HUNTERDON COUNTY HISTORIC
STONE ARCH CULVERT REPORT

HUNTERDON COUNTY PLANNING BOARD

NOVEMBER 1995
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Lichtenstein
INTRODUCTION

Hunterdon County selected A.G. Lichtenstein & Associates, Inc. to conduct a study of the stone arch culverts in the county and to make recommendations about their preservation. The project was twofold, to research the historical significance of the county’s stone arch culverts and to provide general recommendations as to how fourteen (14) specified stone arch culverts are likely to be able to accommodate future traffic needs without compromising their historical integrity. The intent of the study was to examine the historic preservation issues related to the fourteen field-inspected structures; not to serve as an in-depth engineering inspection for structural ratings or to identify all the features that need to be addressed for the culvert to comply with current safety standards.

The project was funded, in part, by an Intermodal Surface Transportation Enhancement Act (ISTEA) grant made to the county. The project was administered by Linda Black Weber, Principal Planner, Hunterdon County Planning Board. Members of the Hunterdon County Cultural and Heritage Commission assisted with conducting background research and photographing the stone arch culverts. Mary E. McCahon and Ronald Giamario, P.E. were the Lichtenstein project managers and principal investigators. The work was completed during the spring of 1995.
HISTORIC CONTEXT OF HUNTERDON COUNTY STONE ARCH CULVERTS

Introduction

The historic rural character of Hunterdon County is enhanced by the survival of over one hundred arch culverts and bridges on the county’s highways and byways. These quaint remnants from an earlier time are threatened by a burgeoning population, but their loss would have a negative effect on the character of the county. Despite its recent rapid growth, the county has a strong tradition of bridge preservation as evidenced by the fact that the only remaining covered bridge in the state is found in Hunterdon. The plethora of metal truss bridges from the 19th and early 20th century further testify to the county’s rich heritage and successful efforts to preserve its links with the past. The stone arch bridges and culverts are particularly noteworthy because they were the earliest type of permanent crossing built in the county.

Stone Arch Technology

The arch is curved construction with the convex side upward consisting of shaped blocks called the arch ring that compress together under vertical loads. To work, the outward thrust at the base of the arch produced by loads imparted to the top of the arch ring must be countered by a resisting force produced at the abutments. Regardless of size, the principle behind the arch remains the same; the vertical forces have to be balanced by equal reactions at the abutments. The arch is constructed by erecting an arched form, called centering or falsework, the size of the arch, placing the arch ring, spandrel walls and wingwalls, backfilling the arch with earth or some other material, then removing the falsework and allowing the structure to compress itself into a locked and stable unit that supports itself through compression. Although there are different shapes of arches, from barrel (semicircular) to elliptical (oval) and pointed, the principal behind the arch is the same. The only difference is the appearance.

An ancient bridge type dating to as early as 3000 B.C. in China and used extensively by the Romans, the closed spandrel earth-filled masonry arch was refined in 16th and 17th centuries in Europe. European immigrants brought the technology with them to America, adapting it to local conditions in areas where stone was plentiful. This was the technology used when a “permanent” structure was desired.

Short masonry spans called culverts (structures with a clear span of less than 20 feet; bridges have a clear span of 20 feet and greater) were ideally suited to the riverlets and tributaries that crisscross Hunterdon, and they were built into the early years of the 20th century. Fine building stone, including shale and limestone, was available in abundance in the county, and while not technologically innovative, the many remaining stone arch culverts (structures with a clear span of less than 20 feet) and bridges in Hunterdon County are noteworthy as survivors of first generation-type bridge technology that was used into the early decades of the 20th century. While generally not individually distinctive, the many stone arch culverts that survive in Hunterdon County are tangible and valued artifacts from the county’s 18th and 19th century agrarian past.

Stone Arch Culverts and Bridges in Hunterdon County

As early as 1785 the Hunterdon County Board of Chosen Freeholders began to levy taxes to fund building culverts and bridges. The earliest documented extant bridges in Hunterdon County (which incorporated a portion of Mercer County including Trenton until 1838) are stone arches. One of the earliest built by the county was the 1774 stone arch bridge carrying Broad Street in Trenton over Assunpink Creek, then the boundary between Hunterdon and Burlington counties. That span replaced a wooden bridge, and it in turn
had to be replaced with stone arch spans in 1822 and 1843. The handsome 1843 arch with rusticated ring stones and ashlar spandrel walls and wingwalls survives. Based on the evidence offered by the surviving population of stone arch structures in the county and limited primary source documentation, the heyday of the stone arch bridge and culvert appears to have been the first three quarters of the 19th century. This was especially true of the middle quarters of the 19th century when secondary roads and their related stream crossings were improved as farm-to-market roads. The local infrastructure took on added importance as part of a multi-modal transportation network that included the railroad beginning in the 1840s.

In addition to the over 100 stone arch culverts in Hunterdon County, fourteen 19th and early 20th century stone arch bridges remain with the earliest dating to 1840 (Woodville Road over Peters Brook in the village of Linvale (West Amwell Township). Most are single-span bridges that are representative of a commonly used type when permanence of a crossing was desired. The three 40 feet long stone arch bridges over Swan Creek in Lambertville (NJDOT bridge numbers 1000056, 100Y040, 100Y041) date from the mid-1870s and with their ring stones defining the arch and rubble or ashlar spandrel walls and wingwalls, the three are representative of the surviving stone arch technology in historic contexts, length and appearance. They are typical of the design that dominated both bridges and culverts throughout the century.

The over 100 surviving stone arch culverts illustrate even more strongly than do the stone arch bridges the dominance of the technology for short spans, especially during the second half of the 19th century. The only difference between the two classifications of stone arch culverts and bridges is that culverts have shorter clear spans and are thus smaller. A culvert has a length or clear span of less than twenty feet (measured as the distance between the abutments or arch springing), and the Hunterdon County examples range from five to twenty feet in length. The high number of stone arch culverts is attributable in part to the inherent soundness and simplicity due to the size of the structural type. Stone works well in compression, and it is forgiving of environmental concerns like rust and rot that plague other technologies and materials. Additionally, an arch can tolerate some deferred maintenance and it may fail slowly and telegraph problems when it is overstressed.

Other contributing reasons for the high number of surviving stone arch structures in the county include the fact that several of the historic roads developed with stone arch structures have been bypassed by modern highways (especially true in the Lambertville area), the rural character of the county, the frugal nature of the freeholders and the economic decline that the county experienced from the 1830s until well into the 1930s. The peak population of 40,758 people in 1865 was not matched again until well into the 1940s. The absence of development pressure proved a benefit to bridge preservation. Another factor was the slower pace of highway and land development in the county that lasted until about 1960. The result is a remarkable assemblage of 19th-century stone arch culverts and bridges that are well distributed, both chronologically and geographically.

The stone arch was also popular in the county because of the abundance of indigenous rock including sandstone, shale, and limestone. Several quarries were located in the southwestern portion of the county, and they shipped quantities of fine building stone via the Delaware and Raritan canal feeder (completed 1838). According to James Snell's 1881 history of the county, Prall's Quarry in the Lambertville area was the source of much of the stone used in building the local bridges (Snell, p. 170). Many other quarries like Wycoff's at Reaville and Nevius' quarry on the east bank of the Neshanic River are also cited. A May, 1835 reference in the freeholders' minutes states that Mr. Prall had enough stone available in his quarries to build a stone arch bridge. The price was ten cents a load (Minutes, 26 May 1835). The stone was especially easy to quarry and dress. Limestone, also used in mortar, could be had from the Musconetcong River valley and the Clinton area. It could be processed at mills in Clinton.

The oldest documented (date stones in parapets) stone arch culvert in the county is the 12 feet long structure on the former Easton-Trenton Turnpike over Branch Wichecheokee Creek (DQ 313). Originally
placed in 1801, it was widened in 1829. With its matched tooled ring stones and rubble-coursed indigenous shale spandrel walls and wingwalls, the arch exhibits the same technology employed for longer arch bridges built throughout the century.

The process of building a bridge or culvert can be gleaned from the minutes of the Hunterdon County Board of Chosen Freeholders, but the exact date of construction for surviving examples generally cannot. Matching structures to references is difficult because references to location are by adjacent property owner(s) or locale rather than feature crossed. They do state the township. The entry frequently does not specify whether the structure in question is wood or stone. In the absence of date stones, it is virtually impossible to date most stone arch structures. While bridges were discussed individually, most small structures like culverts are not mentioned specifically in the freeholders’ minutes because they were inexpensive enough to be authorized by individual freeholders without going before the board, or they were constructed by the townships. By the mid 1880s, the specific amount of money allocated to each township and borough for "bridge orders" was listed annually in the freeholders' minutes.

The Board of Chosen Freeholders spent a great deal of time deliberating the construction of bridges. For at least the first half of the 19th century, traditionally they would convene every May after the spring freshets, or after any major flood to hear damage reports from each township. They would then spend a week or so traveling from bridge site to site, assessing damages or evaluating the necessity of constructing new bridges. The local male residents would have a chance to express their opinion and make recommendations. The board would then vote on whether to construct a new bridge, repair an existing bridge, or require the residents to use another crossing. If they decided to build a new bridge, a committee would be appointed to recommend a plan for a bridge. Discussions about a specific bridge frequently extended over several meetings.

After a decision of bridge type was made, the board appointed a supervisor, or frequently, a separate stone supervisor and a wood supervisor to attend to construction. They also appointed an inspector to audit the accounts, inspect the bridge to determine that it was constructed of quality materials and in a workmanlike manner and accept the work. Supervisors and inspectors were board members or former board members. On occasion, the supervisor was also the inspector.

The freeholders decided on the method of payment, which was usually by contract or by the day (day rates for county work were also set by the freeholders). The stone work and the carpentry were often paid by different methods. The required notice of the intention of the board would be posted in a local meeting place—the general store, the post office, the tavern. Generally, by the middle third of the century, an auction would be held to sell the opportunity to construct the bridge—the lowest bidder getting the work. The 13 June 1838 freeholders’ minutes record that Joshua Apgar was awarded a $500.00 contract to build a two-span stone arch bridge through auction. The same bidding process was used to select contractors to repair both stone and wood bridges.

Frequent appeals were made to the board to increase the payment for bridges when the contractor was hit by "sudden and unexpected weather, snow and misfortunes." Such requests were usually at least partially granted. In some cases, the board specifically requested that certain contractors NOT be employed, usually because they had been unable to finish past work in the specified time. Joshua Apgar and the board even resorted to litigation in a pay dispute.

Through the 1860s, the freeholders' discussion often centered on whether to build a stone arch or a wood (truss or stringer) bridge. Wood and stone technologies dominated through the 1860s, after which date metal trusses increasingly became the choice, especially over wood trusses. Historically, arches were regarded as more expensive, but "more durable" (Minutes, 8 June 1849). Based on the primary and secondary source information and the record of surviving examples, it is known that stone arch structures were often used for spans of less than sixty feet and were seldom more than two spans long. Longer arch
spans require a higher arch ring that would in turn raise the road grade, and that was often not a practical consideration. Multiple span wood truss or wood arch-truss (Burr) bridges historically were used for the longest bridges in the county, and wood stringers as well as kingpost bridges were utilized for shorter, less permanent bridges through the 1870s.

Increasingly, discussions about stone arch bridges in the last two decades of the 19th century were about repairing rather than building stone arch structures. One of the few references to a new stone arch span in the 1880s was in 1883 when the board voted to erect a 30 feet long and 16 feet wide "new arch bridge" at Pittstown (6 June 1883). There was no discussion about any other type of bridge at that site noted. Despite the paucity information about stone arch bridges and culverts in the freeholders' minutes, date stones illustrate that some arch facilities were constructed in Hunterdon County until at least 1900 (Y 112, Lambertville).

The stone arch passed from currency because of advances in other types of technologies that offered permanence and greater ease of erection and economy of maintenance. By the late 1880s metal truss bridges were generally accepted technology, and reinforced concrete came into its own by 1910. As bridges were lost in the great floods of 1885 and 1903, or fell into disrepair, they were replaced by more modern technologies rather than in kind. The last great stone arch structure built in the state appears to be the 1903 Pennsylvania Railroad bridge over the Delaware River at Trenton.

The bridge contractor pool included stone masons, carpenters as well as mill owners and farmers. Contractors mentioned in the freeholders' minutes from the first half of the 19th century include Francis Tomlinson, a tavern owner who undertook to build a bridge near his tavern for $550. Joshua Apgar's name appears frequently, doing both stone masonry work and carpentry. Peter Baylor also contracted to build and repair both wood and stone bridges. Several contractors including Alpheus Chamberlain and Alex Bonnell later became freeholders.

