STILL VALLEY RAILROAD TUNNEL

An Unknown Early Cement in Rural NJ

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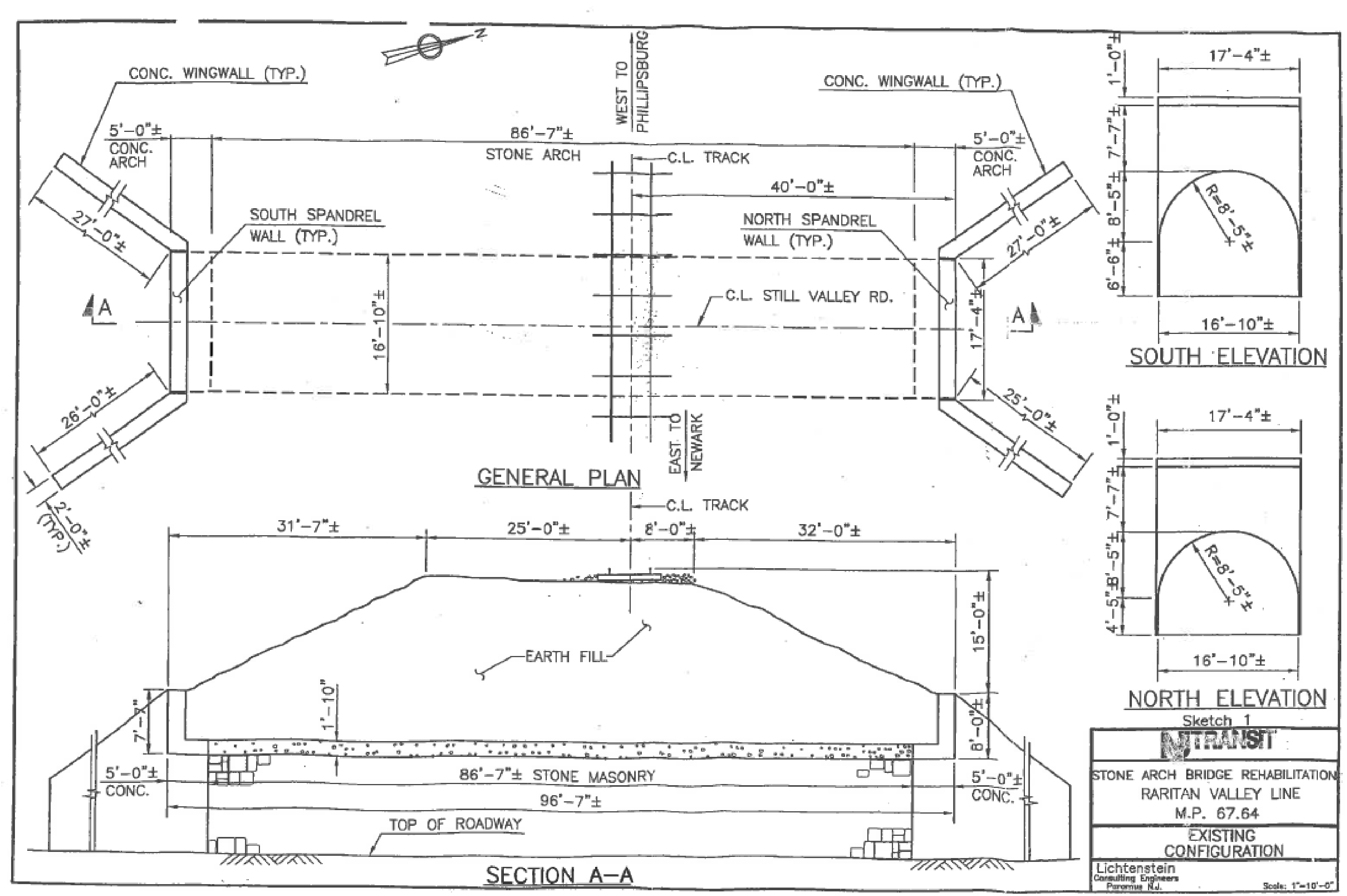
Still Valley Road, Pohatcong, Warren County, New Jersey

Stone Arch Bridge (Tunnel), Raritan Valley Line, Central Railroad of New Jersey (now NJ Transit)

Stone tunnel constructed 1852. Concrete extensions, spandrel walls, wing walls added 1911. 97’ in length. Railroad use ceased about 1975. Tunnel closed to traffic in 1999.



From Lichtenstein Engineering Report, 1999

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel

Interior of tunnel from south to north

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel


West wall of tunnel from south to north

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel

Still Valley Railroad Tunnel

Major Problems

- Falling stones
- Dripping moisture
- Deteriorating stone and mortar
- Misguided previous attempts at repair

Large trees had grown up over the arch and damaged the original, clay, waterproofing layer. Also, 1911 lengthening of tunnel may not have extended clay layer. This photo taken after removal of trees.

