St. Thomas' Vestry
East Elevation and Bell Tower Repairs/Restoration - Summary
March 15, 2020/February 6, 2022 (updated)

The following historical summary was initially prepared in March of 2020 (pages 1 and 2) and has been updated for the subsequent evaluation of alternatives to repair the Bell Tower (pages 3 and 4).

East Elevation
In early 2017, it became apparent that a major structural problem had developed in the East Elevation (wall) of the Church Building:

- The exterior wall had bowed in several locations
- Mortar residue was actively leaching out by the crawl space window frames
- Water damage was apparent around the large stained-glass window and backrow pew

Due to the priceless and irreplaceable nature of the stained-glass window, which depicts the "Sermon on the Mount", we filed an insurance claim with Church Insurance. The Donan Engineering Company, Inc. conducted an engineer's inspection. The claim was denied as the deterioration was the result of time, the original design and building materials utilized, rather than a covered peril.

During this time, we also reached-out to the Diocese for guidance and counsel. The Diocese of Maine is the owner of all church properties in Maine, including St. Thomas'. The parish maintains and holds the properties in trust for the benefit of our members and the Diocese. The Diocese referred us to Building Envelope Specialists (BES), which had performed the engineering and project management for several restoration projects in the Diocese, including St. Luke's Cathedral in Portland.

In July 2017, BES provided a proposal to conduct an Exterior Envelope Assessment and Repair Documents of the East Elevation. The inspection took place in the Fall. The assessment report, including mortar analysis report and engineering drawings of the required repairs were delivered in January 2018. The report concluded an inappropriate mortar mix was utilized in construction, as well as subsequent repairs, resulting in excessive mortar deterioration and freeze/thaw damage. The Assessment and Repair Documents **total cost was $19,666.41.**

In March 2018, BES submitted its repair/restoration proposal. Joseph Gnazzo Company, Inc. was selected as masonry contractor. Gnazzo had been utilized on other Diocesan building projects and are considered experts in dealing with this type of stone and rubble construction. The project began in September and was completed shortly after Christmas. The project was completed on budget at a **cost of $404,144.00.**

Bell Tower
In the Spring of 2019, BES conducted an exterior envelope conditions visual inspection of the remaining masonry, as well as the slate roof, at a **cost of $8,485.60.** This report contained the following conclusions/recommendations and cost estimates, in order of priority:

- Bell Tower had significantly deteriorated, estimated cost to repair $680,000
- Slate roof had outlived its useful life, estimated cost to replace in slate $400,000
  (we discussed using other roofing materials at an estimated cost of ~$100,000)
- Nave, Entrance & Sacristy walls, window surrounds and woodwork $150,000
  (these repairs to be completed as permitted over time)

In June 2019, BES provided a proposal to conduct a Masonry Tower & Roof Assessment and provide Design Documents **at a total cost of $112,989.20.** The project costs were further delineated as follows:

- Pre-design phase (field measure & drawing prep of tower elevations) $5,718.15
- Assessment phase (scaffolding and masonry assistance) $47,625.00
- Assessment phase (BES) $8,613.00
- Assessment phase (insurance, mileage, tolls, supplies) $2,954.55
- Construction documents $46,170.00
- Project insurance and supplies $1,908.50

BES was questioned as to why the cost was so much higher than the ~$20,000 assessment and repair documents cost for the East Elevation. Their response was the cost of scaffolding versus using a hydraulic lift contributed nearly $50,000 in cost due to safety concerns for the Masons removing the stone block, as well as the architectural complexity and scale. After much discussion by the Building & Grounds Committee and the Vestry, it was determined to go forward with this phase.

In September 2019, BES completed the assessment and drawing phase. Their assessment indicated the extent of the deterioration was much greater than expected (essentially the upper third of the tower had to be completely dismantled and rebuilt) and proposed a budget of $1,307,405.79 to restore the Bell Tower utilizing original building materials. This cost was double the initial visual assessment estimate.