Many of the same family names can be found in the 1914 Farm and Business Directory of Hunterdon and Somerset Counties, New Jersey. Contractors and builders listed in the directory include Howard Johnson of Hampton, I.N. Hoffman of High Bridge, William Apgar of Lebanon, Jonathan Hewitt of Rosemont and Hendricks and Buchanan of Stockton. Builders mentioned in the Freeholder's minutes from the late 18th and first half of the 19th centuries include: George Bright, Joseph Yard, James Milligan, William Hazlett, David Snook, John Willson, Lamuel Arnwine, Charles Sargeant, William Van Horn, Alex Bonnell, Peter Gary, Thomas Lequear, Asher Stout, Francis Groff, Joseph Force, Hall Opdycke, John Lair, Harmon Henry, John Sutton, Daniel Potter, Alpheus Chamberlain, Richard Cox, William Hendrickson, Peter Fulper, William Hildebrand, Isaac Rea, John Baitou, Zeba Orman, Jacob Hoffman, Jacob Johnson, Charles Van Camp, Elias Abbot, Aaron Van Kirk, Peter Fisher, Francis Tomlinson, Phillip Fine, Christian Lyttle, George Larason, Lanning Abbot's, Jacob Carkhuff, Nathaniel Britton, Mr. Fischer, Mr. Steele, Jacob Kinney, Abraham Eversole, L Calvin, Mr. Hulsizer, John Stauber, Samuel Fritts, J.W. Hoss, William Young, Oliver Ewing, Gabriel Hortman, and John Hall.

There are 101 remaining stone culverts of which there are 57 elliptical-shaped arches, 21 barrel-shaped arches, 10 slab-like, and 6 box culverts. Seven were indeterminable. These totals were gathered from bridge cards filed in the County Engineer's Office, using photographic information for identification.

The earliest dated stone culvert extant in the county is from 1801 (DQ 313) and the latest dates to 1940 (E 237, Manners-Wertsville Road), which may be a date of rebuilding rather than when it was initially constructed. Alexandria has two stone arches: one elliptical and the other barrel in design. Bethlehem has four; two elliptical and two barrel design. Clinton has eight remaining spans; four elliptical in design, one a box culvert, and two stone slabs and one heavily modified. Delaware has five surviving spans; four elliptical and one barrel. East Amwell has twelve spans; nine elliptical and three barrel in design. Franklin has three remaining culverts; two elliptical and one barrel. Frenchtown has three remaining spans; two

Lichtenstein
elliptical and one barrel shaped. Hampton has one barrel designed arch remaining. High Bridge has two remaining spans, one box shaped and one elliptical. Holland has eight spans; four elliptical, two barrel shaped and two indeterminate. Kingwood has five spans; one elliptical, three barrel and one heavily modified. Lambertville has one remaining stone arch culvert and the three longer significant arch bridges mentioned above. Lebanon Township has nineteen remaining spans; reflecting a variety of styles and alterations. Three of the spans are stone slab designs, three are box culverts, eleven are elliptical, and two are barrel. Several have been heavily modified, altering one side to become a different design. Raritan has four elliptical arch culverts remaining. Readington has three; one elliptical in design, one barrel and one indeterminate. Tewksbury has nineteen culverts; two box design, four stone slabs, ten elliptical, two barrel and one of indeterminate design. Union has one elliptical arch remaining. West Amwell has two culverts; one barrel design and one stone slab.

Based on this data, the typical stone arch culvert found in the county is elliptical in design, constructed of random rubble fieldstone with ringstones, wingwalls and low parapets. Repairs and alterations include heavy repointing on nearly all of the structures, according to the maintenance records recorded on bridge cards in the County Engineer's Office. Other common alterations include lining the culvert with corrugated metal liner and installing metal guide rails.
STONE ARCH CULVERT INVENTORY AND EVALUATION

Field Inspection and Recommendations Methodology

The project was undertaken by historians and engineers experienced with documenting and assessing the historical and structural aspects of stone arch structures. Work on the project commenced with a document search and reviewing and analyzing the information about stone arch structures taken from the Freeholders' records by members of the Hunterdon County Cultural and Heritage Commission. Lichtenstein historians continued the review of the primary and secondary source material, including the freeholder minutes, county histories like James Snell's 1881 history of Hunterdon County and the road return abstracts for information about stone arch structures in the county. The bridge cards maintained by the county engineer for stone culverts (a structure with a clear span of less than 20 feet) were reviewed for (1) specific information about the 14 culverts to be studied, (2) geographic distribution, and (3) general information that could be incorporated into the historic context of stone arch construction in Hunterdon County. The "old" bridge cards were the source of most of the dimensions used on the individual survey forms and some dates of construction, but they proved to be less specific about alterations and modifications to each structure. The cards covered the period from the late 1930s through the 1980s, but descriptions of work were brief and not specific. Some cards include old photographs, which proved to be of assistance. No inspection and rating information on the culverts was located, but some bridge card folders contain correspondence and drawings. That information was also reviewed and incorporated into the report.

The information gathered from the bridge card folders was compiled onto a survey form that served as the base data for the field inspection. Field inspections and evaluations of 14 specified culverts were conducted by Mary E. McCahon, historian, and Ronald Giamario, P. E. Both are experienced in inspecting stone arch structures and assessing historical and technological significance. Each arch was assessed for its (1) historical and technological significance and (2) its physical condition. While the inspections were not in-depth structural inspections or structural rating inspections, each structure was inspected for its structural integrity and identification of expressions of problems that would affect the preservation of the structure or its continued service as a traffic-carrying facility. The condition of the mortar was considered as was movement and undermining. The alignment and surrounding land use/zoning were also assessed from the perspective of how each might impact the present and projected use of the structure. Dates of construction for the undocumented culverts were ascribed by stylistic comparison with documented stone arch structures and the primary source research. The ca. dates are the best judgment of the project personnel. Each structure was photographed.

The historian and engineer used the field data to assess which culverts appear to be viable candidates for preservation. The field data and observations were integrated with the primary and secondary source information and compiled into two summaries; (1) a culvert survey form that serves as a one-page summation of the description and historical/technological significance of the structure and (2) a condition evaluation and preservation recommendation summary report. The two are combined to serve as a report for each of the 14 inspected culverts. Each inspected culvert was also judged against the National Register of Historic Places criteria for evaluation to assess which culverts appeared to meet the eligibility criteria and the seven integrity factors (Appendix 1). The reports were reviewed by a senior engineer, Richard C. Kreppel, P. E. Mr. Kreppel is experienced with inspection and rehabilitation of stone arch bridges and culverts and with evaluating resources against the National Register criteria for evaluation.

None of the stone arch culverts in the study appear to have the significance and/or integrity to individually meet the National Register criteria. With a large population of stone arch structures in the county and region, a potentially eligible example has to be historically and/or technologically significant and have
integrity. Most of the culverts studied were small and technologically and historically undistinguished examples of a technology that is very well represented in the county. Those culverts that had potential technological or historical significance have been altered or are failing and thus no longer retain integrity of original design and workmanship. Culverts that are failing (have lost their arch action) were evaluated as not eligible because they have lost their structural integrity and thus any technological significance. In instances like Back Creek Road over Back Creek in East Amwell (E 250) where the arch has failed, the culvert would have to be taken down and completely rebuilt to correct the observed loss of arch action. Similarly, the 1801 and 1829 culvert on the former Easton-Trenton Turnpike in Delaware and Raritan townships (DQ 313) ranks as the oldest culvert in the study, but it has both significant alterations and failing components; it does not maintain its integrity of original/historic design. The 1801 portion (west side) has been rebuilt with a structural steel arch liner (it is now a steel arch culvert and its appearance is non-historic), and the 1829 portion is failing. In other instances, alterations such as inappropriate repointing or removal of the original parapets compromise the significance. The ca. 1870 culvert on Creek Road over Tributary Alexauken Creek (W 112) north of Lambertville in West Amwell was originally a handsome structure, but repointing and rebuilding over the years and recent removal of the parapets have taken their toll on the historic appearance and thus its overall integrity and significance.

Integrity, defined by the National Park Service as "the ability of a property to convey its significance," is part of the evaluation of determining significance. Within the "concept" of integrity, the National Park Service has outlined seven aspects that define it; location, design, setting, materials, workmanship, feeling and association. The presence of the aspects of integrity does make a resource significant. The National Park Service's revised "National Register Bulletin 15 How to Apply the National Register Criteria for Evaluation" published in 1991 states that "to be listed in the National Register of Historic Places, a property must not only be shown to be significant under the National Register criteria, but it also must have integrity." Seven aspects or qualities that define integrity were developed (location, design, setting, materials, workmanship, feeling and association), and to be defined as having historic integrity, "a property will always possess several, and usually most, of the aspects."

The culverts in the study meet many of the seven aspects of integrity (Figure 1), but they do not individually meet the National Register criteria for evaluation (Appendix 1). Since none of the culverts have been moved and they are built with stone, they all have integrity of location and material. Since "important historic events" are not associated with most of the culverts, the association aspect is not applicable except for L 123. All the culverts retain some degree of their original rural settings and thus maintain the aspect of feeling, "a property's expression of the aesthetic or historic sense of a particular period of time." As noted above, the aspects of workmanship and design are most frequently not present.

It is anticipated that further study of the stone arch culvert population in the county will identify examples that possess the significance and integrity to meet the National Register criteria for evaluation.

While the culvert reports include information specific to each structure, some conditions and recommendations appear to be applicable across the population.
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* = Presence of Condition/Aspect

ALTERATIONS AND SEVEN ASPECTS OF INTEGRITY
HUNTERDON COUNTY STONE ARCH CULVERTS
affixing aesthetic railings (in this case, weathering steel guide rails) directly to the historic stone parapets may not be the ideal solution from a strictly preservation perspective (modern material has been permanently attached to the historic fabric in a non-reversible manner, and impact with the guide rail may well result in stones being dislodged or cracked), it is a solution that maintains the historic appearance and fabric of the structure. The detail improves the crossing without narrowing the roadway. While it may prove to be acceptable to install an aesthetic railing atop a historic parapet, removing the parapet and/or spandrel wall and replacing them with concrete is not. It is recommended that historic masonry be conserved and made sound by rebuilding or repointing prior to installing new safety features.

It is recommended that the county continue to select aesthetic railings for its stone arch structures. FHWA's Report No. FHWA-SA-91-051 "Summary Report on Aesthetic Bridge Rails and Guardrails" provides good details and crash tests on appropriate railings.

Masonry Conservation Techniques

Most of the inspected stone arch structures appear to have extensively rebuilt wingwalls and parapets as well as poor repointing. The repointing is usually incompatible in both material (too hard and wrong color) and application. In many instances, a commercial portland cement ready mix was smeared over the joints and the stones rather than being tuck pointed into the joint after it was cleaned of failed mortar. The result is a coating that is no longer bonded in a weatherproof manner to the stone and is not historic in appearance. The mortar extends beyond joint leaving exposed feather edges that are easily damaged and opened through the normal freeze-thaw cycle. In most cases, the poor pointing detracts from the appearance and significance of the structure and fails to provide the required means of keeping water out of the masonry.

It is recommended that when the county considers remedial work on stone arches that the work is respectful of the original character and style of the masonry. Work should be done in accordance with "The Secretary of the Interior's Standards for Rehabilitation" and generally accepted conservation practices when conditions and circumstances support such action. Although time consuming and labor intensive, sound conservation practices, which include repointing with a soft lime mortar mix, should prove to be cost effective in the long term.

The generally accepted conservation standards can be summarized in three items that if followed should result in repointing that is both visually and technically appropriate; (1) properly clean failed and failing mortar from the joint, (2) use a soft lime mortar mix using mixed sands to control the color and hardness, and (3) slightly recess the joints.

The mortar used for resetting and repointing stones should be a soft lime mortar, not a commercial ready mix that is too hard and the wrong color for historic masonry. The mortar mix should be composed of a small part non-staining white portland cement, hydrated lime for masonry purposes, and sand. It should be mixed by volume ratios, like 1:2:10. The lime and portland cement are the binders. A high lime-content mortar is actually more plastic than portland cement and thus performs better in applications like stone arch structures. Sand affects the hardness and the color and texture of the mortar. The more sand, the softer the mortar. Care should be taken to select sands that match the historic or desired color of the mortar. Because sand was historically not graded or free from impurities like it is now, it may well be necessary to mix sands of varying color and grits. Natural color additives are also acceptable. Test patches of various mixes should be placed in order to evaluate the color and texture prior to undertaking the complete job. This allows for adjustments to be made.

The mortar should be thoroughly mixed and applied to carefully prepared joints. Failed and failing material needs to be removed using hand tools (power tools only when it is demonstrated that there will be no
damage to the stones) to a depth of at least an inch. When the soft mortar is applied, all joints should be thoroughly filled. The final layer should be tooled so as not to project beyond the plane of the adjacent stones. Extended mortar beyond the face of the stones results in feather edges that fail quickly and hasten moisture penetration into the joint and the structure. This principal is visible on many culverts in the county. Slight recessing the joint produces results that are both visually and technically appropriate.

It has been proven that darker color mortar joints are visually less intrusive than lighter ones. Finishing with metal tools produces a smooth joint that is often strikingly different than the surrounding historic mortar. Using wood tools, like a simple wood dowel, is often more successful.