Timeline

- 1999 NJ Transit evaluates alternatives for tunnel remediation from Lichtenstein Engineering Report
- 1999 NJ Transit decides to demolish tunnel
- 1999-2003 Pohatcong Township Council Members and Historic Preservation Commission consider alternatives to demolition. Consult with Iam Cramb, Scottish stone mason, John Harry and others

Timeline (continued)

- 2003-2004 Pohatcong negotiates with NJ Transit to purchase tunnel for $1 and receives $250,000 grant from NJ Transit for restoration
- 2006 Bob Mack, MacDonald & Mack, prepares report on tunnel restoration. Laura Powers and Susanne Papas of WJE do petrographic analysis of mortar for Mack
- 2010 Pohatcong receives grant for $91,000 from Warren County Department of Land Preservation

Timeline (continued)

- 2011 Pohatcong hires contractor to remove trees, over-burden, install membrane and new fill, $61,616 contract. Engineer walks off job; contractor messes up job.
- 2012 Township engineer, Gwen Steckel, Cherry, Weber and Associates, hired to prepare plans and specs for stone restoration. Cherry Weber hires John Harry to assist with details.

Timeline (continued)

- 2012 John Walsh of Highbridge Materials Consulting is hired to perform additional petrographic analysis.
- 2012 Project put out to bid. Steve Ferrari of Works in Stone, Inc. gets contract.
- 2012 After opening areas of sides and ceiling, engineer, consultant and contractor agree to change scope of work. Total project $178,400.
- December 2013 Work finished, tunnel drying out through new mortar.

Timeline (continued)

- January 2013 Tunnel reopened to vehicular traffic.

Petrography

- Binder identified as “hydraulic lime (or possibly an early hydraulic cement).” “White, hydraulic, dolomitic ‘waterlime with properties intermediate between natural cement and hydraulic lime.” “…The binder is not a natural cement. …appears to have been made from a dolomitic limestone that was burned with clay… incomplete burning.” “The binder does not match silica to calcium ratios of any known natural cement..“
- The binder is not hydraulic lime.

Petrography (continued)

- Mortar is “relatively hard and firm when it is dry but crumbly when it is wet” “Mortar is highly water absorptive.” Many small pores.
- Various nodules (lumps) in mortar contain contain glass, reddish brown clay, white binder, and inclusions that appear to be impure belite.
- Binder is mostly carbonated.
- Estimated air content 3 - 6% WJE and 6 – 12% JW

Petrography (continued)

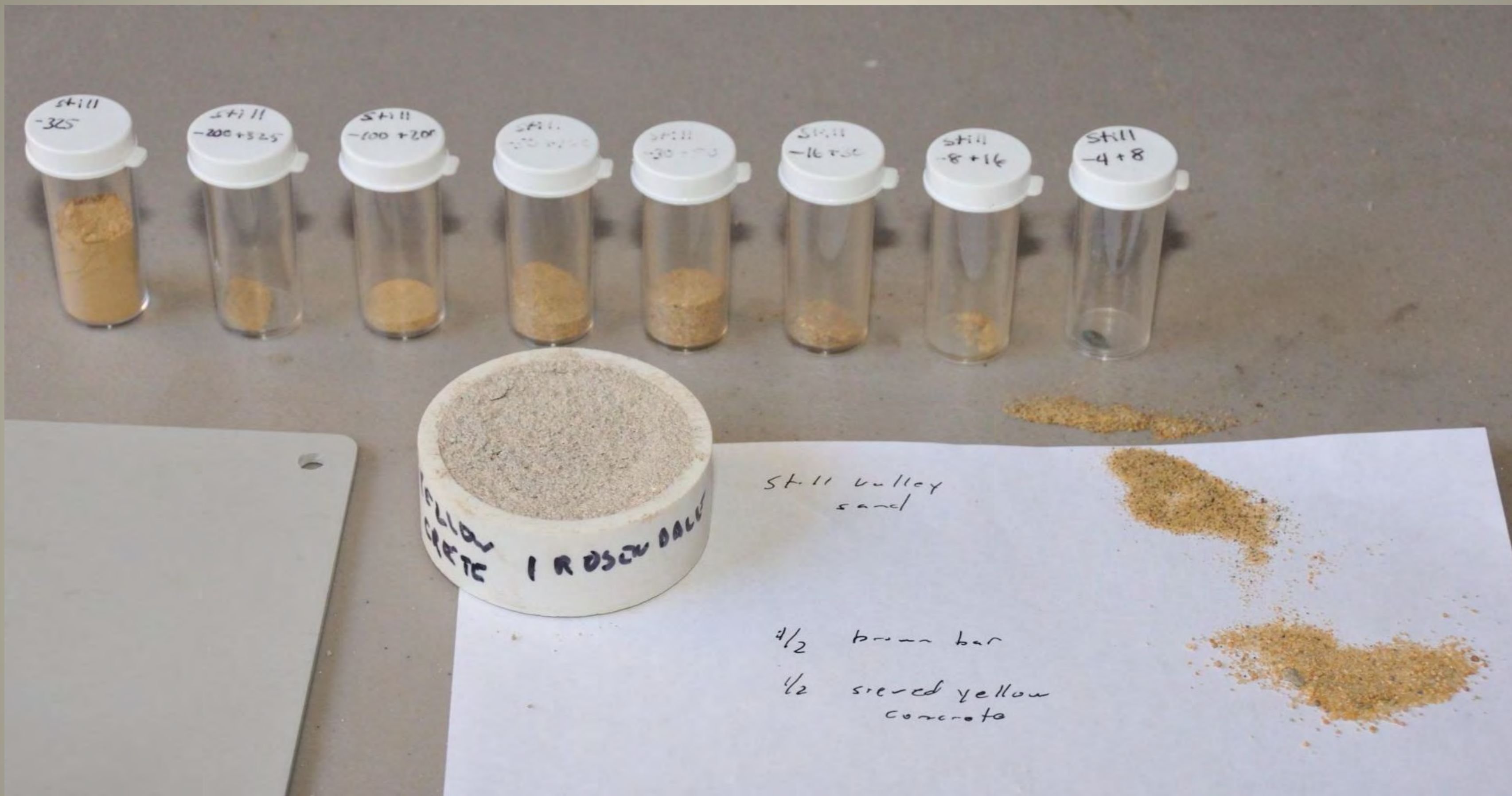
- No secondary deposits. No evidence of leaching of binder. "Few deleterious effects of service"
- Mortar contains clay which is estimated to make up about 15% of aggregate/clay total. Two different colors/types of clay.
- Binder to sand ratio estimated between 1 : 2 to 1 : 2.6.

