STANDING STONE LLC

Brookline Stone Arch Bridge Revised Assessment Report and Repair Cost Guide

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ASSESSMENT:

A basic visual assessment of the current conditions was performed by Brian Post on Feb 7th 2025.
An additional inspection of the bridge was performed by Brian Post on May 17th 2025

Based on these assessments the bridge was built in 3 segments. The downstream section was the original bridge and each subsequent section widened the bridge upstream.

1) The downstream section.
This section is 14 ft long. The stonework was well built and it appears that an early Portland mortar, or a Portland/lime mix was used. It is possible the mortar was a later addition to this section though a basic inspection does not support this. There appears to have been some minor settling and shifting over time, and much of the mortar has fallen out particularly in the lower joints where water often hits it. This section demonstrates a building style that is typical of the work done by James Otis Follet on other bridges he built in Southern VT.

On the southern side, when viewed in the winter, it appeared possible that the foundation appears to be getting undercut by the stream to some degree and the foundation and springer stones appeared to have tilted inward. Based on the May inspection this is not the case. On the southern side there are in fact large slabs of stone which extend outward from from under the springers (bottom of stones of the arch). These large slabs form both a foundation for the bridge and also the bottom of the stream channel on that side. This effectively prevents the foundation from being undercut by erosion.

The north side appears reasonably unmoved and stable, A few stones have cracked but this does not appear to affect the stability.

Overall there does not appear to be much in the way of loose or missing stones or stones falling through the top of the arch.

The vast majority of mortar in the lower joints is gone so minor amounts of water can flow between the stones, however the gaps are narrow and it does not appear to be causing any damage. It appears the stones were well stacked and that there are additional rocks behind the front ones which have and will continue to prevent erosion.

At this time this section of the bridge appears sound, with the exception of the spandrel and wing walls (see below). The recommendation for this section to leave it undisturbed at this time and continue to monitor its condition.

2) The middle section.
This section appears to be an add on to increase the width of the bridge. It was built with stone and mortar or concrete. It was poorly constructed and relied on the mortar and concrete to "glue" it together.

Despite being relatively poorly constructed, the north side appears reasonably unmoved and stable, There are some cracks and missing mortar but this does not appear to affect the stability.

The south side of this section is near to collapsing, a large poorly placed stone at the bottom of the arch has been pushed forward out of the wall. It is precariously balanced on other stones and is holding up the arch above, Once this stone shifts a little further, it will likely lead to the collapse of this section of the arch. This collapse may happen a little at a time or all at once.

There are numerous other poorly placed stones on the south side that may lead to the section failing quickly once that one large stone shifts. Nearly all the mortar on this section has fallen out of the wall. It also appears that water is flowing through the upstream wing wall and washing back out through this section, further destabilizing it. It was observed that there were substantial gabs behind and above stones in this section.

The condition observed was did not change between the dates it was inspected in (Feb 7 and May 17). However it remains very unstable. Based on provided documentation the large poorly placed stone mentioned above was noted as being dislodged (to its current precarious state) in the summer flooding of 2023.

At this time it is recommended that south side of this section of the bridge needs to be rebuilt. It can be accessed by digging through the road bed. The north side can be temporarily supported while the south side it is rebuilt with mortared stone to match the historic structure.

3) The concrete section
This section appears to be a further addition to widen the road to its present width. It is a monolithic cast in place concrete arch. The concrete appears to be in good sound condition. Without knowing if or how much steel is in the concrete it is not possible to determine the strength of the arch, however it appears to be sound and quite sturdy.

The bottom of the concrete was poured just at the level of the stream bed. In places water is observed to be flowing underneath of the concrete particularly on the south side. However there are enough stones beneath the concrete to prevent any substantial erosion that could cause settling. It is possible that a stone foundation was built below the concrete, or that the streamed was naturally rocky enough to achieve the same result. While not ideal, the water flowing beneath the concrete does not appear to be causing destabilization to the concrete section. However it is possible that it could be having a negative affect on the other sections of the bridge, if water is finding its way behind the stones in the middle or lower section of the bridge.