Additionally, it is recommended that the county consider having personnel trained in appropriate masonry conservation techniques and having those individuals specialize in conserving the stone arch structures as part of its overall culvert maintenance program. No detail has as much impact on the aesthetic quality of a historic masonry structure as the pointing. (Please refer to Appendix 2).

Inspection and Rating

To facilitate a proactive program of culvert conservation and thus preservation, which appears to be in keeping with the intent of the county transportation plan that emphasizes the desire to retain the "rural environment and historic character," it is recommended that the county establish a cyclical inspection program for culverts. In addition to identifying structures with severe structural problems that may warrant immediate attention, the program would result in the detection of other concerns that left unchecked develop into loss of structural integrity. Masonry problems are typically best and most economically addressed before they become serious.
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STONE ARCH
N.T.S.

RUBBLE MASONRY
RANDOM ASHLAR
ASHLAR
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: A 39        TOWNSHIP: ALEXANDRIA

FACILITY CARRIED: PIEL ROAD

CARRIED/INTERSECTE: PIEL ROAD OVER BRANCH NISHISAKAWICK CREEK
DUCT: 
STRUCTURE TYPE: STONE ARCH        DESIGN: ELLIPTICAL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1        LENGTH: 5'-4"        WIDTH: 12'

DATE: ca. 1900        SOURCE: STYLE        BUILDER: UNKNOWN

SETTING/CONTEXT: The bridge carries one lane of an unimproved road over a minor stream the divides an active farm. Farm buildings are on both sides of the stream, which runs very near the farm house. There are modern subdivisions in the vicinity. The bridge contributes to the historic character of the agricultural area.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 5'-4" long stone arch culvert is laid up with rubble-coursed indigenous stone. It has flared wingwalls and low parapets that have been parged on the roadway face. They are finished with cap stones. The small arch has been partially filled by oversized toe walls and an invert slab. The spandrel walls and wingwalls have been repointed with heavy joints. County records indicate that the work was done in 1979. The small arch is representative of a common structure type that has survived in great numbers in part because of the durability of the design and building material. It contributes to the character of the historic farm, but it is not individually significant.

PHOTO INDEX: 2:10-14        FIELD INSPECT: 4/95
A 39  PIEL ROAD OVER BRANCH NISHISAKAWICK CREEK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

PHYSICAL CONDITION

The arch of the 12’ wide culvert is 5’-4" long and 4’-2" high. It has flared wingwalls at each quadrant. It is constructed of rubble-coursed fieldstone that has been repointed with very thick but neat and tight joints. The parapets are low, following the vertical crest of the arch itself, and they are parged on the roadway face. Capping is stone. County records indicate that the walls at the arch were rebuilt and pointed in 1979.

The most dramatic alteration to the culvert is the addition of concrete toe walls and an invert slab. The size of the toe walls dwarfs the diminutive scale of the arch, but they do provide scour protection for the arch abutments.

TRAFFIC AND LAND USE CONSIDERATIONS

The culvert is located on a tangent (straight) section of unimproved roadway with several hundred feet of sight distance in each direction. A traffic count provided by the county indicate an ADT (average daily traffic) count of 40 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO's "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 12 feet and the approach roadway is 15 feet.

PRESERVATION RECOMMENDATIONS

The culvert appears to be a good candidate for preservation given its condition, alignment, and the low traffic volume. Any work on the masonry should be done in accordance with generally accepted preservation/conservation methods including repointing with a soft lime mortar that is compatible in style and color with the historic mortar. The joints should be slightly recessed from the plane of the stones. Approach guide rail safety measures should be evaluated.

Integrity and thus historical significance of the adjacent farm is being lost by deterioration and collapse of farm buildings, and this will diminish the setting and contextual significance of the culvert.
Photo #3 - Detail of roadway face of south parapet.

Photo #4 - Detail of north spandrel wall.
Photo #5 - Detail of south spandrel wall and wingwall.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS

A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: DQ 313 TOWNSHIP: DELAWARE & RARITAN

FACILITY CARRIED: CR 579

CARRIED/INTERSECTED: CR 579 OVER BRANCH WICHECHEOKE CREEK

STRUCTURE TYPE: STONE ARCH DESIGN: BARREL

COURSING: RANDOM ASHLAR

# SPANS: 1 LENGTH: 12' WIDTH: 34'

DATE: 1801, 1829 SOURCE: PLAQUE BUILDER:

SETTING/CONTEXT: The culvert is located on the historic Easton-Trenton Turnpike (chartered in 1806). The area, just south of the historic settlement of Croton, is agricultural, but the road is a county route and thus is a collector road. The original portion of the arch predates the turnpike, which took over an existing right of way -- a common practice.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The culvert on the early turnpike was built in two sections with the western portion dating to 1801 and the eastern widening to 1829. It ranks as the oldest documented stone arch structure in the county, but its historical and technological significance has been reduced by the fact that the eastern portion of the span has failed. It has lost its integrity of design. The western portion was rehabilitated with the addition of a steel arch liner ca. 1985.

PHOTO INDEX: 1:32-36A FIELD INSPECT: 4/95
DQ 313  CR 579 OVER WICHECCHOKE CREEK

CONDITION EVALUATION AND PRESERVATION RECOMMENDATIONS

PHYSICAL CONDITION INSPECTION FINDINGS

The 22 feet wide and 12 feet long stone arch culvert was built in two sections with indigenous slatey shale. The original section (west) was placed in 1801, according to the date stone. It was widened to the east in 1829, probably as part of a turnpike improvement. The west arch is laid up with matched ring stones and random-coursed ashlar spandrel walls and wingwalls. There are no capstones. The masonry is sensitively pointed, and it appears to be sound. A corrugated steel arch liner was installed at an unspecified date, but it appears to have been placed within the last ten to twenty years. The west side of the structure appears to be in good and stable condition.

The eastern portion of the arch with matched ring stones is in poor condition. The arch ring was parged, but most of the materials and much of the pointing has been lost. The spandrel walls, parapets and flared and tapered wingwalls have been so insensitively pointed with portland cement mix smeared across the joints that it has obscured the original masonry pattern. The southeast wingwall was noted to be bowed out extensively. The bow continued into the spandrel wall of the arch resulting in a large separation between the ring stones and the arch ring. At the southerly base of the arch, stones were noted to be missing and loose. The observed conditions were reported to the county engineer’s office.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The stone arch culvert, dating in part to 1801, ranks as the oldest documented examples of the structure type in the county. Its historical significance was augmented by the fact that it was widened in-kind in 1829 when the road was the Easton-Trenton Turnpike (chartered in 1806).

The culvert carries a county road (defined as a facility designed to collect traffic from local roads and link it with other county roads, state highways, or interstate routes). According to traffic counts provided by the county, the culvert has an ADT (average daily traffic) count of 2,935 vehicles. Sight distance and width appear to be adequate. The low ADT places the culvert and roadway in the lowest category when determining required travelled way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum width for a roadway of this type is 20 feet. The surrounding land use is agricultural-residential with agricultural dominating.
PRESERVATION RECOMMENDATIONS

Based on its poor condition and heavy usage, the eastern portion of the structure is not a good candidate for preservation. Rather than removing and replacing the entire span, it is recommended that consideration be given to replacing only the deteriorated eastern portion of the culvert with a modern arch span and tying it to the recently rehabilitated historic 1801 arch. Another alternate would be to reconstruct the eastern portion using a steel arch liner and to rebuild the spandrel walls and wingwalls. Either arrangement of half-width construction would have the advantage of (1) maintaining one lane of traffic throughout construction and (2) ensuring the preservation and continued use of the oldest documented arch structure in the county. It would also meet the county goals of providing a safe and efficient transportation system while maintaining its historic character. Placing a new arched span on the east side affords the opportunity to design the culvert to current AASHTO width and safety standards. The stone parapet could be retained and a safety railing, like weathering steel beam guide rails or an aesthetic steel-backed wood railing, could be placed in front of the parapet. It is also recommended that the new portion of the structure be finished in a manner that compliments the historic portion. This could be accomplished through the use of stone facing, custom form work, and/or tinted material.
Photo #1 - Through view looking south.

Photo #2 - West elevation.
Photo #3 - Intrados looking west.

Photo #4 - Detail of southeast wingwall parapet.
Photo #5 - East elevation showing crack between ringstones and arch ring.

Photo #6 - Detail east elevation showing crack and loose/missing stones.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: E 229 TOWNSHIP: EAST AMWELL
FACILITY CARRIED: RAINBOW HILL ROAD
CARRIED/INTERSECTE RAINBOW HILL ROAD OVER BRANCH NESHANIC RIVER
D:
STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL
COURSING: RANDOM COURSED
# SPANS: 1 LENGTH: 8' WIDTH: 12'
DATE: ca. 1890 SOURCE: STYLE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert carries one lane of an improved rural road over a stream
at a T intersection with CR 514. The area is agricultural. There is
modern subdivision development on 3-acre lots.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 8'-long culvert is laid up random coursed indigenous shale. It is
finished with cap stones and plumber-fitting pipe railings placed at the
curb level. It appears to date stylistically to ca. 1890. While not
individually distinguished, the span is representative of the common
county structural type that has survived in great number because of the
durability of the design and material. The span contributes to the overall
historic agrarian character of the area.

PHOTO INDEX: 4:4-8 FIELD INSPECT: 5/95
FIELD INSPECTION FINDINGS AND EVALUATIONS

The 8 feet long stone arch culvert with a vertical opening of 3 feet is laid up in random coursed indigenous red shale stone. As a result of its placement at a T intersection, the wingwalls on the south side are flared. The walls are finished with large contrasting stone (perhaps granite) cap stones with a rusticated face placed at the curb line. They are topped by pipe railings with standard plumber fittings. Concrete toe walls have been placed on the east (upstream) side. The structure has been repointed with thick but neat joints, and many appear to be water tight, especially those on the east elevation.

A slight bowing and related crack between the ring stones and the arch ring was noted in both spandrel walls. Movement and cracking was noted in the northwest wingwall. Some water leakage from the roadway fill was noted in the intrados.

TRAFFIC AND ALIGNMENT CONSIDERATIONS

The culvert is located just north of a T intersection with CR 514. From the north the roadway is tangent with a sight distance of approximately 500 feet. A traffic count provided by the county indicates an ADT (average daily trip) of 141 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO's "A Policy on Geometric Design of Highways and Streets." AASHTO's minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 13 feet, and across the approach roadway it is about 15 feet.

The culvert is located in a rural area that is being redeveloped for residential use. Some modern housing is being constructed in the vicinity of the culvert, and East Amwell is projected to be a township of high growth between 2000 and 2010, according to the county's population projections.

PRESCRIPTION RECOMMENDATIONS

Because of its structural condition, alignment and low traffic volume, the culvert appears to be a good candidate for preservation. In order to ensure its structural integrity, however, several remedial actions are necessary. The fill should be removed, and a waterproofing membrane should be installed. Weep holes should be provided through the arch to accommodate proper drainage of the fill. Any resetting of stone or repointing should be done in accordance with generally accepted preservation/conservation methods for historic masonry using a soft lime mortar. The joints should be thin and not project beyond the face of the stones.
The crack at the northwest wingwall should be monitored. It appears to be a settlement crack, but observation over time will indicate whether the settlement is done or not.

Because the culvert and approach roadway are substandard, traffic control measures should be installed. Additionally, it is recommended that an adequate aesthetic railing or guide rail system be installed. The pipe railings that are in place are not of historical significance and can be removed and replaced with no effect on the significance of the structure. It is not recommended that these railings be stockpiled.
Photo #1 - Through view looking south.

Photo #2 - West elevation.
Photo #3 - East elevation.

Photo #4 - Detail of bow in east spandrel wall.
Photo # 5 - Detail of crack in west spandrel wall.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: E 250          TOWNSHIP: EAST AMWELL
FACILITY CARRIED: BACK BROOK ROAD
CARRIED/INTERSECTED: BACK BROOK ROAD OVER BACK BROOK
STRUCTURE TYPE: STONE ARCH          DESIGN: ELLIPTICAL
COURSING: RANDOM ASHLAR
# SPANS: 1          LENGTH: 18'-6"          WIDTH: 15'-6"
DATE: ca. 1870          SOURCE: STYLE          BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on an improved but narrow rural road in an agricultural area that is undergoing redevelopment with large houses on a minimum of 3-acre lots.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The graceful, attenuated lines of the rubble-coursed fieldstone arch culvert are achieved by its skewing and shallow depth. It is finished with sloped parapets with concrete cap stones. The skewed alignment has resulted in failure of the arch, which in turn has diminished its structural integrity and technologically significance. Based on its condition, it is no longer individually distinguished. The span appears to date to ca. 1870, but a record of its date of construction was not located.

PHOTO INDEX: 4:9-15          FIELD INSPECT: 5/95
E 250  BACK BROOK ROAD OVER BACK BROOK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The skewed 18'-6" long and 14 feet wide stone arch culvert is laid up in rubble-coursed indigenous shale. It has low parapets with a sloping profile topped with concrete cap stones. Because of its length, skew, shallowness of the fill over the crown of the arch, and low parapets, the span has graceful, attenuated lines that make it one of the more handsome stone arch structures in the county. The aesthetics, however, are marred by the poor repointing that has occurred over the years and the failing structural condition. A large concrete toe wall has been placed at the northwest wingwall (upstream). The northwest wingwall has been parged. According to county records, the culvert was repaired in 1942.