At this point, St. Thomas' requested BES conduct an engineering analysis of potential, less costly solutions. A budget not to exceed **$2,500.00** was established. The following is a summary of the potential restoration/repair options BES considered. The costs are based on BES acting as Construction Manager at Risk and providing a warranty:

- Restoration using original building materials $1,307,405.79
- Restoration using modern building materials $979,817.11
- Wood rebuild of upper third $842,994.16
- Upper third removed with lowered crenellation* $799,749.71
- Upper third removed with hipped wooden roof and gutter* $732,253.89
- Tower stabilization wrap from crenel to grade $76,753.35

(* in both of these options the bells would be removed and St. Thomas' would no longer have a functioning bell tower)

None of the permanent alternatives were considered acceptable. Therefore, a determination was made for a stabilization wrap be applied to the Bell Tower at **a cost of $57,272.20**. St. Thomas' is the at-risk party. The wrap has an estimated life of three-years, which should be sufficient for St. Thomas' to consider alternative restoration plans, designs, engineering firms and raise the necessary funding. The membership of St. Thomas' will be consulted, have the opportunity to provide input, as well as have their concerns and questions addressed before a final determination is made.

Throughout, the Building & Grounds Committee, Vestry, Wardens and Rector have provided leadership, been consulted, and approved each expenditure. In addition, tidings articles and several meetings were held to brief the membership on the status of the East Elevation and Bell Tower repairs.

Costs incurred through March 2020 for both the East Elevation and Bell Tower restorations have totaled $605,057.44.

January 30, 2022 (update)

Bell Tower Alternatives
Recognizing that none of the above options outlined by BES were acceptable, St. Thomas's retained local architect Chuck Campbell, assisted by the Cordjia Capital Projects Group (Camden based construction risk management, architecture and engineering firm) in developing alternative recommendations.

Utilizing the assessment and drawings completed by BES (the Bell Tower is currently wrapped and not available for physical inspection), Campbell and Cordjia provided the following class 4 estimates for reconstruction of the Bell Tower:

- Stone Tower Reconstruction (original building materials) $934,571
- New Stone Tower (stone veneer and CMU block) 722,221

Further investigation led the Building and Grounds Committee to determine the Bell Tower has been subject to periodic failure and has required significant maintenance over time.

A December 21, 1993, letter to Fellow Parishioners from the Finance & Stewardship Committee indicated ………*" The recently discovered disastrous leaks in the Lady Chapel roof and the direct threat it poses to our beloved new organ proves that we cannot give up a substantial reserve for repairs. Today we have been informed that there is substantial water damage to the bell tower which will result in considerable unforeseen expense. These repairs will have to be carried out immediately if we are to avoid major structural damage to both the tower and the organ." …….*

Thirty years later we find ourselves in a similar situation. As many are aware, the third-row keys of the organ are not in use due to water damage to the bellows. It is believed water seepage from the cricket between the Church roof and the Bell Tower south elevation was the cause.

This concern regarding periodic failure and maintenance costs led the Building and Grounds Committee and Vestry to seek an alternative. Recognizing these concerns, Campbell and Cordjia presented a third alternative class 4 estimate for St. Thomas' consideration:

- Tower Removal with New Hip Roof (over the Lady Chapel) $483,704

This alternative retains at least one bell for liturgical purposes. The disposition or relocation elsewhere on Church property of the remaining bell carillon will be considered if this alternative option is pursued.

As noted by BES the slate Church roof has outlived its useful life and in need of replacement. Campbell and Cordjia provided the following four options for consideration:

- Asphalt Shingle Roof (20-year useful life) $135,836
- Standing Seam Metal Roof (50-year useful life) 202,777
- Faux Slate/Composite Roof (50-year useful life) 226,426
- Slate Roof (100-year useful life) 272,461

Bell Tower & Church Roof Recommendation

The Building & Grounds Committee and Vestry are proposing the following course of action for the remediation of the Bell Tower and Slate Roof:

• **Tower Removal with New Hip Roof (over the Lady Chapel)**	**$483,704**
• **Asphalt Shingle Roof (20-year useful life)**	**$135,836**
Total estimate cost, approximately	**$620,000**

