ESTIMATE

The following represents a rough budgetary level order-of-magnitude opinion of probable cost for the conceptual repairs provided above. The cost estimate is based on our experience with similar projects in similar locations. Construction costs vary and Collins does not provide any warranty, expressed or implied, for construction costs. This estimate does not include any mechanical, electrical, or plumbing repairs that may be required. The cost for mobilization is based on the assumption that all repairs will be performed at the same time by one Contractor.

Central of Georgia Railway Viaduct Cost Estimate

Item	Description	Quantity	Per	Cost Per	Cost
1	Vegetation Removal	1	LS	$ 76,066.46	$ 76,066.46
2	Soil Removal at 4th Arch	1	LS	$ 27,166.59	$ 27,166.59
3	Equipment Rental	1	LS	$ 21,733.27	$ 21,733.27
4	Access	1	LS	$ 8,693.31	$ 8,693.31
5	Masonry Re-pointing, Repairs, and Reconstruction	1	LS	$ 1,754,405.88	$ 1,754,405.88
6	Restore Drainage	1	LS	$ 78,239.78	$ 78,239.78
7	Seal Top of Arches	1	LS	$ 162,999.55	$ 162,999.55
8	Fill Material	1	LS	$ 78,103.95	$ 78,103.95
9	Backfill	1	LS	$ 39,119.82	$ 39,119.82
10	Management	1	LS	$ 65,199.82	$ 65,199.82
11	Remediation of 4th Arch Soil	1	LS	$ 135,832.96	$ 135,832.96
12	Traffic Control and Road Closures	1	LS	$ 10,866.64	$ 10,866.64
13	Install Metal Hardware	1	LS	$ 33,958.24	$ 33,958.24
14	P&P Bonds	1	LS	$ 63,907.31	$ 63,907.31
				TOTAL	**$ 2,556,293.58**

Note: The order-of-magnitude cost estimate above does not include engineering or construction administration/management costs associated with the repairs.

5.0 CONCLUSION

Collins Engineers, Inc. was engaged by CHA Consulting, Inc. to assess the condition of the existing brick masonry viaduct that crosses over West Boundary Street and the Savannah-Ogeechee Canal along Louisville Road in Savannah, Georgia. The purpose of the assessment was to review the existing condition of the viaduct and determine if it can safely support pedestrian and light vehicular loads for a proposed trail. Collins performed a visual assessment of the viaduct on April 14th, 2020.

Based on Collins' observations, the viaduct does not currently have sufficient capacity to support the proposed pedestrian and light vehicular loads for the trail. However, by implementing an extensive repair program, including stabilization of the arch rings, restoration of the deteriorated, cracked, or broken brick masonry and mortar, and reconstruction of the drainage system, it is Collins' opinion that the structural capacity of the viaduct may be reinstated and the viaduct may be used to support the proposed trail.

Collins Engineers, Inc. appreciates the opportunity to work with CHA Consulting, Inc. on this project and looks forward to working with you in the future. We would be pleased to discuss any aspect of this report with you in person, via phone or by email.

Respectfully submitted,
COLLINS ENGINEERS, INC.

Jonathan Sigman, P.E.
Regional Manager

Originated by:
Daniel Campbell, P.E. and John Beach, E.I.T.

APPENDIX A
INSPECTION PHOTOGRAPHS

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Photograph 2 - Viaduct from West Approach

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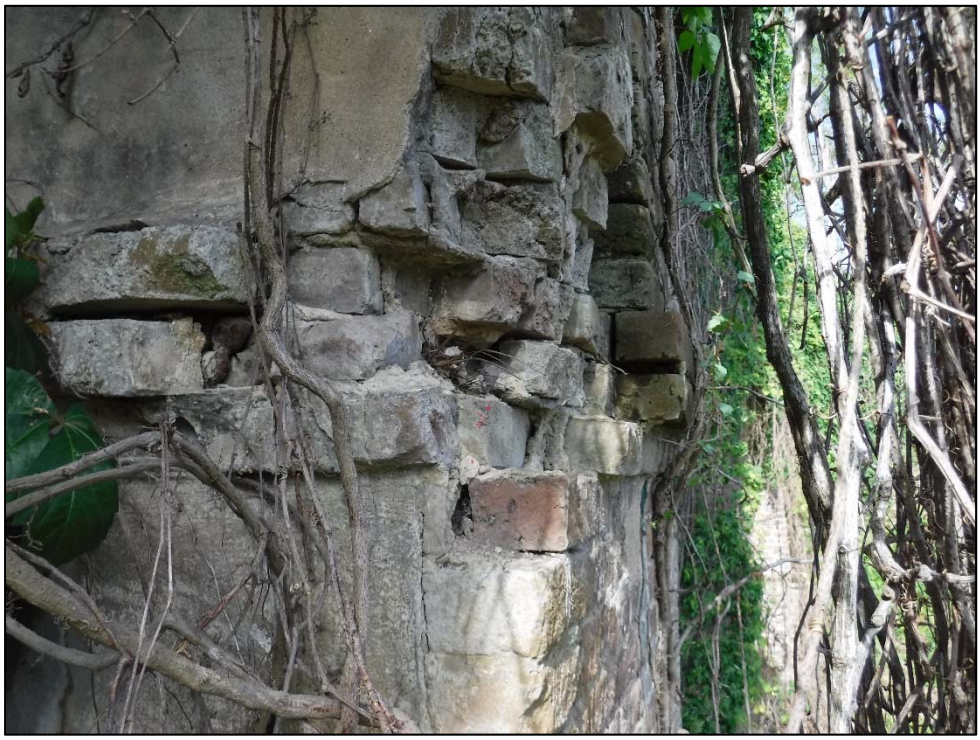
Photograph 33 – Damaged/Missing Brick Masonry in Arches