A large crack is located in the arch ring at the northwest corner of the culvert. This crack commences at the base and continues to the crown. There also appears to be crushing at the base of the arch at this location. This condition is attributable in part to the skewing and low profile of the arch geometry. Water leakage from the roadway fill was noted through the arch and at both north-elevation corners. Some concrete cap stones are not firmly attached to the spandrel wall on the north elevation.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is located on a gentle curve. Sight distance is approximately 500 feet in both directions. A traffic count provided by the county indicates an ADT (average daily traffic) count of 192 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 14 feet and the approach roadway is 15'-6".

The historic land use of the area is agricultural, but farms are being converted to residential use with large homes placed on 3-acre lots. Between 2000 and 2010, East Amwell will be a high-growth township, according to the county’s population projections.

PRESERVATION RECOMMENDATIONS

Because of its poor structural condition, which cannot be corrected without major reconstruction, the culvert is not a good candidate for preservation. In order to correct the observed structural problems, it would be necessary to remove the roadway and fill, erect falsework or centering, dismantle the structure, relay the arch, spandrel walls and wingwalls, and then replace the fill and roadway. Approach guide rail safety measures should be evaluated.
Photo #1 - North elevation.

Photo #2 - South elevation.
Photo #3 - Through view looking west.

Photo #4 - Detail of compression crack at northwest abutment.
Photo #5 - Intrados of arch ring at northwest corner.

Photo #6 - Parapet and cap stone detail of north elevation showing gap.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: L 119 TOWNSHIP: LEBANON

FACILITY CARRIED: HOLLOW BROOK ROAD

CARRIED/INTERSECTED: HOLLOW BROOK ROAD OVER TEETERTOWN BROOK

STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1 LENGTH: 16'-6" WIDTH: 13'-6"

DATE: ca. 1870 SOURCE: STYLE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on an unimproved road in the hilly, northeast corner of the county near the Morris County line. The area was the historic ironmaking region of the county. It is either in or adjacent to the Teetertown Ravine Nature Preserve. The terrain is particularly rugged and appears to be a glacial moraine. No development is visible from the culvert.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 16'-6" long stone arch culvert is laid up in rubble-coursed fieldstone with roughly squared stones for cap stones. It appears to date to ca. 1870, and while not individually distinguished, it is representative of the strong stone arch tradition in the county. Many examples survive due to the durability of the arch design and the stone building material. Like most other stone arch culverts in the county, it appears that the spandrel walls and wingwalls have been extensively rebuilt over time. The culvert is in a protected setting.

PHOTO INDEX: 1:20-25 FIELD INSPECT: 4/95
L 119 HOLLOW BROOK RD. OVER TEETERTOWN BROOK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The 16'-6" long stone arch culvert with a 6'-6" rise carries a 13'-6" unimproved roadway over a stream. It is in or adjacent to Teetertown Ravine Nature Reserve in the extreme northeast corner of the county near the Morris County line. There is a curve on the north approach of the lightly traveled road, and no development is visible from the structure. The span is laid up with matched ring stones and rubble-coursed indigenous stone spandrel walls and wingwalls. Large, roughly hewn stones are used for cap stones. The low parapet on the west side has a sloped profile while the parapet on the east side is flat suggesting that one or both have altered over time. It is probable that both are extensively rebuilt. Cracks visible on the west (downstream) wall indicate that the wall is moving or has moved. The mortar joints have thick applications of mortar rather than tuck pointing, and most have failed.

The arch itself has also been repointed. A crack was found extending from abutment to abutment between the ring stones and the arch ring on the west side. A 1" to 3" outward movement of the west spandrel wall was noted, and that movement is believed to be related to the crack.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

From the north the unimproved roadway is steeply inclined and curves sharply resulting in a sight distance from the culvert of approximately 100 feet. To the south the sight distance is approximately 300 feet. A traffic count provided by the county indicate an ADT of 40 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travel-way widths as outlined in AASHTO's "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 13'-6" feet, and the approach roadway is the same.

It is assumed that this protection precludes development pressure on the setting.

PRESERVATION RECOMMENDATIONS

The culvert appears to be a good candidate for preservation given its apparent structural condition and the low traffic volume of its protected setting. Because of the insufficient width across the culvert, it is recommended that traffic control devices in the form of signage be placed to regulate opposing traffic across the span. It is also recommended that the structure be inspected on a regular basis to determine whether additional movement occurs primarily at the west spandrel wall.
The structure should be made water tight by repointing it with a soft lime mortar and
done in a technique that produces slightly recessed joints. All failed and failing mortar
should be carefully and completely removed prior to repointing.
Photo #1 - Through view looking south.

Photo #2 - East elevation.
Photo #3 - Detail roadway face east elevation parapet.

Photo #4 - West elevation.
Photo #5 - Detail west elevation spandrel wall.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: L123 TOWNSHIP: LEBANON

FACILITY CARRIED: TEETERTOWN ROAD

CARRIED/INTERSECTE D: TEETERTOWN ROAD OVER TEETERTOWN BROOK

STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1 LENGTH: 19' WIDTH: 11'

DATE: ca. 1865 SOURCE: STYLE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert carries one lane of an unimproved road over a minor water feature in a small, 19th century settlement that developed around a water-powered mill. A mill was at the site before 1814. The area retains some of its 19th century buildings, including the mill, and it may be a potential historic district, based on the integrity of the mill itself. The millers house has been altered, and there are also some post-WW II buildings present.

NATIONAL REGISTER RECOMMENDATION: Potentially Eligible (Historic District)

SIGNIFICANCE: The 19'-long rubble-coursed stone arch culvert is located at the 19th century settlement of Teertertown that developed around the water-powered grist mill. A mill was established prior to 1814, and in 1873, the settlement was composed of at least 6 buildings. The mill complex, including the stone wall-defined tail race and stone arch culvert, retains its integrity, but the miller's house has been significantly altered. There are also modern houses. The culvert is not individually significant, but it would contribute to the potential mill historic district.

PHOTO INDEX: 1:26-31 FIELD INSPECT: 4/95
L 123 TEETERTOWN ROAD OVER TEETERTOWN BROOK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The 19 feet long and 11 feet wide stone arch culvert with matched ring stones and rubble-coursed indigenous material spandrel walls and wingwalls is located immediately downstream from a former water-powered mill. The mill tail race, defined by stone retaining walls, enters the stream at the southwest abutment of the culvert. The stone wall is washed out where it meets the bridge. Left unattended, the condition could result in undermining of the arch.

The arch has a rise of 10 feet, and roadway is placed very close to the crown of the arch ring. There are no cap stones or concrete capping on the parapets, which have a sloped profile. The spandrel and wing walls have been repointed with heavy joints extending beyond the historic limits of the original/early pointing, but the joints appear to be, for the most part, water tight.

The arch ring was once parged, but most of it and the historic mortar have been lost leaving many open or loose joints.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is located in sparsely developed section of the county with residential development on lots ranging from one and one half acre and five-acre parcels. It is located approximately 85 feet south of a T intersection with Hollow Brook Road. To the south, the roadway curves to the east providing a sight distance of approximately 200 feet. The culvert is a prominent feature of what was the small settlement of Teetertown that developed adjacent to the water-powered grist mill (extant). A mill was in place by 1814. The entire settlement does not appear to have the integrity to be National Register historic district (main house altered; modern dwellings), but the mill complex, including the tail race and culvert, may. Regardless of National Register eligibility, the settlement is picturesque, and it contributes to the agrarian, 19th century character that is important to maintaining the sense of place and heritage in the county. The site is just south of the Teetertown Ravine Nature Reserve.

Traffic counts provided by the county indicate an ADT of 55 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travel-way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard roadway width for a roadway of this type is 20 feet. The clear width across the culvert is about 15 feet and the approach roadway is 13’-6".
PRESERVATION RECOMMENDATIONS

The culvert appears to be a good candidate for preservation based on its low traffic volume setting and condition. In order to ensure its continued service, however, the masonry, especially the arch ring and the mill race retaining walls need to be sensitively rebuilt where it has washed out. The whole should be repointed in accordance with generally accepted conservation methods for historic masonry. The old failing mortar should be carefully removed, and the new pointing should be done with a soft lime mortar that is held within the historic joint limits. Adequate weep holes need to be provided to ensure drainage of the roadway fill. When the spandrel and wingwalls are repointed, they should be done in the same manner.

At the 55 ADT, the clear width of 11 feet is not of sufficient width to safely carry two lanes of traffic. Since the traffic volume does not now nor in the foreseeable future warrant widening, it is recommended that the traffic control devices be installed on either side of the culvert to regulate opposing traffic across the span.
Photo #1 - East elevation.

Photo #2 - Through view looking north.
Photo #3 - View south from east approach showing former mill.

Photo #4 - Arch ring looking west showing washed out section of Mill Tail Race.
Photo #5 - Tail Race on southwest side of culvert. Looking west.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS

A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: Q 94  TOWNSHIP: RARITAN

FACILITY CARRIED: OLD CLINTON ROAD

CARRIED/INTERSECTED: OLD CLINTON ROAD OVER SOUTH BRANCH RARITAN RIVER

STRUCTURE TYPE: STONE ARCH  DESIGN: BARREL

COURSING: RUBBLE-COURSED FIELDSTONE

# SPANS: 1  LENGTH: 9'  WIDTH: 17'

DATE: 1916  SOURCE: BRIDGE CARD  BUILDER: UNKNOWN

SETTING/CONTEXT: The bridge carries a two-lane rural road over a stream on a curving alignment at a Y intersection. Wooded subdivisions and farms are in the vicinity. The area does not appear to have district potential.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: According to county records, the rubble-coursed, 9'-long stone arch culvert with sloped parapets was built in 1916, but stylistically it appears to be from the last quarter of the 19th century. The southwest approach wall was rebuilt recently, and the whole has been periodically repointed with thick joints of portland cement. Despite the non-historic appearance of the masonry and cap stones, its original alignment is preserved, and it contributes to the historic, agrarian character of the area. It is not individually significant, based on its size, poor pointing, and absense of significant details or setting.

PHOTO INDEX: 2:1-4  FIELD INSPECT: 4/95
Q. 94  OLD CLINTON ROAD OVER BRANCH OF SOUTH BRANCH RARITAN RIVER

EVALUATION OF CONDITION AND PRESERVATION OPTIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The stone arch culvert laid up in rubble-coursed fieldstone and finished with replacement concrete cap stones has a 9 feet long span. The vingwalls are flared on the south approach, which is contiguous to a Y intersection. All but the southwest approach are protected by modern beam guide rails (rails initially installed in 1944). The parapets have a slightly sloped profile. The southwest parapet has recently been rebuilt. County records indicate that the westerly walls were rebuilt in 1976 and that additional repointing was done in 1985. While the overall condition of the pointing appears to be sound and primarily watertight, the thick size of the joints and the use of portland cement (too hard and aesthetically not compatible with the historic lime mortars) is an irreversible alteration that mars the historical significance of the structure. The masonry work is not distinctive and is best described as being representative of that commonly found throughout the county.

The arch ring has been repointed. The crown of the arch is slightly flattened on the west side. This suggests that there has been some settlement of the arch. Flattening can result in the loss of arch action, the engineering principal that controls structural integrity. It was not determined whether this condition has occurred over time or whether the culvert was constructed with this shape. There does not appear to be progressive movement taking place.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The bridge is positioned with a Y intersection to the south. From the north, the roadway approaches the culvert on a horizontal curve resulting in a sight distance of approximately 100 feet.

A traffic count provided by the county indicates an ADT of 240 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 12 feet and the approach roadway is 17 feet.

The surrounding area has a land use designation of rural residential and residential. There appears to be development pressure in what has historically been an agricultural area. Raritan is one of the fastest growing townships in the county. The county has projected that growth rate in the township will be high, consistent with recent trends.
PRESERVATION RECOMMENDATIONS

The preservation recommendation for the Old Clinton Road culvert is dependent on resolving the question of movement of the arch. It is recommended that the structure be inspected on a regular basis to determine whether movement is occurring in the arch ring. Aside from that issue, the culvert appears to be in better physical condition that others in the county, making it a good candidate for preservation. Additionally its size and parapet/wingwall proportioning are generous enough to make it a character-defining feature on the roadway.

Because of the insufficient width across the culvert for passage to two lanes of traffic, it is recommended that traffic control measures be provided to regulate opposing traffic across the span and the intersection.

It is recommended that all future repointing be done in accordance with generally accepted preservation standards and procedures. This would include the proper removal of the inappropriate Portland cement mortar now in place and repointing with thin joints and soft lime mortar custom mixed to match the color and texture of the historic. The debris that has accumulated in the channel should be removed.
Photo #1 - Through view looking south toward Y intersection.