<u>Tower Removal with New Hip Roof</u>

Recommendation is based on the following:

- The history of architectural and maintenance challenges with the existing bell tower
- The propensity for freeze-thaw damage to the existing bell tower stonework
- The lower ongoing maintenance cost, as a result of improved rainwater and snow shedding provided by a pitched roof, as well as reduced exposed stonework
- It is the most fiscally responsible choice, given the limited resources of St. Thomas'

<u>Asphalt Shingle Roof</u>

Recommendation is based on the following:

- Advancements in solar panel design and architectural aesthetic are likely to continue at an accelerating pace
- The southern roof exposure represents a substantial surface to generate solar energy
- Using the lowest cost alternative, best positions St. Thomas' to take advantage of clean energy alternatives, as the costs and aesthetics become optimal

<u>Next Steps</u>

- Parish considers alternatives and recommendation at a February 2022 meeting(s) and approves final selection
- Final architectural and engineering drawings completed
- Contractor and sub-contractor bids attained
- Building permits filed with Town of Camden and State (registered historic building/landmark)
- Capital campaign to raise necessary funding
- Disposition or relocation of bell carillon, if appropriate
- Building permits attained
- Execution of construction contracts
- Construction targeted for Spring/Summer 2023

Please see the attached exhibits for additional detailed information.

Index

East Elevation

Bell Tower

Bell Tower & Roof (Campbell & Cordjia)

CHURCH INSURANCE
COMPANY OF VERMONT

PO Box 5000
210 South St
Bennington VT 05201
800-223-5705 - Claims
802-753-1383 - Fax
sgulley@cpg.org

June 5, 2017

St Thomas Episcopal Church
Mr. Carlos Mello
PO Box 631
Camden, ME 04843-0631

Re: Claim #: 35080
Policy Number: VPP0012636
Date of Loss: 05/07/2017
Policy Effective Dates: 12/31/2016-12/31/2017

Dear Carlos,

This will acknowledge receipt of this claim. On May 10, 2017 we received notice of a claim for water damage to an exterior wall of the church and some interior water damage at the church located at 33 Chestnut St, Camden, ME. Mr. Joseph Malo, P.E. with Donan was assigned to this loss to determine causation of the exterior leaking. Mr. Malo conducted a site study on May 18, 2017 and his summary of conclusions is the cracked, missing, and deteriorated mortar is the result of age-related deterioration and improper maintenance (improper tuck-point). Water penetrates the cracks and gaps in the mortar joints as observed on the east elevation and the east and west elevations of the altar. During the winter, water trapped inside cracked mortar freezes, causing heaving and displacement of the mortar. The open cracks, gaps, and spalling are caused by water penetrating the exterior wall as a result of age-related deterioration of construction materials, deferred maintenance, and improper maintenance (improper tuck-point). The spalled stone around the windows are the result of age-related deterioration of construction materials and deferred maintenance. The spalling of the stone and cracking of the mortar joints are a long-term and ongoing maintenance issue and are not the result of any single weather event. The characteristics of the mortar are consistent with that of lime-putty mortar. The mortar repairs are Portland cement. The tuck-pointing lime mortar with Portland cement mortar is a contributing cause to the cracking and spalling of the surface mortar.

Policy number VPP0012636 with the effective dates 12/31/16-12/31/17 affords property insurance coverage against risks of direct physical loss to building(s) and contents covered, except as hereinafter or otherwise excluded. We refer you to the Policy form CP -85, Ed 1.0

CHURCH INSURANCE
COMPANY OF VERMONT

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Bennington VT 05201
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PERILS EXCLUDED

1. **We** do not pay for loss if one or more of the following exclusions apply to the loss, regardless of other causes or events that contribute to or aggravate the loss, whether such causes or events act to produce the loss before, at the same time as, or after the excluded causes or events.