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Photograph 37 – Vegetation Growth Throughout North Elevation

Photograph 38 – Vegetation Growth Throughout North Elevation

Photograph 39 – Broken Brick in Arch 4

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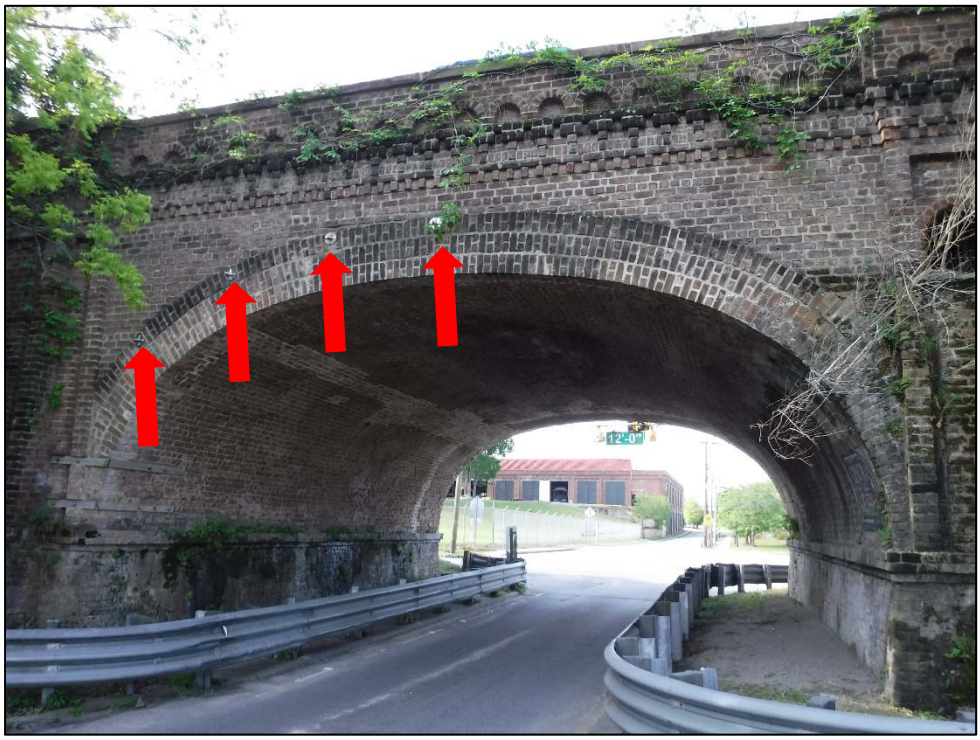
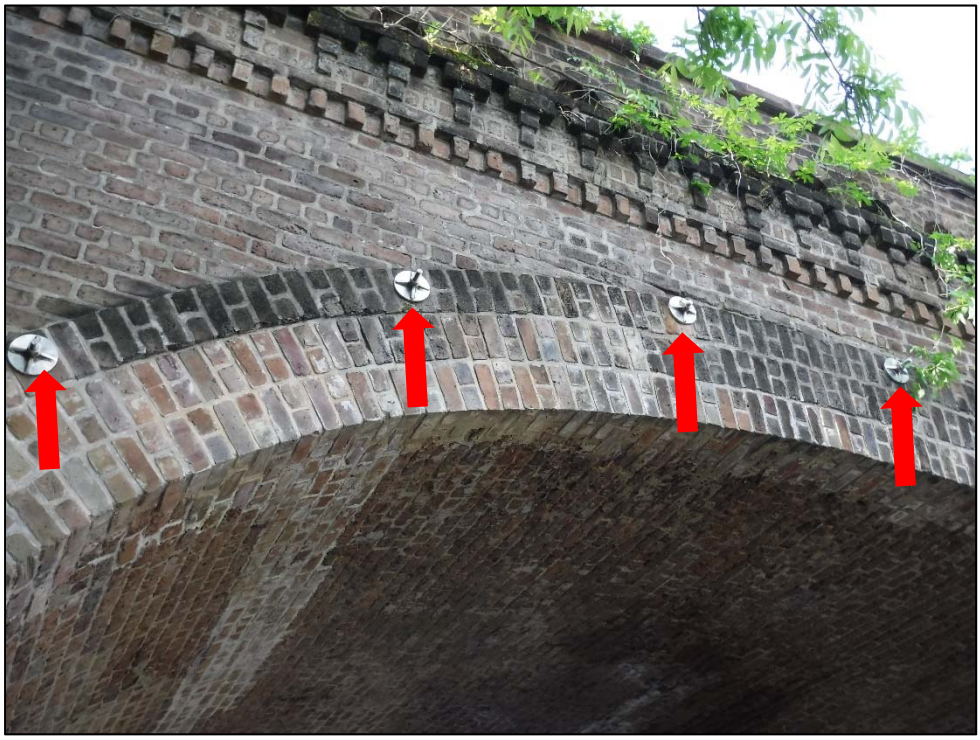