Photo #2 - Through view looking north.
Photo #3 - West elevation.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: R 165  TOWNSHIP: READINGTON
FACILITY CARRIED: BARLEY SHEAF ROAD
CARRIED/INTERSECTED: BARLEY SHEAF RD OVER BRANCH SOUTH BR RARITAN RIVER
STRUCTURE TYPE: STONE ARCH  DESIGN: ELLIPTICAL
COURSING: RUBBLE COURSED FIELDSTONE
# SPANS: 1  LENGTH: 10'  WIDTH: 12'
DATE: ca. 1900, 1924  SOURCE: STYLE  BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on what appears to be the historic highway between Barley Sheaf and Pleasant Run. The road is depicted on the 1873 Beers map. A new, straighter alignment was developed (present CR 523), but the historic right-of-way and culvert survive as part of Barley Sheaf Road. The Ramey farmstead depicted on the 1873 map survives and contributes to the historic character of the setting. Modern residential development is also present.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 10' long rubble-coursed stone arch culvert is located on a portion of roadway that was a main route in the mid 1800s. While not technologically innovative, the span retains its original character and contributes to the overall bucolic character of the area. It is typical of 19th century stone arch construction and is a type well represented in the county. It is adjacent to a 19th century farm, but the main house has been altered, so it does not appear to be a potentially eligible district. Documentation for the date of construction was not found.

PHOTO INDEX: 2:5-9  FIELD INSPECT: 4/95
R 165 BARELY SHEAF ROAD OVER BRANCH SOUTH BRANCH RARITAN RIVER

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

INSPECTION FINDINGS OF PHYSICAL CONDITION

The 14'-8" wide stone arch culvert carries a 12' wide improved roadway over a minor stream east of a T intersection with CR 523. The arch has a clear span of 10 feet, and it has a rise of 4'-8". The ring stones are matched, and the spandrel and wing walls with modern concrete cap stones are laid up with indigenous rubble-coursed material. The tapered wingwalls flare at the approaches. The north end of the east wingwall has been rebuilt, and the earlier cap stones have fallen into the stream bed. Concrete toe walls (scour countermeasure) have been placed along each arch abutment and along the northwest wingwall, which has been extended with a concrete wall. The northeast wingwall is undermined.

The mortar condition and appearance (more of a smear coating with a variety of portland cement mixes rather than tuck pointing) is representative of that found throughout the county. Few of the joints appear weather tight.

The arch ring has been parged, and some sections are still in place. There are several small areas of missing stone. The arch appears to have maintained its structural integrity.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is located 150 feet east of CR 523, which serves a collector road linking with I-78. Sight distance to the west is several hundred feet. Traffic data provided by the county indicates an ADT (average daily traffic) count of 1,170 vehicles per day. At this ADT the 14'-8" clear width across the bridge is insufficient for the passage of two lanes of traffic in accordance with AASHTO's "A policy on Geometric Design of Highways and Streets." The 1,170 ADT is a substantial traffic volume for a facility less than 20 feet wide.

The culvert is located in one of the fastest growing sections of the county, and, according to county projections, the growth rate will continue to be high in the 1990s consistent with recent trends. There are modern subdivisions to the east of the culvert, which makes Barley Sheaf Road a minor collector thoroughfare. In addition to feeding I-78, Barely Sheaf Road appears to be a link from Readington to Flemington.
PRESERVATION RECOMMENDATIONS

This culvert represents the conflict between preserving the country's character-defining rural byways with their substandard widths and safety features and the need to accommodate modern usage demands. The culvert appears to be in generally sound condition. But, the current ADTs indicate that preserving the structure at its present 14'-6" width is not appropriate. The traffic volume is presently too great to recommend a long-term preservation plan for the structure in its present configuration. Until such time that it is decided to improve the crossing, the culvert should be sensitively maintained. The required maintenance should include filling and installing a masonry wall to correct the undermining of the northeast wingwall. Approach guide rail safety measures should be evaluated.

The significance and preservation value of the structure is enhanced by its size and highly visible setting at a farm. This is the historic character and ambiance that, according to the 1993 transportation plan, the county wishes to preserve whenever possible. While the farm itself does not appear to have the architectural integrity on the exterior to meet National Register criteria, the house and barn complex provide the contextual backdrop for the culvert.

It is recommended that consideration be given to improving the crossing by widening the arch to one side or the other. Each side has advantages and disadvantages. One side appears to be in wetlands while the other is developed as a farmstead.

It is recommended that the new parapet and wingwalls be faced with salvaged material to match the undisturbed treatment. The unaltered side should be hand cleaned of all inappropriate mortar joints and sensitively repointed in accordance with generally accepted preservation standards by using a compatible soft lime mortar and recessing the joints. Safety barriers/railings should be selected to compliment the historic character of the structure and might be weathering steel or a steel-backed timber barrier placed inside the stone parapets.
1873 Beers Atlas Map
Readington Detail

Showing historic right of way of Barley Sheaf Road.
Photo #1 - Through view looking west toward CR 523.

Photo #2 - North elevation.
Photo #3 - South elevation.

Photo #4 - Detail north elevation showing wingwall undermining.
Photo #5 - Parapet detail showing poor condition of mortar joints.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: T 23  TOWNSHIP: TEWKSBURY

FACILITY CARRIED: HOLLOW BROOK ROAD

CARRIED/INTERSECTED: HOLLOW BROOK RD OVER BRANCH LAMINGTON RIVER

STRUCTURE TYPE: STONE ARCH  DESIGN: BARREL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1  LENGTH: 7'  WIDTH: 12'

DATE: ca. 1885  SOURCE:  STYLE  BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert carries a narrow, improved road over a minor water feature in the hilly and sparsely developed northeast corner of the county. The area, which is wooded, is zoned for 3-acre house lots.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 5'-long stone arch culvert is laid up in rubble-coursed fieldstone and finished with parapets with no cap stones. The small span has been repointed, and the mortar has failed. The date of construction was not documented, but the culvert is representative of the type and design commonly built in the county in the last half of the 19th century. It is not individually distinguished based on its size, setting, modified mortar joints, and overall comparison with other stone arch structures. The stone arch is an extremely durable type, and there are over 110 of them surviving in the county.

PHOTO INDEX: 1:15-19  FIELD INSPECT: 4/95
T 23  HOLLOW BROOK ROAD OVER BRANCH LAMINGTON RIVER

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The arched opening of the slightly skewed, 12 feet wide culvert is 5 feet long and 6 feet high. It is laid up in rubble-coursed fieldstone, and there are no cap stones or concrete caps; the top of the parapets are simply parged. The arch ring was also parged, and what cementitious material remains is easily removed. There is a very high percentage of loose or open mortar joints throughout, and the arch and walls are not waterproof. The stone walls are insensitively pointed with thick smears of portland cement mix. The wingwall at the southeast approach is flared. Some undermining at the abutment on the southeast corner was noted.

The arch itself appears to have retained its structural integrity.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is on an improved, 14'-4" roadway located in the sparsely developed, hilly, wooded northeast section of the county north of I-78 and near the Morris and Somerset county lines. There is subdivision pressure, and the area is zoned for three-acre building lots. The structure is located on a tangent (straight) section of roadway with good sight distance in both directions. Traffic data provided by the county indicates an ADT (average daily traffic) of 207 vehicles per day. This low ADT places the culvert in the lowest classification category when determining required travelled-way widths as outlined in AASHTO's "A Policy on Geometric Design for Highways and Streets." The minimum AASHTO width for a roadway of this type is 20 feet. The clear width provided across the culvert is 12 feet and the approach roadway width is 14'-4". Widening of the culvert would not be meaningful unless extensive approach roadway work was also done.

PRESERVATION RECOMMENDATIONS

Considering the daily traffic volume, land use, and overall condition, the Hollow Brook Road culvert appears to be a good candidate for preservation and for providing continued service. The undermined area of the southeast abutment should be filled and stabilized. Because of the insufficient roadway width across the structure, it is recommended that traffic control measures to regulate opposing traffic across the culvert be provided. Approach guide rail safety measures should be evaluated.

The mortar joints need to be sensitively repointed with a soft lime mortar mix and technique that are compatible with the vintage and style of the structure. Making the joints water tight will significantly reduce potential damage from freeze/thaw cycles and will, more than any other conservation action, contribute to the longevity of the structure.
Photo #1 - Through view looking west. Note adjacent culvert.

Photo #2 - South elevation.
Photo #3 - North elevation.

Photo #4 - Detail arch ring intrados.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: T 91 TOWNSHIP: TEWKSBURY

FACILITY CARRIED: SUTTON ROAD

CARRIED/INTERSECTED: SUTTON ROAD OVER BRANCH ROCKAWAY RIVER

STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1 LENGTH: 6' WIDTH: 12'

DATE: ca. 1890 SOURCE: STYLE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert carries one lane of an improved narrow road over a minor stream in a wooded, sparsely developed setting. The terrain is hilly, and there is scattered modern residential development.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The skewed, 6'-long stone arch is laid up in rubble coursed fieldstone and is finished with slightly sloped parapets with no cap stones. It has been repointed with wide mortar joints that are not historic in appearance. The small span is representative of a type and design that was used extensively throughout the 19th century in Hunterdon County. A great many stone arch culverts survive because of the durability of the design and material. This example, one of over 100 stone arch culverts in the county, is not individually distinguished based on its size, appearance, and setting.

PHOTO INDEX: 1-1-7 FIELD INSPECT: 4/95
T 91 SUTTON ROAD OVER BRANCH ROCKAWAY CREEK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The rubble-coursed, indigenous stone, arch culvert has a clear span of 6 feet and is 14 feet wide carrying a 12 feet wide improved roadway. The arch is built on a slight skew, and it has a rise of approximately three and a half feet. The roadway appears to be placed very close to the crown of the arch. The low parapets with a slight sloped profile flare at the approaches. They do not have cap stones and appear to have missing stones. A section of the northeasterly parapet has been dislodged and is laying to the side, evidence of vehicular impact. The west side wing walls exhibit slight bowing. The entire structure has been insensitively repointed over time. There are lost and failing mortar joints throughout. The arch has lost mortar and many voids were observed. The presence of numerous voids raises questions about the transfer of compression to the abutments.

The crown of the arch is slightly flattened suggesting that there has been some settlement in the arch. This condition can result in the loss of "arch action" which is the prime structural mechanism that controls the integrity of the arch. In conjunction with the flattening of the arch many stones in the arch ring are missing or are loose. This is a sign that tension has been introduced -- an indication that there has been a loss of arch action.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is location in the middle of an S curve and is approximately 150 feet south of the intersection with Philhower Road. The intersection is not visible from the culvert, and the sight distance in the other direction is approximately 200 feet. Traffic counts provided by the county indicate an ADT of 335 vehicles per day. This low ADT places the culvert and roadway in the lowest classification category when determining required travel-way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard roadway width for a roadway of this type is 20 feet. The clear width provided across the culvert is 12 feet and the approach roadway is 14 feet.

The land use for area is rural. There is development pressure in vicinity with subdivisions of modern homes on large lots. Tewksbury is not one of the fastest growing townships in the county, due in part to its hilly terrain.
PRESERVATION RECOMMENDATIONS

Because of the poor structural condition of the arch combined with its poor sight distance and narrow width, it is not recommended as a good candidate for preservation. It appears that the structural deficiencies of the arch and its geometry may be so severe that rebuilding the structure on an improved and widened alignment is the preferred action. In order to maintain the bucolic quality of the setting, it is recommended any new structure be finished with an aesthetic railing treatment.

The tree in the roadway at the northwest approach should be removed for safety considerations independent of any maintenance on the culvert.
Photo #1 - Through view looking north.

Photo #2 - Through view looking south. Note tree in right-of-way.
Photo #3 - East elevation.

Photo #4 - Arch ring intrados.
Photo #5 - Detail northeast parapet.

Photo #6 - Detail west wingwall.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS

A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: T 114 TOWNSHIP: TEWKSBURY

FACILITY CARRIED: SAW MILL ROAD

CARRIED/INTERSECTED: SAW MILL ROAD OVER BRANCH ROCKAWAY CREEK

STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL

COURSING: RUBBLE COURSED FIELDSTONE

# SPANS: 1 LENGTH: 19' WIDTH: 15'

DATE: 1887 OR 1882 SOURCE: DATE STONE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on a rural road that serves as a collector. Its setting is wooded, and while the historic land use in the area is agricultural, there is modern residential development.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 19'-long stone arch culvert is laid up in rubble-coursed fieldstone. It is finished with sloped parapets, but the cap stones have been lost. Neither the culvert nor its setting are individually distinguished. The structure is a representative example of a common county type, and it is documented (date stone). The arch has flattened, which compromises its structural integrity and thus technological significance. The arch tradition is strong and long-lived in Hunterdon County because of its abundance of stone and the durability of the stone arch design.

