Case Study: Greenville Bridge Rehabilitation

Slip-Lining to Stabilize Stone Masonry Culvert, Smithfield, RI

A busy intersection, a steady flow and an unstable stone masonry structure were the key ingredients combine to serve one distasteful dilemma – how does an aging infrastructure become replaced without being removed?

Even with trenchless methods on the rise, each case presents its own challenges and dictates a unique solution. In essence, identify the parameters and the solution will present itself. In this case, a slip-line pipe material with a custom shape to maximize waterway and a smooth interior to maximize capacity.

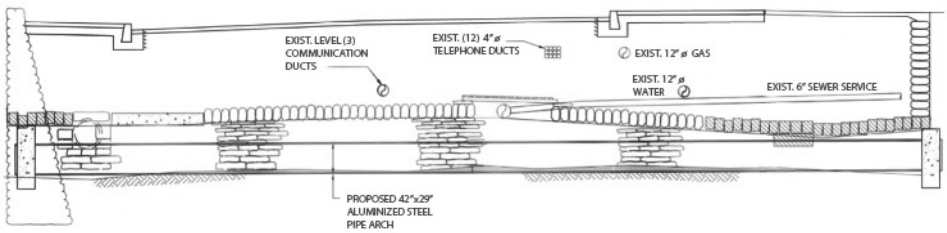
The call for trenchless methods was apparent. Relentless traffic from a bottlenecked commuter thoroughfare, a critical waterway 12' to 14' beneath with a series of upstream dams regulating flow, and all the buried utilities we have come to expect.

Outfall of the newly relined stone masonry culvert completed as part of the reconstruction of Route 44 in Smithfield, Rhode Island near Smith Avenue (Route 116).

What was not so obvious was how to rehabilitate a century old stone masonry structure, irregularly shaped from a series of extensions and repairs, from boulder walls under a granite slab to the more traditional stone arch, replete with repaired areas, obstructions, settlements and cave-ins, and a vertical clearance ranging from 2' to 4½'.

The project specifications detailed a 42" x 29" corrugated steel pipe-arch with the spiral rib profile, a custom size for that profile. Specified as a 14 gage Aluminized Type-2 material, the new structure enjoys the added benefit of 100-yr. service life touted by the industry, and virtually gives the structure a completely renewed life.

The spiral rib profile is a corrugation with outwardly projected rectangular ribs and a smooth interior with a Manning's roughness coefficient of 0.012, primarily developed for storm sewer applications, but ideal as a reline material due to the narrow wall profile and smooth interior (see Spiral Rib Profile on page 2). With the ability to manufacture corrugated steel pipe in custom sizes, the spiral rib reline pipe was arched to the specified dimensions, matching the hydraulic capacity of the existing structure with a slight increase in grade, and thereby eliminating any additional bureaucracy associated with changing the impact upstream or downstream of the culvert.



RIDOT Consultant
Commonwealth Engineers & Consultants, Inc.
Providence, RI

General Contractor
Cardi Corporation
Warwick, RI
$63,000 (78' slip-line)

Reline Pipe Supplier
Vellano Corporation
Riverside, RI

Reline Pipe Manufacturer
Lane Enterprises, Inc.
Ballston Spa, NY

Before - Stone Masonry Culvert
5' span, 3' rise (assumed avg.)
Manning's roughness, n = 0.04
Slope at 0.5% (assumed avg.)
Hydraulic capacity ~ 55.14 cfs

After - Spiral Rib Pipe-Arch
42" span, 29" rise
Manning's roughness, n = 0.012
Slope at 0.61%
Hydraulic capacity ~ 55.20 cfs

Spiral Rib Reline Pipe

The 42” x 29” pipe-arch was an ostensible reduction in waterway from the geometrically averaged 5’ x 3’ stone box culvert (6.5’^{2} vs. 15’^{2}), but a slight increase in grade (0.5% to 0.61%) and a marked improvement in the roughness coefficient (0.040-rough rock vs. 0.012-spiral rib pipe) provided the needed hydraulic match.

Modifications to the existing channel were needed to accommodate the slip-lining process, primarily the creation of additional vertical clearance in an area. Preparatory work included obstruction removal, void blocking/filling and streambed regrading. The photo at right illustrates the variable nature of the channel cross-section and the challenges presented both in design and construction.

Grouting the annular space created by the reline pipe is the final and most risky part of the installation. Project specifications called for detailed submittals to ensure adequate experience, proper equipment and appropriate procedures. Preliminary measures included securing the pipe alignment, the installation of bulkheads, maintaining a dewatered annular space, and ensuring a continuous flow bypass.

Grouting was completed in several lifts to keep buoyant forces on the pipe to acceptable levels. A number of injection ports fabricated into the reline pipe is conducive to observation, ventilation, and complete filling. Grouting pressure is a critical component, especially in the latter stages, as excessive pressures can be damaging.

Submittals identifying the mix design, pumping schedule, and pumping rate were also required. A certified pressure gauge and continuous monitoring is paramount to a successful operation, as the pressures generated from blockages can deform the reline pipe. Experience, expertise and diligence during this most sensitive portion of the installation was the necessary capstone to all the planning, design and preparation leading up to this point ... looks like another 100 years for Greenville Bridge No. 99.