Photograph 42 – Stainless Steel Bolts Above Arch 4



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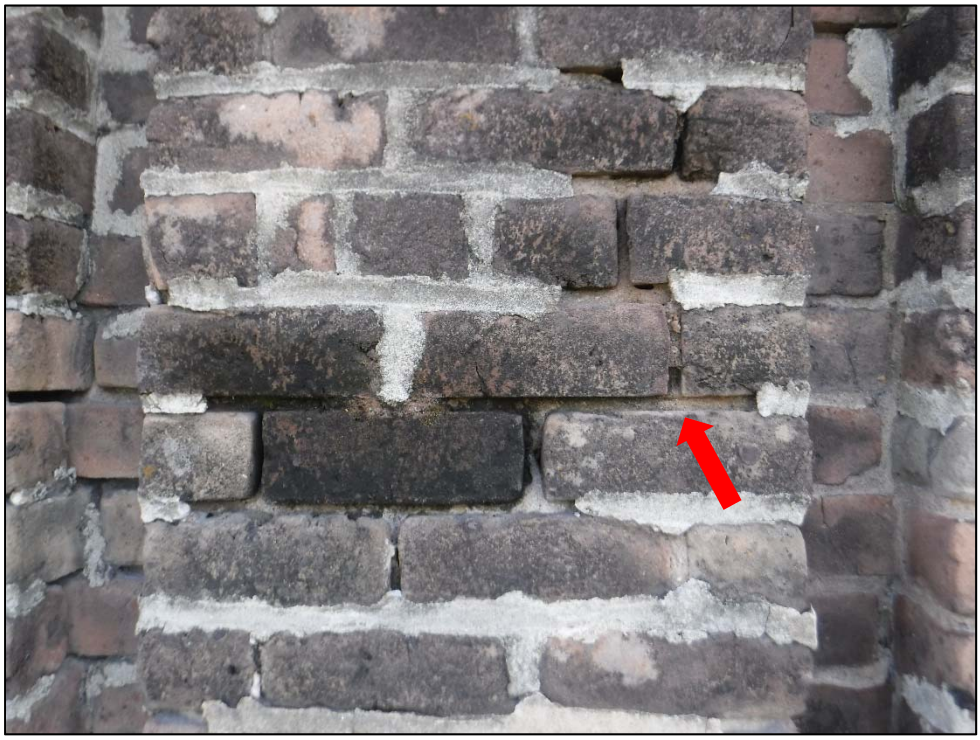

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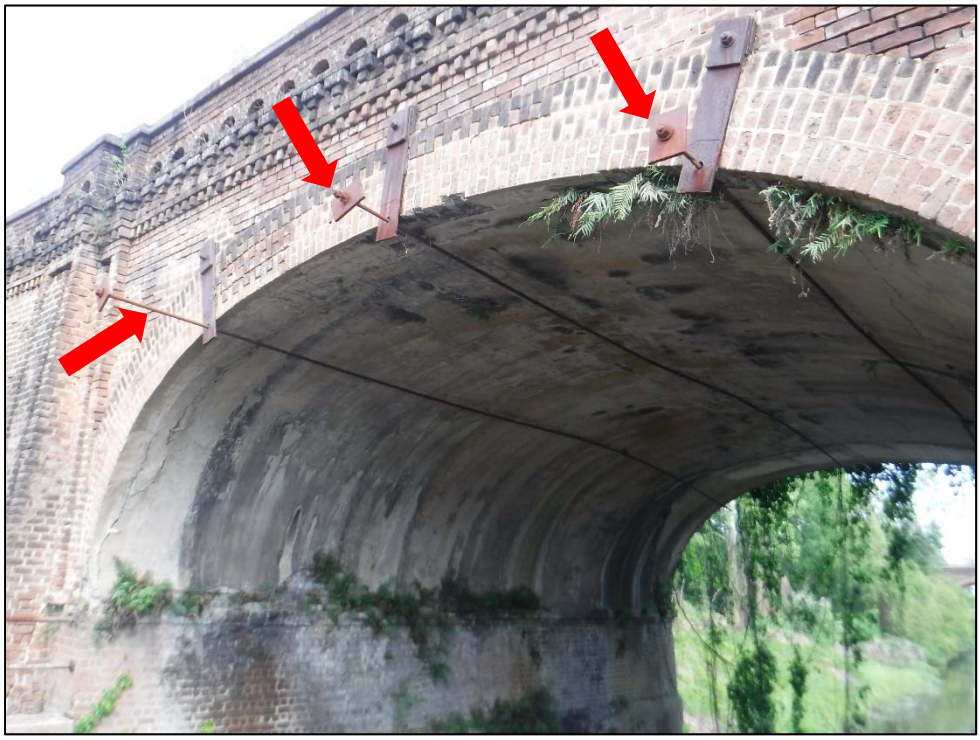
Photograph 73 – Crack with Spalled Mortar in Arch 1