PHOTO INDEX: 1:9-14 FIELD INSPECT: 4/95
T 114 SAW MILL ROAD OVER BRANCH ROCKAWAY CREEK

EVALUATION OF CONDITION AND PRESERVATION OPTIONS

PHYSICAL CONDITION

The 19’ long, 15’ wide stone arch culvert in Tewksbury is located on a collector road in a wooded setting with scattered modern housing. The township is located in the rapidly developing east central portion of the county. The arch has slightly sloped parapets. A low stone wall extends from the northwest parapet for about 100 feet. The arch is laid up with rubble-coursed indigenous stone. The matched ring stones contrast nicely with the irregularity of the rubble stone spandrel walls and wingwalls, but the original styling of the structure has been compromised by historically poor rebuilding and insensitive repointing. The present appearance of the culvert suggests that, over the years, it has been extensively rebuilt, and that the joints have been repaired in an expedient manner rather than being sensitively repointed. County records indicate that the masonry walls were repaired in 1973. The mortar joints are not in good condition. The original cap stones have been lost along with some of the parapet. The parapets are presently finished with parging.

The crown of the arch is slightly flattened at the south fascia suggesting that there has been some settlement. This condition can result in loss of "arch action," which is the controlling engineering principal related to the structural integrity of the arch. In conjunction with the flattening of the arch, it was noted that some of the ring stones are loose suggesting that tension has been introduced into the arch. This also suggests loss of arch action. Some arch ring mortar joints are open.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The bridge is located in the middle of an S curve. To the east the roadway approaches from the north and to the west the roadway approaches from the south. The sight distance from either direction is approximately 200 feet.

Traffic counts provided by the county indicate an ADT (average daily traffic) count of 793 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO’s "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 15 feet.

PRESERVATION RECOMMENDATIONS

Based on the poor structural condition of the arch, inadequate sight distance, and the current and projected traffic volume, this culvert does not appear to be a good candidate for preservation. In order for the structural problems to be corrected, it would have to be dismantled and rebuilt and strengthened on falsework. Rebuilding
the arch would not correct the substandard roadway or safety issues such as the railings. It appears that complete replacement would be appropriate at this site.

Approach guide rail safety measures should be evaluated.
Photo #1 - Through view looking west.

Photo #2 - Through view looking east.
Photo #3 - North elevation. Note flattening of shape.

Photo #4 - North parapet from roadway.
Photo #5 - Arch ring intrados. Note missing mortar.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: W 112 TOWNSHIP: WEST AMWELL

FACILITY CARRIED: CREEK ROAD

CARRIED/INTERSECTE CREEK ROAD OVER TRIBUTARY ALEXAUKEN CREEK
D:

STRUCTURE TYPE: STONE ARCH DESIGN: BARREL

COURSING: RANDOM ASHLAR (RUSTICATED)

# SPANS: 1 LENGTH: 10'-5" WIDTH: 15'

DATE: ca. 1870, 1995 SOURCE: STYLE BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on a road laid out on the south side of Alexauken Creek after 1851 but prior to 1870. The Flemington Branch of the Belvidere-Delaware Railroad was developed through the area in 1853-54, and the highway may have been associated with it. There is sparse development along the unimproved road, which is in an agricultural area.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The 10'-5" long arch culvert with rusticated ashlar spandrel walls and wingwalls of indigenous shale was one of the most handsome examples of the structural type in the county. Its historical and technological significance was diminished in 1995 when the parapets and topmost portions of the walls were removed and replaced with concrete and weathering steel railings. Otherwise, the original character of the culvert remains. It is one of two stone arch culverts built ca. 1870 on the historic road between Lambertville and Bowne.

PHOTO INDEX: 3:14-22 FIELD INSPECT: 5/95
W 112 CREEK ROAD OVER BRANCH ALEXAUKEN CREEK

EVALUATION OF CONDITIONS AND PRESERVATION RECOMMENDATIONS

This is the southerly of the two culverts on the road.

FIELD INSPECTION FINDINGS AND EVALUATIONS

The 10'-5" long and 15' wide stone arch culvert has a vertical opening of 11 feet. It is laid up with rusticated coursed ashlar shale, an indigenous stone. The arch, with its matched ring stones, springs from defined abutments. The structure retains its original appearance and exhibits some of the most handsome masonry work observed in the county. The grapevine-type mortar joints are not original. Many of the joints are open. A small crack (possibly a settlement crack) was noted on the south spandrel wall. Historical associations and styling suggest that the span was built between 1855 and 1875.

The culvert was modified in 1995 when the low parapets and several courses of stone from the spandrel walls were removed and replaced with raw concrete walls that are level with the roadway. More courses were removed on the upstream side. The new material bears directly on the historic stonework. The area exhibiting movement at the northwest corner was not reset before the concrete was placed. The pipe railings that had been in place since at least 1961 were also removed and, subsequent to the field inspection, replaced with weathering steel beam guide rails.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The culvert is located on a tangent section of roadway with approximately 300' of sight distance in either direction. Traffic counts provided by the county indicate an ADT (average daily traffic) of 125 vehicles per day. The low ADT places the culvert and roadway in the lowest classification category when determining required travelled-way widths as outlined in AASHTO's "A Policy on Geometric Design of Highways and Streets." AASHTO's minimum standard width for a roadway of this type is 20 feet. The clear width across the culvert is about 12 feet and across the approach roadway width is 13'-6".

The surrounding area has a zoning of R-3 (three-acre residential). The right-of-way of US 202/NJ 31 is on an embankment to the south of the culvert and wetlands and Alexauken Creek are to the north. There is sparse residential development along Creek Road.
PRESERVATION RECOMMENDATIONS

Prior to the 1995 work that resulted in replacement of the uppermost courses of stonework, the culvert appears to have been one of the most distinguished in the county. It is recommended that, in order to preserve its remaining historical significance, any subsequent work, like repointing, be done in accordance with generally accepted preservation standards and in a manner that is historically and materially compatible with the surviving fabric. The culvert still remains one of the most handsome stone arch structures in the county, but that distinction could be irreversibly altered with more insensitive modifications.

Because of the insufficient width across the culvert, it is recommended that traffic control measures be provided to regulate opposing traffic across the span. The new capacity of the guide rail system (anchorage in particular) should be verified.

It is recommended that in the future when old railings like the pipe railings formerly in place on this structure are removed by the county, they should be stockpiled rather than discarded. Such details are amenities that have become increasingly rare and difficult to replace due to the unavailability of the component parts. Photodocumentation suggests that the railing may have been or was very similar to the standard Pennsylvania Railroad railings found along their Belvidere-Delaware Railroad line and the D & R Canal feeder.
1873 Beers Atlas Map (Detail) showing Creek Road south of Alexauken Creek.
Photo #1 - South elevation.

Photo #2 - North elevation.
Photo #3 - Detail northwest spandrel wall.

Photo #4 - Arch ring intrados.
Photo #5 - Through view looking west.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: W 115  TOWNSHIP: WEST AMWELL

FACILITY CARRIED: CREEK ROAD
CARRIED/INTERSECTE CREEK ROAD OVER BRANCH ALEXAUKEN CREEK
D: STRUCTURE TYPE: STONE ARCH  DESIGN: ELLIPTICAL
COURSING: RANDOM ASHLAR

# SPANS: 1  LENGTH: 9'  WIDTH: 13'-6"

DATE: CA. 1870  SOURCE: STYLE  BUILDER: UNKNOWN

SETTING/CONTEXT: The culvert is located on a road that is not shown on the 1851 county atlas map but is depicted on the 1873 Beers map. The development of the highway on the south side of the creek may have been influenced by the right-of-way of the Flemington RR that was developed north of the creek in 1853-54. There is sparse residential development, woodlands, and farm land in the vicinity of the culvert.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The most distinctive feature of the 9' long stone arch culvert is the approximately 6" recess that frame the arch ring. This detail is uncommon and may be unique in the county. Laid up with random coursed ashlarp indigenous slatey shale spandrel walls and wingwalls, the arch is finished with matched ring stones. Once a handsome structure, it has been altered by insensitive repointing and loss of portions of the original parapets. All walls appear to have been largely rebuilt. The construction date is based on the history of road and style of the arch. It is one of two ca. 1870 stone arch culverts on the historic road between Bowne and Lambertville.

PHOTO INDEX: 3: 9-12  FIELD INSPECT: 5/95
W 115 CREEK ROAD OVER BRANCH ALEXAUKEN CREEK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

This is the northern of the two culverts on this road

FIELD INSPECTION FINDINGS AND EVALUATIONS

The 9 feet long and 12 feet wide stone arch culvert with matched ring stones is laid up primarily with random ashlar slatey shale know locally as "altered shale." The fact that the arch ring is also curved suggests that the spandrel walls exhibiting random coursing are sections that have been rebuilt. The arch, which appears to be sound, is defined by an approximate 6" deep rectangular inset that extends from the abutments to height of the crown. The detail was not observed on any other surveyed stone arch bridge or culvert in Hunterdon County. The original/historic appearance of the culvert has been significantly altered by insensitive repointing. A white portland cement mix has been smeared on the joints instead of using a darker mix when tuck pointing the joints. The result is a jarring appearance. According to county records, the masonry walls were repaired in 1969 and 1971. The wingwalls flare at the approaches, and the low parapets have been modified (probably lowered) over time. There are no cap stones, and weathering steel guide rails were attached directly to the topmost stones about 1994.

The walls exhibit movement. The northeast wingwall is leaning out and has extreme misalignment. There is pronounced bowing in the upstream (south) spandrel wall above the arch crown.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

The area adjacent to the culvert is a mix of agricultural and scattered residences. The culvert is located on a tangent section of 13'-6" wide roadway at the sag of a vertical curve. This produces a sight distance of approximately 100 feet in either direction. Traffic data provided by the county indicates an ADT (average daily traffic) of 125 vehicles per day. This low ADT places the culvert and roadway in the lowest category when determining required travelled-way widths as outlined in AASHTO's "A Policy on Geometric Design of Highways and Streets." AASHTO’s minimum width for a roadway of this type is 20 feet. The clear width provided across the culvert is about 12 feet, and the approach roadway width is 13'-6". The culvert and approach roadway are thus substandard for a two-lane facility in regard to width. Widening the culvert to meet AASHTO’s minimum standard would not be meaningful unless extensive approach work was also performed. The ADTs indicate that such work would not be warranted until there is a dramatic increase in traffic volume.
PRESERVATION RECOMMENDATIONS

The culvert appears to be a good candidate for preservation given the low traffic volume and overall condition of the arch ring, which appeared to be sound. The bowed portions of the northeast wingwall and the south spandrel wall should be dismantled and rebuilt.

It is recommended that the entire structure be repointed accordance with generally accepted preservation practices. This would include removing the existing failed and failing mortar in a manner that does not damage the stones and repointing with a soft lime mortar mix that is compatible in color and in composition with the original period of construction. The original color will be found under the modern mortar. It is important to place the mortar so that it does not extend onto the face of the stones.

Because of the insufficient width across the culvert, it is recommended that traffic control measures be provided to regulate opposing traffic across the span. The capacity of the guide rail system (anchorage in particular) should also be verified.
Photo #1 - Through view looking west.

Photo #2 - South elevation showing bow in spandrel wall.
Photo #3 - Detail of guide rail attachment.

Photo #4 - Northeast approach showing bowed wingwall.
Photo #5 - Elevation view of bowed northeast wingwall.
HUNTERDON COUNTY HISTORIC STONE ARCH CULVERT
INVENTORY AND ANALYSIS
A. G. LICHTENSTEIN & ASSOCIATES, INC.

STRUCTURE #: Y 112 TOWNSHIP: LAMBERTVILLE

FACILITY CARRIED: WEEDEN STREET

CARRIED/INTERSECTE WEEDEN STREET OVER RUBBER MILL CREEK
D:

STRUCTURE TYPE: STONE ARCH DESIGN: ELLIPTICAL

COURSING: RANDOM ASHLAR

# SPANS: 1 LENGTH: 16' WIDTH: 12'

DATE: 1900 SOURCE: PLAQUE BUILDER: UNKNOWN

SETTING/CONTEXT: Road return record file 21-9-11 dating from 1863 shows that the road up Goat Hill was petitioned for in the early 1860s. It ran from River Road up the hill parallel to Rubber Mill Creek. The road is shown on the 1873 Beers atlas map. The steep road is not passable beyond the culvert. Historic houses are located on the north side of the road and culvert. There is modern development to the southwest of the culvert.

NATIONAL REGISTER RECOMMENDATION: Not Eligible

SIGNIFICANCE: The documented, 16 feet long stone arch culvert is laid up random coursed ashlar. Portions of the parapets and wingwalls, finished with cap stones, have been lost on the south elevation. The structure is representative of a type and design that was used throughout the county with great frequency in the 19th century. This 1900 example illustrates how long-lived the stone arch tradition was in Hunterdon County, but it is not individually significant. It has been altered.