2. **We** do not pay for loss if one or more of the following exclusions apply to the loss:

c. **Contamination or Deterioration -- We** do not cover loss caused by contamination or deterioration including corrosion, decay, fungus, mildew, mold, rot, rust or any quality, fault, or weakness in property that causes it to damage or destroy itself. **We** cover any resulting loss caused by a **specified peril** or breakage of building glass

e. **Defects, Errors, and Omissions -- We** do not cover loss which results from one or more of the following;

1) an act, error, or omission (negligent or not) relating to:

a) land use;

b) the design, specification, construction, workmanship, installation, or maintenance of property;

c) planning, zoning, development, siting, surveying, grading, or compaction; or

d) maintenance of property (including land, structures, or improvements); whether on or off the described premises

s. **Wear and Tear -- We** do not cover loss caused by wear and tear, marring, or scratching. **We** cover any resulting loss caused by a **specified peril** or breakage of building glass.

Since the damages are expressly excluded by the policy, The Church Insurance Company of Vermont hereby disclaims coverage of this claim.

Church Insurance Company of Vermont bases its coverage analysis and disclaimer upon the information it currently knows. If any of the factual information relied upon by us in this letter is inaccurate in any way, please advise us immediately in writing.

CHURCH INSURANCE
COMPANY OF VERMONT

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This letter and the company's actions to date in the investigation of this matter do not constitute a waiver of any policy provisions or defenses available to the company. We reserve the right to amend, alter or supplement this letter should information become known in the future that would affect the contents of this letter.

Sincerely yours,

Sylvia Gulley
Associate Property Claims Examiner

DONAN®

PREPARED FOR:

MS. SYLVIA WOODSIDE
CHURCH INSURANCE COMPANY OF VERMONT
P.O. BOX 5000
BENNINGTON, VERMONT 05201

ST. THOMAS EPISCOPAL CHURCH
33 CHESTNUT STREET
CAMDEN, MAINE 04843
CLAIM NUMBER: 35080
DONAN PROJECT NUMBER: 52-17050083-0

PREPARED BY:

DONAN ENGINEERING CO., INC.
12450 LAKE STATION PLACE
LOUISVILLE, KENTUCKY 40299
800-482-5611

MAY 23, 2017

JOSEPH W. MALO, P.E.
FORENSIC ENGINEER
MAINE P.E.: 13953
EXPIRES: DECEMBER 31, 2017

John G. Donan, Jr., P.E.
Chairman of the Board

J. Lyle Donan, P.E.
President, CEO

DONAN
TO BE SURE.

CORRESPOND TO:
Donan Engineering Co., Inc.
12450 Lake Station Place
Louisville, Kentucky 40299
800-482-5611
502-267-6976 fax

May 23, 2017

Ms. Sylvia Woodside
Church Insurance Company of Vermont
P.O. Box 5000
Bennington, Vermont 05201

RE: **St. Thomas Episcopal Church**
33 Chestnut Street
Camden, Maine 04843
Claim Number: 35080
Donan Project Number: 52-17050083-0

Dear Ms. Woodside:

At your request, on May 18, 2017, a study was made on the church at the above-referenced address. The purpose of the study was to determine the origin and cause of the exterior and interior leaks. Mr. Chris Glass, a representative of the church, was present to point out areas of concern and to provide firsthand information. This letter, with the enclosed photographs, is the report of my findings and conclusions.

Description of Property

For purposes of this report, the church is considered to face east toward Chestnut Street (Photographs 1 and 2). The church is a single-story stone structure. The roof is covered with slate. According to Mr. Glass, the church building was built in 1891, and the church has owned it since.

Background

Mr. Glass stated between 2015 and 2016, the plants and vegetation along the front of the church were removed. He stated once the vegetation was removed, they noticed the stone below the window was bowing outward and crushed/disintegrated concrete was on the ground below the crawlspace windows. Mr. Glass reported in 2011 the church was repointed and, during the fall of 2016, roof repairs were made. He pointed out water stains to the interior of the church along the east wall and below the bell tower. Mr. Glass said the water stains and deterioration have not gotten worse since the repairs have been made to the roof. Mr. Glass pointed out areas along the north elevation that are being repaired by a mason. No access was provided to the bell tower. Mr. Glass provided photographs of the bell towner. Mr. Glass stated the bell tower roof and floor drain are in the wall between the church's north wall and the altar's east wall, a location of water stains.