Photograph 74 – Crack with Spalled Mortar in Arch 1



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Photograph 89 – Evidence of Previous Repairs to Brick and Mortar Joints in Arch 4

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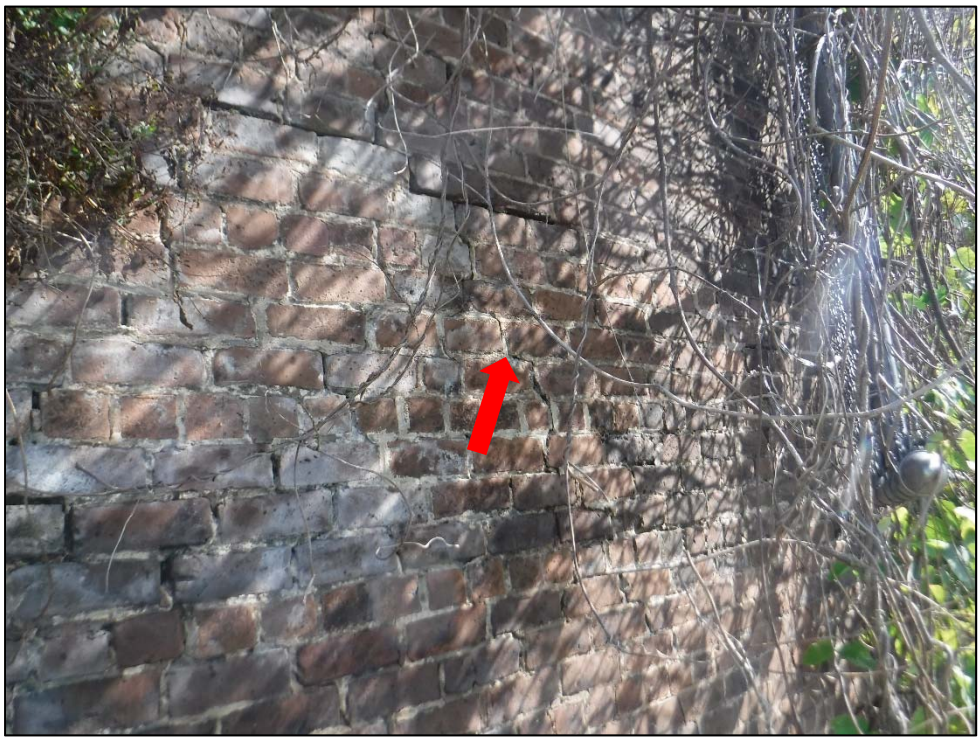
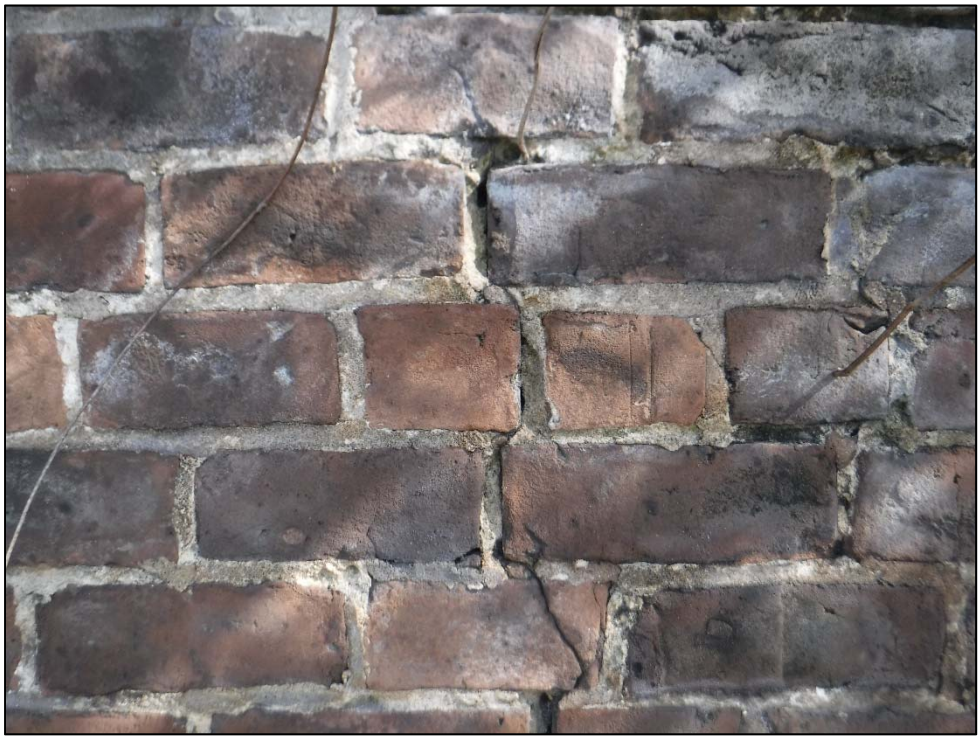
Photograph 91 – Diagonal Crack Obstructed by Vegetation Growth
At Southwest Wingwall