PHOTO INDEX: 4:1-3, 3:23 FIELD INSPECT: 5/95
Y 112 WEEDEN STREET OVER RUBBER MILL CREEK

EVALUATION OF CONDITION AND PRESERVATION RECOMMENDATIONS

FIELD INSPECTION FINDINGS AND EVALUATIONS

The skewed, 16 feet long and 12 feet wide stone arch culvert was built in 1900, according to the date stone set into the roadway face of the low parapets. The road itself was petitioned to be included in the county road system in the 1860s, and some historical development depicted on the early 1860s road application maps remains. The arch has rusticated matched ring stones, and the spandrel walls and flared wingwalls are random-coursed ashlar finished with stone cap stones. The walls appear to have been rebuilt several times, and the mortar joints have been repointed using a variety of portland cement mixes, none of which are appropriate for a 1900 stone arch. The joints are also too large. Other alterations include the loss of the end of the southeast and northeast wingwalls and parapets. A concrete pipe under a new roadway has been placed at the southeast wingwall with the outflow paralleling the embankment at the base of the wingwall. Riprap has been placed in front of the wingwall. A large tree at the southwest abutment is affecting the integrity of the structure.

Water was observed running under the wingwall at the northeast quadrant, and a large tree located in the roadway has moved the same wingwall.

ALIGNMENT AND TRAFFIC CONSIDERATIONS

There is no traffic on this section of the steep, unimproved road, which is not maintained or passable by vehicle immediately east of the bridge. A traffic count provided by the county indicates an ADT (average daily traffic) of no vehicles per day. However, there is development taking place on the south side of the culvert, so the ADTs may change. The crossing appears adequate for the occasional vehicle. The clear width across the culvert is about 12 feet and the approach roadway is the same.

The area, which has sparse historic development on the north side of the culvert, is zoned residential. The extreme terrain in the vicinity of the culvert does not appear to be conducive to development.

PRESERVATION RECOMMENDATIONS

Given its condition and the traffic volume, the culvert appears to be a good candidate for preservation. To ensure its continued service, however, several remedial actions should be considered. The trees that are encroaching on the culvert and affecting its structural integrity should be killed and then removed. Killing the root system rather than dislodging it will result in no disturbance or undermining of the culvert.
A proper headwall should be constructed at the pipe on the southeast corner of the structure to prevent wash out potential. Missing sections of wingwalls on the south elevation should be replaced. Approach guide rail safety measures should also be evaluated.

When repointing is scheduled, it should be done in accordance with generally accepted masonry conservation standards for such work. Old mortar should be removed by hand, and the new mix needs to be a soft lime mortar that is compatible with the original detailing of the structure. It should match the historic in color and texture. Also, the joints should be slightly recessed.
Photo #1 - South elevation showing encroaching tree and lost section of wingwall.

Photo #2 - North elevation.
Photo #3 - Arch ring intrados looking northerly.

Photo #4 - Water running under northeast wingwall.
APPENDIX 1

National Register of Historic Places Criteria for Evaluation
The National Register of Historic Places criteria for evaluation are

The quality of significance in American history, architecture, archeology, engineering and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of person significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose component may lack individual distinction; or

D. that have yielded or may be likely to yield information important in prehistory or history.

Criteria considerations: Ordinarily cemeteries, birthplaces, or graves of historical figures, properties owned by religious institutions or used for religious purposes, structures that have been moved from their original locations, reconstructed historic buildings, properties primarily commemorative in nature, and properties that have achieved significance within the past 50 years shall not be considered eligible for the National Register. However, such properties will qualify if they are integral parts of districts that do not meet the criteria or they fall within the following categories:

a. a religious property deriving primary significance from architectural or artistic distinction or historical importance; or

b. a building or structure removed from its original location but which is significant primarily for architectural value or which is the surviving structure most importantly associated with a historic person or event; or

c. a birthplace or grave of a historical figure of outstanding importance if there is no other appropriate site or building directly associated with his or her productive life; or

d. a cemetery that derives its primary significance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or

e. a reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or

f. a property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own historical significance; or

g. a property achieving significance within the past 50 years if it is of exceptional importance.
APPENDIX 2:

Preservation Brief: 2 Repointing Mortar Joints in Historic Brick Buildings
Preservation Briefs: 2
Repointing Mortar Joints in Historic Brick Buildings

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de Teel Patterson Tiller
James S. Askins

Repointing is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar. Properly done, repointing restores the visual and physical integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may, in fact, cause physical damage to the masonry units themselves.

The purpose of this brief is to provide general guidance on appropriate materials and methods for repointing historic brick buildings and is intended to benefit building owners, architects, and contractors alike. Because of its general nature, this publication should not be considered a specification for repointing. Rather, it should serve as a guide to prepare such specifications; to develop sensitivity to the particular needs of historic masonry; and to assist historic building owners in working cooperatively with contractors and architects.

Identifying the Problem

The decision to repoint is most often related to some obvious sign of deterioration (figure 1) such as disintegrating mortar, cracks in mortar joints, loose bricks, damp walls, or damaged plasterwork. It is, however, erroneous to assume that repointing alone will solve all these problems. Therefore, the true cause of the deterioration should be determined before beginning any repointing work. Leaking roofs or gutters, differential settlement of the building, capillary action causing rising damp, or extreme weather exposure should all be recognized as sources of deterioration and should be dealt with immediately. Without such action, mortar deterioration will continue and any repointing work will have been a waste of time and money.

Budgeting and Scheduling

It is important to recognize that repointing will probably be both expensive and time-consuming due to the extent of handwork and special materials required; however, it should also be emphasized that it is not only possible, but preferable to repoint only those areas that require work rather than an entire wall, as is often specified. Recognizing this at the outset may prevent many restoration/rehabilitation jobs from becoming prohibitively expensive.

In scheduling, seasonal aspects need to be considered first. Generally speaking, repointing should only be undertaken when the wall temperatures are between 40° and 95° (F) to prevent freezing or excessive evaporation of the water in the mortar. During hot weather, repointing should ideally be done on the shady side of the building in order to slow the drying process of the mortar.

The relationship of repointing to other proposed work on the building must also be recognized. For example, if paint removal or cleaning are anticipated and if the mortar joints are basically in sound condition and only need selective repointing, it is generally better to postpone repointing until after completion of these activities. However, if the mortar has badly eroded, thus allowing moisture to penetrate deeply into the wall, repointing should be accomplished before cleaning. Related work such as structural or roof repairs should be scheduled so that they do not interfere with repointing and so that all work can take maximum advantage of scaffolding.
Visual Examination

All repointing work on historic masonry buildings should be preceded by an analysis of the mortar and by an examination of the bricks and the techniques used in the original construction of the wall. For most projects, a simple visual analysis of the historic mortar is sufficient to allow an appropriate match for the new mortar. The exact physical and chemical properties of the historic mortar are not of major significance as long as the new mortar:

- matches the historic mortar in color, texture, and detailing;
- is softer (measured in compressive strength) than the brick;
- is as soft, or softer (measured in compressive strength) than the historic mortar.

A simple method of analyzing the historic mortar to aid in developing an appropriate repointing mortar for many restoration jobs and most rehabilitation work follows:

1) Remove three or four unweathered samples of the mortar to be matched from several locations on the building (set the largest sample aside—this will be used later for comparison with the repointing mortar). It is important to recognize that many historic buildings have been repointed a number of times and that on any given wall surface there may be a variety of mortars. Therefore, it is important to remove as many samples as are representative to obtain a “mean” mortar sample.

2) Break the remaining samples apart with a wooden mallet until they are separated into their constituent parts. There should be a good handful of the material.

3) Carefully blow away the powdery material (the lime or cement matrix which bound the mortar together).

4) With a low power (10 power) magnifying glass, examine the remaining sand and other materials such as oyster shells.

5) Note and record the wide range of color as well as the varying sizes of the individual grains of sand or shell.

Historic sand colors may range from white to grey to yellow within a given mortar sample. Furthermore, the varying sizes of the grains of sand or other materials such as shell play an important role in the texture of the repointing mortar. Historic sand was not screened or graded by size as it is today. Therefore, when specifying sand for repointing mortar, consideration may need to be given to obtaining sand from several sources and then combining them in order to approximate the range of sand colors and grain sizes in the historic mortar sample. The role of the sand in the overall appearance of the replacement mortar should not be underestimated.

Pointing styles and the methods of producing them should be examined (figure 2). It is important to look at both the horizontal and the vertical joints to determine the order in which they were tooled and whether they were the same style. Some late-19th- and 20th-century buildings, for example, have horizontal joints that were tooled while the vertical joints were finished flush and stained to match the bricks, thus creating the illusion of horizontal bands. It is significant to note that pointing styles often differed from one facade to another. Front walls often received greater attention to mortar detailing than side and rear walls.

Bricks should also be examined so that any replacement will match the historic brick. Within a wall there may be a surprising range of colors, textures, and sizes, particularly with hand-made brick. Replacement should match the full range of the historic brick rather than a single brick. Although many bricks can be matched from existing stock, they must often be custom-ordered, a lengthy process that can seriously affect the project budget and schedule. Here, there should be a note of caution! The use of recycled brick from demolished buildings for replacement brick often results in an excellent color and texture match; however, it is important to remember that historic brick was manufactured in varying grades, ranging from high-fired exterior brick to low-fired interior “bat” or “clinker” brick. This low-fired brick was never intended to be exposed to the weather, and, when used for replacement brick on an exterior wall, will deteriorate at a rapid rate, often needing replacement within a year or two. Great care, therefore, should be taken in choosing the proper type of recycled brick.

Properties of Mortar

In general, mortars for repointing should be softer (measured in compressive strength) than the masonry units and no harder than the historic mortar. This is necessary to prevent damage to the masonry units. It is a common error to assume that hardness or high strength is a measure of durability. Stresses within a wall caused by expansion, contraction, moisture migration, or settlement must be accommodated. In a masonry wall, these stresses should be relieved by the mortar rather than by the bricks. A mortar that is stronger or harder than the bricks will not “give” thus causing the stresses to be relieved through the bricks—resulting in cracking and spalling (figure 3). Stresses can also break the bond between the mortar and the brick, permitting water to penetrate the resulting hairline cracks.

Constituents of Mortar

Sand: Sand is the largest constituent of mortar and the material that gives mortar its characteristic color and texture. When viewed under a magnifying glass or low-power binocular microscope, particles of sand generally have either rounded edges, such as found in beach or river sand, or sharp, angular edges, found in crushed or manufactured sand. For repointing mortar, rounded or natural sand is preferred for two reasons. First, it is usually similar to the sand in the historic mortar; thus providing a better visual match. Second, it has better “working” qualities or plasticity and can thus be forced into the joint more easily, forming a good contact with the historic mortar and the surface of the bricks.

Although manufactured sand is frequently the only type readily available, it is worth the search to locate a sufficient quantity of rounded or natural salt-free sand for repointing.

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Lime or Portland Cement: The two commonly used binders for mortar are lime and portland cement. Of the two, lime produces a mortar that meets nearly all the requirements for a good mortar for historic buildings, while portland cement produces a mortar that does not perform as well. High lime mortar is soft, porous, and changes little in volume during temperature fluctuations. In addition, lime mortar is slightly water soluble and thus is able to re-seal any hairline cracks that may develop during the life of the mortar. Portland cement, on the other hand, can be extremely hard, is resistant to movement of water, shrinks upon setting, and undergoes relatively large thermal movements. The use of a high lime mortar, therefore, is recommended for nearly all repointing projects. However, the addition of 5 percent white portland cement for not more than 20 percent of the lime will usually improve workability or plasticity without adversely affecting the desirable qualities of the lime mortar. Workability or plasticity of the mortar is important to ensure that the new mortar forms a good bond with the original mortar and the bricks.

Water: Water should be clean and relatively free of salts or acids.

Historic Additives: In addition to the color of the sand, the texture of the mortar is of critical importance in duplicating historic mortar. While modern mortars are finely ground and present a uniform texture and color, historic mortars were not as well ground. They may contain lumps of oyster shell, partially burned lime, animal hair, or particles of clay. The visual characteristics of these additives should be duplicated through the use of similar materials in the repointing mortar.

Matching Color and Texture of Mortar

In matching the repointing mortar, the new mortar should match the unweathered interior portions of the historic mortar. The simplest way to check the match is to make a small sample of the proposed mix and allow it to cure; this sample is then broken open and the broken surface is compared with the broken surface of the largest “saved” sample of historic mortar.

If it is not possible to obtain a proper color match through the use of natural materials because locally available sands are not a close match to the original sand, it may be necessary to use a modern mortar pigment, and, in fact, some historic mortars did use such additives. In the late 19th century, some mortars were colored with pigments to match or contrast with the brick. Red, brown, and black pigments were commonly used. Pigments are available as separate ingredients or already mixed with mortar; however, the premixed mortars normally are not suited for use on repointing projects because of their high portland cement content. Only chemically pure mineral oxides, which are alkali-proof and sun-fast, should be used in order to prevent bleaching and fading.

Material Specifications

Modern materials specified for use in repointing mortar should conform to specifications of the American Society for Testing Materials (ASTM) or comparable federal specifications.

Sand should conform to ASTM C-144 to assure proper gradation and freedom from impurities. Sand color, size, and texture should match the original as closely as possible to provide the proper color match without other additives. Samples of sand proposed for use should be submitted for approval prior to beginning work.