Observations

The walls of the church consist of stone and mortar masonry construction. The mortar is cracked throughout the church elevations (Photographs 3 and 4). The mortar is both light and gray in color (Photograph 5). Ivy is along the bottom portion of the east elevation. Piles of deteriorated and washed-out mortar and stone are below the bottom windows on the east elevation (Photograph 6). The stone surrounding the crawlspace window and the stained glass on the east elevation is cracked, broken, or deteriorated (Photograph 7). Paint is peeling and missing on the wood trim around the stained glass window on the east elevation. The wood trim along the top of the stained glass window on the east elevation is cracked and deteriorated (Photograph 8). A gap and deteriorated wood is around the crawlspace windows on the east elevation (Photograph 9). Deteriorated concrete is loose in the gap between the crawlspace windows and stone lintel. The stone approximately 3 feet below the stained glass window on the east elevation is bowing outward (Photograph 10). The stone surrounding the stained glass window on the east elevation is cracked and deteriorated (Photograph 11).

The stone mortar on the east and west elevations of the altar are cracked and deteriorated. The roof step-flashing on the sides of the altar are loose and a gap is between the flashing and the north elevation (Photograph 12). Sections of the concrete on the north elevation are removed and being replaced, as indicated by Mr. Glass (Photograph 13). White stains are on the stones on the east elevation below the bell tower (Photograph 14). Thick ivy covers the top of the bell tower. Water is leaching out of the stone on the east elevation of the bell tower (Photograph 15). The stones around the bell tower's east elevation window are cracked, displaced, and deteriorated (Photograph 16). The wood trim on the west elevation of the altar is rotted, and a gap is between the wood and the stone (Photograph 17).

Stains, a white substance, and cracks are in the church below the east wall stained glass window, the north wall below the bell tower, and the southwest corner of the altar (Photographs 18 through 22). The floor and roof drains from the bell tower are within the wall and have no access. The photographs of the bell towner provided by Mr. Glass have wear and tear, deterioration, and water stains to the bell tower ceiling, wall, and floor.

Key Concepts

Lime-Putty Mortar

Portland-cement mortar became popular in the United States in about 1900. It is a hard mortar, with good compressive strength and very little tensile strength. That means that it will make a very strong bearing wall but has virtually no flexibility. A portland-cement-mortared masonry wall will crack and separate if the wall settles.

Lime-putty mortar has been used for thousands of years. Its advantage is its flexibility. It can bend without cracking, and when it is overstressed and cracks, it has a tendency to heal itself. However, it has a much lower compressive strength, and the lime-based cement eventually dissolves and leaches out of the mortar.[1] Prior to the advent of portland-cement mortar, masons recommended tuck pointing (replacement of the exterior inch or so of mortar) every 50 years. This recommendation took into account that the exterior thickness of the mortar would weather away, and the lime cement would dissolve.

Masonry-restoration contractors familiar with lime-putty mortar strongly recommend that portland-cement mortar not be used to tuck point a building with original lime-based mortar. The thin layer of mortar applied during tuck-pointing gives virtually no strength to the joints in the wall. As the interior lime mortar flexes, the stiff portland-cement mortar on the edges of the joint cracks and eventually falls off the wall. These voids leave the interior of the lime-mortared walls exposed to the weather, and the mortar deteriorates deep into the wall.

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[1] Compressive strength: The ability of a material to resist forces that attempt to squeeze or compress the material together.

Freeze Damage to Masonry

In general, concrete masonry, brick, sandstone, and mortar products, unless they have a glazed surface, are somewhat porous. Water from rain, snow, and splatter hits the face of the masonry and is absorbed. This water is concentrated along the exposed face of the masonry. When outdoor temperatures drop below 32 Fahrenheit (° F), the water at the face of the masonry freezes. Freezing water expands with a force sufficient to break the bond between the face and body of the masonry. The spalling layers of masonry can be as thin as $^{1}/_{16}$ inch. Water expanding within fissures in sandstone can cause the spalling of pieces greater than 1 inch in thickness.