Photograph 92 – Diagonal Crack with Damaged/Crack Brick in Southwest Wingwall

Photograph 93 – Diagonal Crack with Damaged Brick in Southwest Wingwall

Photograph 94 – Vertical Crack with Damaged Brick in Southwest Wingwall

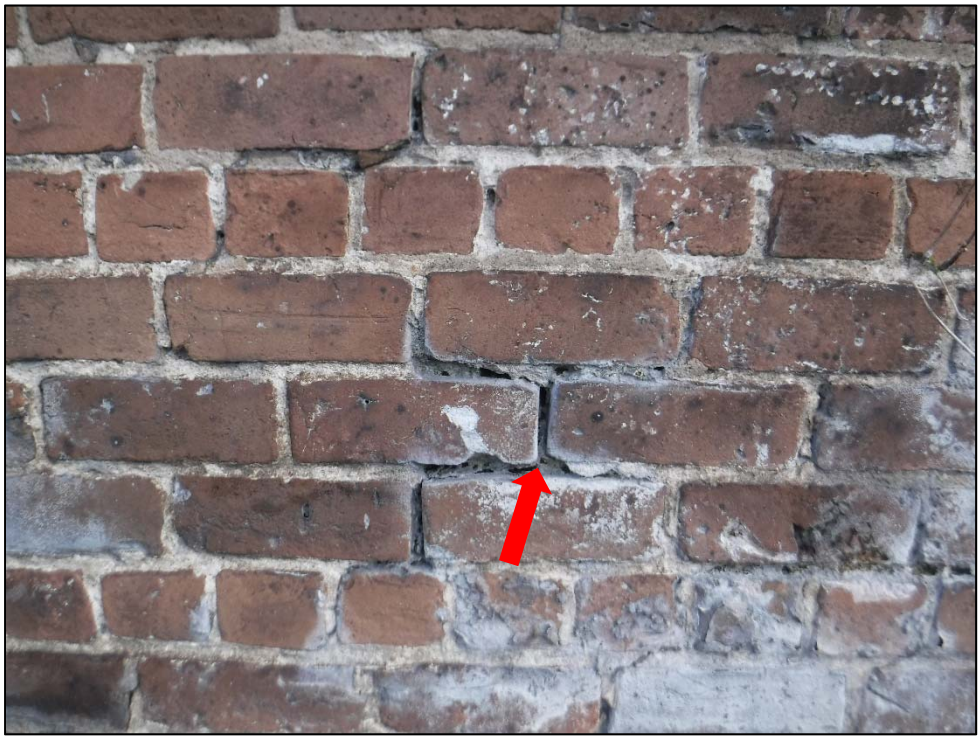


Photograph 95 – Vertical Crack with Damaged Brick in Southwest Wingwall

Photograph 96 – Vertical Crack with Damaged Brick in Southwest Wingwall

Photograph 97 – Veritcal Crack with Damaged Brick in Southwest Wingwall

Photograph 98 – Mortar Loss Along Construction Joint in Southwest Wingwall



Photograph 99 – Deteriorated/Missing Mortar in Southwest Wingwall

Photograph 100 – Deteriorated/Missing Mortar in Southwest Wingwall

Photograph 101 – Vegetation Growth on Southwest Wingwall

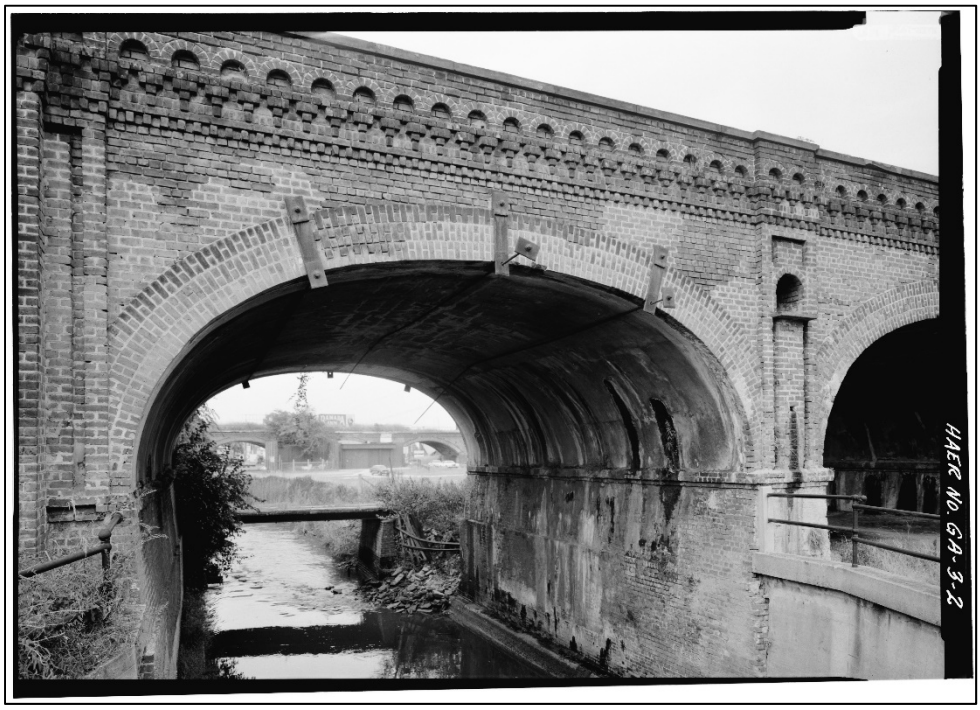
Photograph 102 – Fallen Fence in Vegetation Growth at Southwest Wingwall

Photograph 103 – Dislodged Coping Piece at Southwest Wingwall

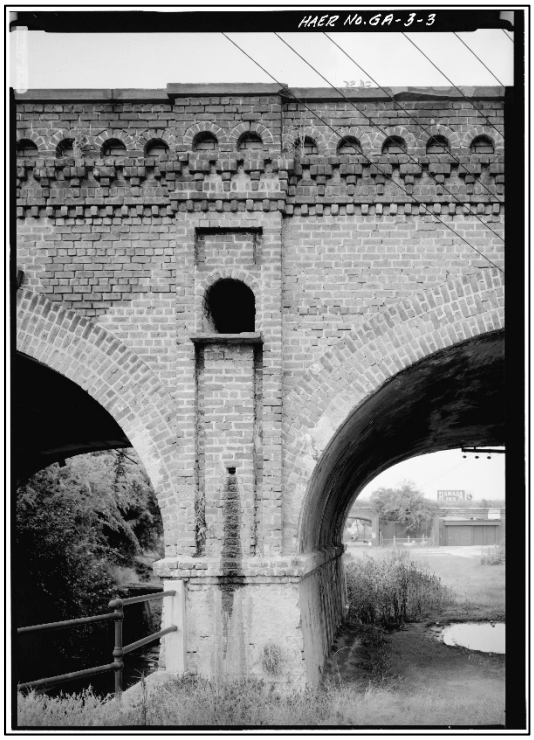
Photograph 104 – Dislodged Coping Piece at Southwest Wingwall