Lime should conform to ASTM C-207, Type S, Hydrated Lime for Masonry Purposes. This lime is designed to assure high plasticity and water retention with a safe degree of strength. The use of quicklime, which must be slaked and soaked, does not necessarily provide better results.

Cement should conform to ASTM C-150, Type II (white non-staining) portland cement. It should not have more than 0.60 percent alkali to help avoid efflorescence.

Water should be potable—clean and free from acids, alkalies, or large amounts of organic materials.

Historic Additives will require writing new specifications for each project. If possible, suggested sources for special materials should be included. For example, crushed oyster shells frequently can be obtained in a variety of sizes from poultry supply dealers.

Mortar Mix: Specifying the proportions for the repointing mortar for a specific job is often a perplexing task for the architect, engineer, contractor, or preservationist...
consultant alike. The following guidelines can assist in writing specifications:

- Material proportions should be given in volumes, that is, 4 parts of lime to 12 parts of sand, rather than 2 bags of lime to 6 cubic feet of sand. This will avoid any confusion on the job site when substitution of sources occur with differing packaging sizes.
- Repointing mortar for most historic buildings should ideally be composed only of lime and sand. A proportion of 1 part of lime to 2 parts of sand is a useful starting point.
- ASTM C-150, Type II (white non-staining) portland cement may be added to the repointing mortar to increase workability or to achieve whiteness in color; however, no more than 20 percent of the total volume of the lime and portland cement—combined—should be portland cement. Above 20 percent, the portland cement increases the hardness of the repointing mortar to a potentially damaging degree.
- For surfaces of extreme weather such as parapet walls or water tables, a harder mortar (6 parts of sand, to 3 parts of lime, to 2 parts of white portland cement) may be more desirable.

Execution of the Work

The Test Panel: In choosing a contractor or mason, perhaps the best way to award the contract and for the contractor or mason to demonstrate his or her work in a repointing job is the test panel: a small demonstration section of joint preparation and repointing actually done on the historic masonry. The test panel should be carefully selected to include all types of masonry, joint styles, and types of problems to be encountered on the job. Usually a 3-foot by 6-foot area located in an inconspicuous yet readily accessible place is sufficient.

Joint Preparation: Old mortar should generally be removed to a minimum depth of 2½ times the width of the joint to ensure an adequate bond and to prevent mortar "popouts." For most brick joints, this will require removal of the mortar to a depth of approximately ½–1 inch. Any loose or disintegrated mortar beyond this minimum depth should be removed (figure 4). The use of power tools such as saws with carbide blades or impact hammers for the removal of mortar almost always results in damage to the bricks by breaking the edges and by overcutting on the head, or vertical, joints (figure 5). Damage to the bricks not only affects their visual character but can also lead to accelerated weather damage. Where joints are uniform and fairly wide, it may be possible to use a grinder to assist the removal of mortar; however, final preparation of the joint should be done by hand.

Test panels are quite helpful, but they cannot adequately assess the potential effect of using a grinder since such panels are not prepared under actual working conditions. If there is any chance of damaging the masonry, hand-methods should be used exclusively. Although slower, these methods are easier to control and less likely to cause irreversible damage to the bricks. Mortar should be removed cleanly from the bricks, leaving square corners at the back of the cut. Before filling, the joints should be rinsed with a jet of water to remove all loose particles and dust. At the time of filling, the joints should be damp but with no standing water present.

Mortar Preparation: Mortar should be mixed carefully to obtain uniformity of visual and physical characteristics.
Dry ingredients should be measured by volume and thoroughly mixed before the addition of any water. Half the water should be added, followed by mixing for approximately 5 minutes. The remaining water should then be added in small portions until a mortar of the desired consistency is reached. The total volume of water necessary may vary from batch to batch, depending on weather conditions. Mortar should be used within 30 minutes of final mixing, and “re-tempering,” or adding more water after the initial mix is prepared, should not be permitted.

**Modern Additives:** In general, modern chemical additives are unnecessary and may, in fact, have detrimental effects. The use of antifreeze compounds is not recommended. They are not very effective with high lime mortars and may introduce salts, which will later cause efflorescence. A better practice is to warm the sand and water, and to protect the completed work from freezing. The use of air-entraining additives to resist frost action and enhance plasticity, are also discouraged, since the air has a detrimental effect on both bond and strength of the mortar. In areas of extreme exposure requiring high-strength mortars (see formula for “extreme weather exposure” under Mortar Mix section), air-entrainment of 10–16 percent may, however, be desirable. Bonding agents that increase the bond of the new mortar to the old should also be avoided. If the joint is properly prepared, there will be a good bond between the new mortar and the adjacent surfaces; chemical agents do not significantly improve this bond and are not a substitute for proper joint preparation. In addition, some of the agent will inevitably become smeared on the surface of the masonry and removal is very difficult.

**Filling the Joint:** Where existing mortar has been removed to a depth of greater than 1 inch, these deeper areas should be filled first, compacting the new mortar in several layers. The back of the entire joint should be filled successively by applying approximately ¼ inch of mortar. packing it well into the back corners. This application may extend for several feet. As soon as the mortar has reached thumb-print hardness, another ¼ inch layer of mortar—approximately the same thickness—may be applied. Several layers will be needed to fill the joint flush with the outer surface of the brick. It is important to allow each layer time to harden before the next layer is applied; most of the mortar shrinkage occurs during the hardening process and layering thus minimizes overall shrinkage.

The rate of hardening can be controlled by dampening the brick and the old mortar before beginning to fill the joint, but free water or excessive dampness in the joint should be avoided. Too much water will delay the tooling or cause excessive shrinkage; too little water will be absorbed from the mortar before it is properly set, thus reducing bond strength.

When the final layer of mortar is thumb-print hard, the joint should be tooled to match the historic joint. Proper timing of the tooling is important for uniform color and appearance. If tooled when too soft, the color will be lighter than expected, and hairline cracks may occur; if tooled when too hard, there may be dark streaks called “tool burning,” and good closure of the mortar against the brick will not be achieved.

If the old bricks have wcrn, rounded edges, it is usually best to recess the final mortar slightly from the face of the bricks. This treatment will help avoid a joint visually wider than the actual joint width; it will also avoid creation of a large, thin featheredge which is easily damaged, thus admitting water (figures 6 and 7). After tooing, it is frequently necessary to remove excess mortar from the edge of the joint by brushing with a bristle brush.

“**Aging**” the Mortar: Even with the best efforts at matching the existing mortar color, texture, and materials, there will usually be a visible difference between the old work and the new, partly because the new mortar has been matched to the unweathered portions of the historic mortar. If the mortars have been properly matched, the best treatment for surface color differences is to let the mortars age naturally. Another reason for a slight mismatch may be that the sand is more exposed in old mortar due to the slight erosion of the lime or cement. Several methods of treatment have been attempted in an effort to overcome these differences. As with all work, however, any proposed treatment should be carefully tested prior to implementation.

Efforts to stain the new mortar to produce a color match should, in most cases, be avoided. Although such a process may provide an initial match, the old and new mortars may weather at different rates, leading to visual differences after a few seasons. In addition, the mixtures used to stain the mortar may be harmful to the masonry, for example, introducing salts into the masonry which can lead to efflorescence.

**Cleaning:** If repointing work is carefully executed, there will be little need for cleaning other than the small

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**Figure 4.** Comparison of incorrect and correct preparation of mortar joints for repointing. Drawing: Robert C. Mack and David W. Look.
amount of mortar brushed from the edge of the joint following toothing. This type of cleaning is best accomplished with a stiff bristle brush after the mortar has dried, but before it is fully hardened (1–2 hours). Mortar that has hardened can usually be removed with a wooden paddle or, if necessary, a chisel.

Further cleaning is best accomplished with plain water and bristle brushes. If chemicals must be used, their selection should be made with extreme caution. Improper cleaning can lead to deterioration of the masonry units, deterioration of the mortar, mortar smear, and efflorescence. New mortar joints are especially susceptible to damage because they do not become fully cured for several months. Chemical cleaners, particularly acids, should be used only once and should be flushed freely with plain water to remove all traces of the chemicals.

Several precautions should be taken if freshly re-pointed mortar joints are being cleaned. First, the mortar should be fully hardened before cleaning—30 days is usually sufficient, depending on weather and exposure (as mentioned above, the mortar will continue to cure even after the mortar has hardened). Test panels should be prepared to evaluate the effects of different cleaning methods. Only stiff natural bristle brushes should be used, except on glazed or polished surfaces. Here, only soft cloths should be used. Further information concerning masonry cleaning is presented in Preservation Briefs 1 “The Cleaning and Waterproof Coating of Masonry Buildings.”

New construction “bloom” or efflorescence occasionally appears within the first few months of re-pointing and usually disappears through the normal process of weathering. If the efflorescence is not removed by natural processes, the safest way to remove it is by dry brushing with stiff natural or nylon bristle brushes and water. Hydrochloric (muriatic) acid, is generally ineffective and should be avoided in the removal of efflorescence. In fact, this chemical may deposit additional salts, which, in turn, can lead to additional efflorescence.

Scrub Coats: A variety of new and purportedly useful re-pointing techniques for historic buildings are being offered by contractors which appear to have limited usefulness in historic preservation. These techniques are identified under a variety of names that include: slurry coats, slurry coating, and, most commonly, scrub coating. All involve the brushing of a thinned, low-aggregate coat of mortar over the entire masonry surface which, when dry, is scrubbed off the brick with a brush, presumably leaving a residue in the mortar joint. These techniques have become increasingly appealing as they are quick, inexpensive in comparison to traditional re-pointing costs, and do not require particularly skilled labor or craftsmanship. Their greatest attraction lies in re-pointing large masonry surfaces such as highrise structures, but their benefit to historic masonry is essentially cosmetic. A certain amount of crack sealing in the mortar joint does occur, and for these limited applications it is a useful technique; however, these techniques should not be confused with, or substituted for, re-pointing. It is not the same process. Slurry coats and slurry and scrub coatings, tend to mask joint detailing or toothing, have a life expectancy of only a few years, and are extremely difficult to clean from the surface of the brick without leaving a residue, called “veiling.” While of some limited use in specific instances, these new techniques are not
appropriate for historic buildings and should therefore not be considered when a lasting and durable repointing job is desired.

Summary

For the Owner/Administrator: The owner or administrator of an historic building must constantly remember that repointing is likely to be a lengthy and expensive process. The owner will need to allow adequate time for evaluation by a qualified preservationist, for preparation of plans and specifications for the work, and for a lengthy work period with scaffolding in place. Schedules for both repointing work and other activities will thus require careful coordination to avoid unanticipated conflicts. The owner must avoid the tendency to rush the work or economize if the building is to retain its visual integrity and the job is to be durable.

For the Architect/Consultant: The architect/consultant must assist the owner in planning for logistical problems relating to research and construction. The consultant must also realize that older buildings have special problems usually not encountered with modern building materials or techniques of construction. Therefore, extra research will be required, and nonstandard materials and procedures will need to be used in evaluating the work of potential contractors to ensure that they are qualified to work on projects of the type anticipated. The consultant must also be prepared to spend more time than is customary in modern construction to inspect the work.

For the Contractor/Craftsman: The contractor or craftsman must keep in mind that a repointing project for a historic building will be slower and more expensive per unit cost than work on a modern building. The contractor must understand the reasons for these special requirements, and must convey them to the workers at all levels. Understanding the nature of the project and the potential problems will not only allow the contractor to submit a more accurate bid, but will also provide for the use of nonstandard methods in performing work.

Conclusion

First and foremost, a good repointing job is meant to last, often in the range of 50–100 years. Shortcuts and poor craftsmanship not only result in a job that looks bad, but also in one that will require future repointing more frequently than if the job had been done correctly in the first place. The mortar joint in a historic brick building has often been called the wall's "first line of defense." Good repointing practices guarantee the long life of the mortar joint, the wall, and the historic structure. However, while careful preservation, restoration, and maintenance will guarantee the long life of the freshly repointed mortar joints, it is important to remember that these mortar joints will probably require repointing some time in the future. It is the nature of mortar joints to deteriorate. Nevertheless, if the historic mortar joints proved durable for many years, then careful repointing should have an equally long life, ultimately contributing to the preservation of the historic brick building.

This brief was first written by Robert C. Mack, AIA, in 1976. It has been revised and updated in 1980 by Robert C. Mack, de Teel Patterson Tiller. Architectural Historian, Heritage Conservation and Recreation Service (HCRS), Department of the Interior; and James S. Askins, Preservation Craftsman, National Park Service, Department of the Interior. Other HCRS staff members who contributed materially to the development of this revised brief are Kay D. Weeks, Technical Writer-Editor, and James A. Caufield, Historical Architect.

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Preservation Briefs 2 has been developed under the technical editorship of Lee H. Nelson, AIA, Chief, Technical Preservation Services, Heritage Conservation and Recreation Service, U.S. Department of the Interior, Washington, D.C. 20243. Comments on the usefulness of this information are welcome and can be sent to Mr. Nelson at the above address.

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Preservation Briefs: 1 The Cleaning and Waterproof Coating of Masonry Buildings. Stock Number: 024-005-00650-8


Selected Reading List