It does appear clear that in high water events like the flood in the summer of 2023 water flows through the wing wall on the north side behind the concrete and then re-enters the stream channel from behind the large stone in the center section. This water has eroded out some cavity spaces, and caused the road surface to settle above it. This will likely continue in future flood conditions.

It would make sense to do a minor amount of hand work in the stream bed to add concrete to the gaps below the existing concrete down to any firm stones in the stream bed. This should ensure that future erosion is averted. Also the wing wall will need to be rebuilt and water will need to be prevented from flowing through it.

Headers and wing walls:

Much of the header walls and wing walls were buried in snow during the February inspection but were clearly visible in May.

On the upstream end the stonework on south side is in poor and deteriorating condition. Stones are loose and slipping from the wall, and gaps were observed. It should be rebuilt following correct procedures for dry stone retaining walls along with a method of preventing water from flowing through it. This could be a rubber membrane or a concrete wall or similar structure. Rebuilding this wing wall should be done soon.

The wing wall on the north side of upstream end is minor and almost a vegetated slope. It is the most stable of the 4 corners and repairs there could be put off.

On the downstream end both spandrels and wing walls are quite deteriorated. Erosion, pressure from the road infill, the installation of the guardrail posts, and some stones themselves weathering away seem to be the main culprits. This should be rebuilt following correct procedures for dry stone retaining walls soon.

Photos of the conditions observed are in Appendix B

RECOMMENDATIONS:

Monitor:

The most important thing to do at the moment is closely monitor the center section of the arch for further deterioration. Visually inspecting it after every storm and at least every two weeks. If there is further displacement of stones in the middle section of the bridge or if the large stone noted shifts further, it is recommended that the bridge be closed to traffic until it can be closely assessed and at a minimum temporary reinforcement can be added.

Repair and Restoration

There are a variety of ways to address the restoration of this bridge: Rough order of magnitude costs are provided in Appendix A.

For the stone sections of the bridge, repointing (re-mortaring the joints between stones) is an option that should be reserved for a major restoration where the top/outer side of the arch is uncovered such that it can also be repointed. Without that, repointing the underside will prevent water in the soil above from being able to drain out through the arch.

Repointing on the underside alone could trap water in the arch and lead to more damage. Trapping water behind the repointing will also result in the repointing failing rather quickly. As repointing at the recommended level would be a costly undertaking, likely similar to the cost of a full rebuild, it is not recommended to pursue it at this time.

1) Do repairs to the sections most in need:

This would entail specific targeted rebuilding of sections as they get near to collapse. At present this would be addressing the south wall of the center section, and also the spandrels and wing walls. It would make sense to also add concrete to the gaps observed under the concrete section.

Key Advantages:

- This would best preserve what is there now, in that only the sections near to collapse would be rebuilt.
- It would also have the lowest initial cost, and likely the lowest cost overall for many decades

Key Disadvantages:

- There is no way to determine an engineered strength to the bridge
- It is more likely to need repairs in the future as additional sections deteriorate. This could result in some rework of previously repaired sections
- Small bridge opening size means increased likelihood of damage from future flooding

2) Installing a bypass culvert:

By installing a large culvert to the north of the bridge it would relieve flood water pressure on the bridge. This would mean water would flow through the bridge at a reduced speed and would be less likely to further damage the bridge.

Key Advantages:

- Allows for the preservation of the existing bridge while reducing flooding concerns
- Less expensive than a full rebuild and expansion of the stone bridge

Key Disadvantages:

- Only recommended in addition to patch repairs as above. It will not repair current damage.
- Increases the complexity of the stream channel, and may require additional maintenance after major flooding to maintain both channels.
- Would require work to be done outside of the road right of way. Neighboring land owners would need to allow this.
- Creates additional infrastructure that will need repair or replacement at some point.