APPENDIX B
1975 HISTORIC ENGINEERING AMERICAN RECORD SURVEY

Photograph 1 - West Approach Looking West

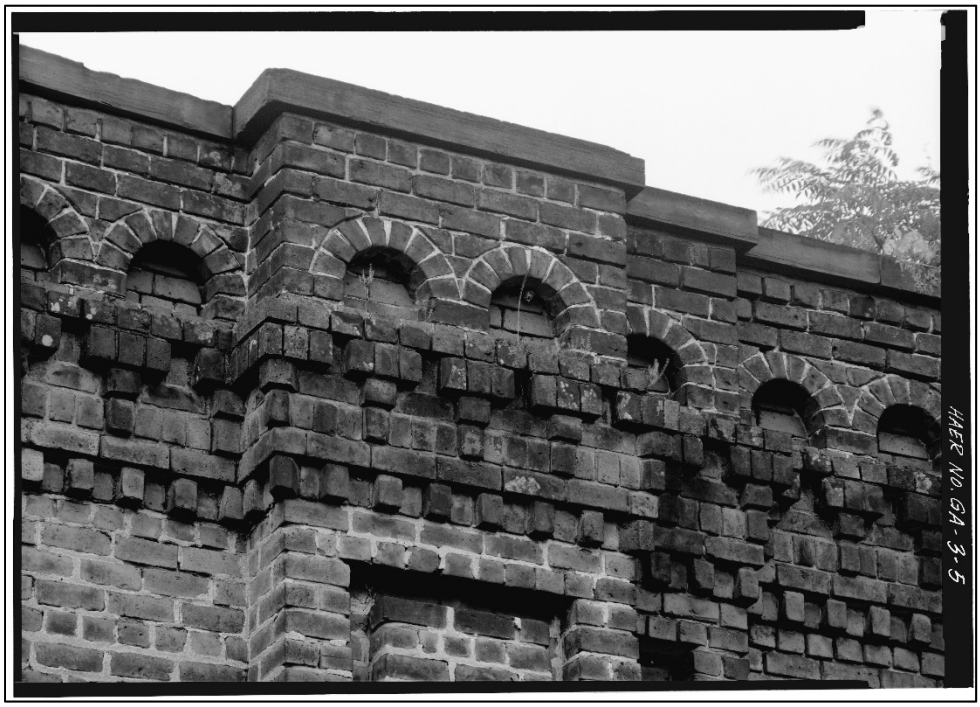


Photograph 2 - Viaduct from West Approach



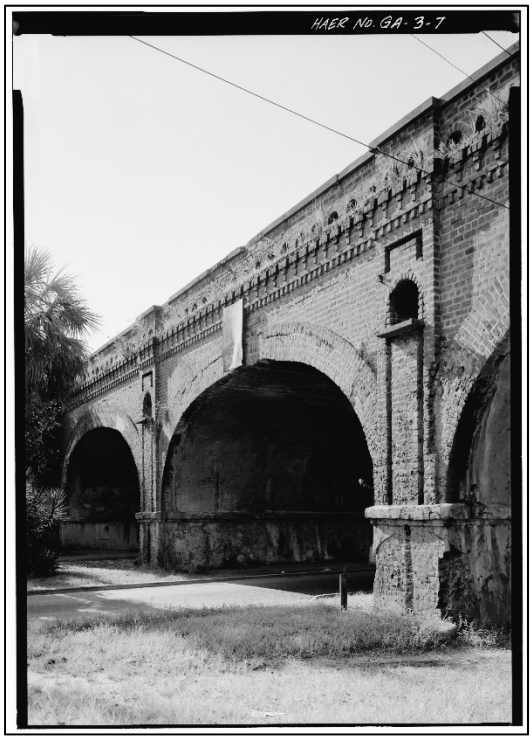
Photograph 3 - East Approach Looking East