Quotes are from WJE and Highbridge (John Walsh) reports.

Mortar Mix

- Two sands blended to match original. No clay added.
- Mix of Natural Cement and Hydrated Dolomitic Lime binder used to approximate original properties.
- Mortar Formula - Cement:Lime:Sand 1:1:5
- Binder : Sand ratio: 1 : 2.5

Quotes are from WJE and Highbridge (John Walsh) reports.



Graded sand from original mortar in bottles, original sand and new blend, and cured mortar sample

Planned Scope of Work

- Remove loose stones, reset them or replace with new stone.
- Perform repointing in selected areas subject to square foot allowance.

Handy tool for stone removal/replacement

Major part of project as originally planned: replace loose and missing stones.

Replacement stone is a higher quality local limestone similar in color and texture

New Findings

- This construction was not traditional masonry with tight fitting joints, stone-to-stone contact (suitable for soft, slow setting mortars).
- Rather, this method utilized large stones with one somewhat-flat face placed on form and then spaces filled in with large amounts of mortar and some additional stones but no fitting. More like concrete construction.
- Required fast-setting mortar but low skills.
- Stones weren't falling out; faces were spalling.

Realization: stones were not falling out; stones were fracturing and spalling.

Hard, Portland mortar and Gunite were trapping moisture in stone and joints. Freezing caused poor-quality limestone to spall.

No fitting of stones. Large spaces filled with quick-setting cement mortar. Mortar in excellent condition. No loss or leaching of binder.

Without quick-setting mortar, it would have taken years for arch to become self-supporting.

Unexpected problem: the bear slide.

New work plan

- Stop removing stones
- Sound stones throughout most of tunnel to find loose and delaminated pieces
- Remove fractured pieces and fill in only when deeper that about 6”
- Remove as much hard mortar as budget allowed
- Only do pointing where obvious holes

Sounding stones to find delaminated faces.

During the work.

Prepared area ready for insertion of fill stones and mortar.

Completed area. Only deep stone spalls refilled with new stone.

Contractor Steve Ferrari holds typical spalled stone removed from tunnel ceiling

Some of the spalled and fractured stone removed from the surface of the tunnel.

Finished work. Lighter mortar indicates areas that are drying out. No funds available to address appearance issues. Would be possible in the future to remove Gunite, unmatching mortar, and dirt.

Project was successful!

- Interior of tunnel is drying out.
- Rate of stone and mortar deterioration has been very substantially slowed.
- No stones falling out onto roadway.
- Improvised restoration mortar was a good match to original in appearance, hardness and high permeability. And, it softens when wet similar to the original.

But there are still problems

- Concrete end walls should be repaired.
- Leaks at the end of the tunnel must be corrected.

Continuing moisture intrusion and damage at north end of tunnel. Protective membrane over top of tunnel was not connected to concrete end walls. Water gets in between.

Insights and Questions

- This quiet country setting masks the importance of the high-tech innovation occurring here in 1852.
- The original binder was a previously-unknown form of hydraulic cement. Likely that it was local product or "home grown" by the railroad.
- Was the binder an early experiment in an "unnatural" cement where limestone was fired with additions of clay?

Insights and Questions (continued)

- The new fast setting mortar allowed a new variation of construction where the mortar is important structural component. Faster construction with less skilled labor.
- Why was the clay added to the mix? It was a lot of clay to be an impurity in the sand. And why two types of clay? Was it a filler? Was it added to modify the porosity or the compressive strength of the mortar?

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