3) A complete rebuild and expansion of a stone arch bridge

This approach would entail completely dismantling the existing bridge and building a new stone arch bridge in its place. This includes increasing the span to the recommendations of the state. All three sections of the bridge would be removed and rebuilt as a larger single span stone arch bridge. For the greatest strength and lowest cost, the arch barrel would be built with granite and the local ledge stone from the existing bridge would be repurposed for the spandrels and wing walls. The road surface would likely need to be raised a bit to accommodate the larger arch.

Key Advantages:

- Less costly than the proposed concrete box culvert
- Preserves the history of a stone arch bridge in this location
- Reuses the existing stone
- Much better longevity than a concrete structure in this climate
- Can be built to a known engineered strength and design load
- Significant reduction in project CO2 emissions by avoiding the use of concrete

Key Disadvantages:

- Does not leave any part of the existing historic structure intact
- Higher cost than doing patch repairs

Conclusions:

Based on this initial assessment there does not seem to be any benefits to the standard modern engineered approach of using a concrete structure in this location. It is costly and does not preserve the history of the bridge in any way. The decision between the strategies outlined above can best be determined by the available funding, long term durability, and desired preservation goals. Standing Stone can provide additional consulting to assist with determination process as needed.

APPENDIX A:

Rough Order of Magnitude (ROM) Costs

The costs outlined below are based on numerous assumptions of the scope of work and conditions. These are provided as a guide for decision making on the direction to move forward with the bridge. The costs shown here are not bid prices. Once a direction to move forward has been identified a work proposal and bid price or time and materials proposal can be prepared and submitted.

Project Element	Notes	ROM Cost
Repair to the south side of the center portion of the bridge	Includes temporarily supporting areas to remain, digging through the roadbed, placing large footing stones and rebuilding the failing section using existing stone which will be supplemented with additional similar stone. Hydraulic Lime mortar will be used in the repaired section. The area dug will be refilled and compacted and the road bed replaced. Repaving is not included.	$20,000 to $35,000
Rebuild the wing walls	Rebuild all 4 wing walls using existing stone supplemented by additional similar stone. Address erosion and water infiltration issues. Existing guard rails will stay in place.	$25,000 to $35,000
Add concrete below the concrete section down to any secure rocks.	Typically this depth is only a few inches. It would require some minor hand work in the stream bed to divert the water from that edge of the stream bed while the work is being done.	$3000 to $5000

Project Element	Notes	ROM Cost
Install an additional 4ft diameter culvert	Includes the excavation, and installation of the culvert as well as digging a the inlet and outlet channels needed, building stone header walls for the culvert and rip-rap armoring for stream channels and steep slopes. Repaving is not included.	$50,000 to $65,000
	Total if all the work above is done	*$98,000 to $140,000*
	Total if section repairs are done without the additional bypass culvert.	$48,000 to $75,000
Complete rebuild of a new expanded stone arch bridge	As described above a complete rebuild of a new stone arch bridge to modern load capacities, and the needed size to accommodate flood waters. Guard rails and repaving are not included.	$220,000 to $260,000

Notes: Cost estimates above include all work associated with the project except for anything noted as not being included. Removing and preparing the road bed etc. is included in the estimates. These estimates are based on 2024 rates. It is recommended that an additional percentage be included for work that may not happen for a few years. Costs assume Hill Rd would be closed to traffic for the duration of the work, and the town would be responsible for putting up road construction signage.

APPENDIX B:

Photos of existing conditions:

Above and below: Middle section of bridge south side. Large stone precariously balanced and holding the bridge above.

North side of middle section. Shows poor building technique, but it appears to be relatively stable

North side, downstream portion, shows some cracked stone and mortar loss, but is generally in good condition.

Downstream end. Note the stones on the south side (left) at the bottom of the arch appear to be sloped downward, but are in fact well supported and secure. The spandrel and wing walls are in very poor condition and need rebuilding.

Upstream end. Concrete is stable but the stone wing walls are deteriorating, particularly the one to the south (right).