Photograph 4 - Viaduct from East Approach

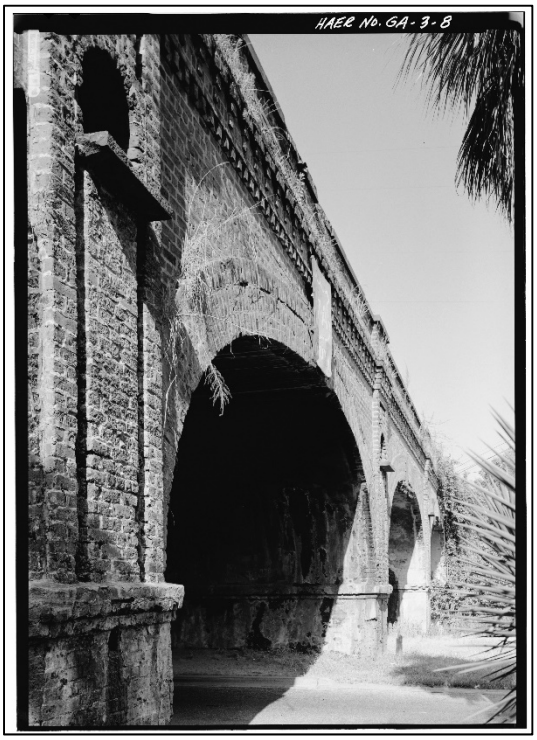


Photograph 5 – North Elevation

Photograph 6 – South Elevation

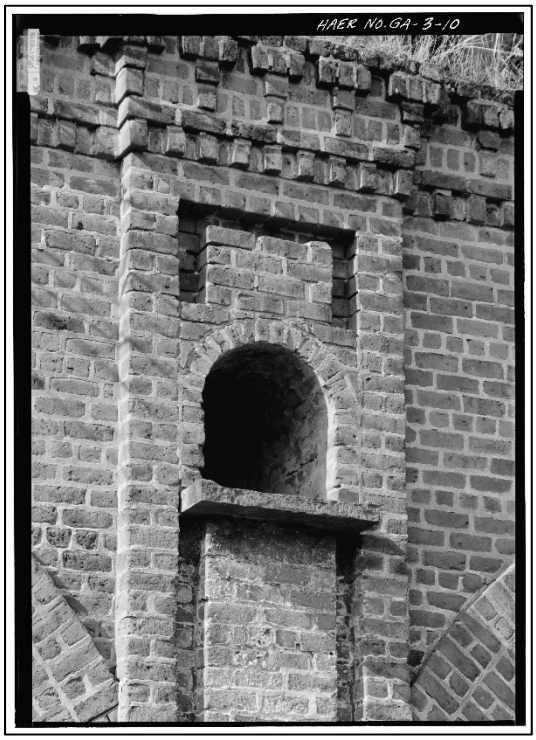


Photograph 7 – Arch 1 Looking Northeast

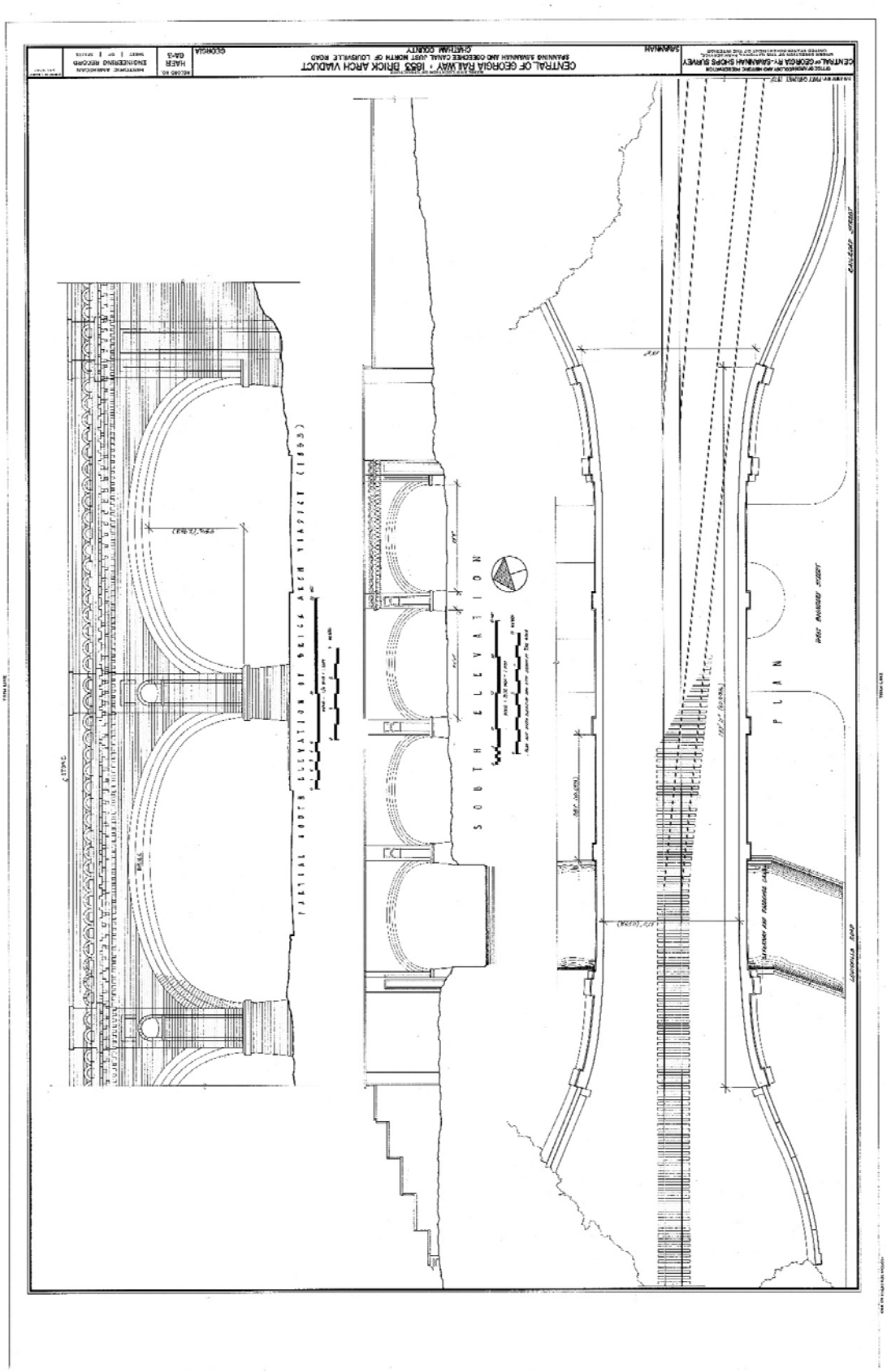


Photograph 8 – Arch 2 Looking Northeast

Photograph 9 – Arch 3 Looking Northeast



Photograph 10 – Arch 4 Looking Northwest


CENTRAL OF GEORGIA RAILWAY · 1853 BRICK ARCH VIADUCT
SAVANNAH & SUMMARY AND OGEECHEE CANAL JUST NORTH OF LOUISVILLE ROAD
CHATHAM COUNTY
GEORGIA
HAER GA-13
SOUTH ELEVATION
PLAN