With the face broken, more water can enter the masonry. Eventually, the face of the masonry will spall off, leaving the body of the masonry exposed. Thus, the process repeats itself and is accelerated.

The ability of a masonry wall to withstand deterioration is a function of the interaction of the original design, the quality in construction, and the prompt and proper attention to water-entry problems. The natural tendency of the porous surface to absorb water is not, in itself, necessarily something to worry about. Normally, during a rainstorm, the masonry will absorb water, but very rarely will it penetrate through the masonry units themselves.

If a water-resistant or "waterproof" coating is used on masonry, moisture may enter through cracks and become trapped behind the coating. Water in the masonry pores that is unable to escape through the coating can freeze within the wall, causing pieces of masonry to fall off the surface. Even if moisture can escape through a "breathable" coating by evaporation, the salts acquired by the passage of the water through the construction materials (such as concrete or mortar) will crystallize just below the outer surface of the masonry. This condition, if left untreated, allows the salts to build up and facilitate exfoliation or spalling.

Not only is spalled material extremely hazardous to anyone underneath it when it falls, but it can also contribute to spiraling deterioration. In brick masonry, for example, because of the way it is made, the surface is harder and less porous than the interior. When this protective surface is removed by spalling, the soft, porous interior is exposed. Since it is more porous than the outer surface, more water can be absorbed and trapped in the wall. This water can freeze, causing further spalling and greater damage. A frequently overlooked issue in the prevention of spalling is that of routine maintenance, particularly repointing any loose masonry joints or other areas where water can penetrate the masonry structure. Inspection and repair of deteriorated mortar joints, brick and sandstone should be performed as part of an annual property maintenance program. Inspection and repair of stone, brick, or concrete masonry above head-height is of particular importance to minimize the potential of falling masonry causing injury or damage to people and property below.

Efflorescence

Water migrating through cement-based materials such as concrete, bricks, mortar, or similar porous substances dissolves soluble salts and other water-dispersible compounds. In cement-based products, the soluble salts are most commonly calcium carbonate, along with hydroxides and sulfates of sodium or potassium. When the moisture reaches the face of the material and evaporates, the salts are left on the surface. Over time, the buildup of salts creates a white discoloration known as efflorescence.

Conclusions

The cracked, missing, and deteriorated mortar is the result of age-related deterioration and improper maintenance (improper tuck-point). Water penetrates the cracks and gaps in the mortar joints as observed on the east elevation and the east and west elevations of the altar. During the winter, water trapped inside cracked mortar freezes, causing heaving and displacement of the mortar. The open cracks, gaps, and spalling are caused by water penetrating the exterior wall as a result of age-related deterioration of construction materials, deferred maintenance, and improper maintenance (improper tuck-point). The spalled stone around the windows are the result of age-related deterioration of construction materials and deferred maintenance. The spalling of the stone and cracking of the mortar joints are a long-term and ongoing maintenance issue and are not the result of any single weather event. The characteristics of the mortar is consistent with that of lime-putty mortar. The mortar repairs are Portland cement. The tuck-pointing lime mortar with Portland cement mortar is a contributing cause to the cracking and spalling of the surface mortar. Tuck-pointing over lime putty mortar with a more brittle Portland Cement (PC) mortar, you create a brittle outer shell of mortar (PC mortar). The interior and main support of the stone structure are provided by lime putty mortar (which is soft and flexible and allows movement of the stone). The lime putty mortar still allows for flexibility and movement of the stones, which causes cracks in the hard and brittle outer shell mortar (tuck-pointed

PC mortar). These cracks allow moisture to penetrate through essentially "washing out" interior lime putty mortar, causing trapped moisture to result in freeze thaw and deterioration. Lime mortar should be repaired and tuck-pointed with lime mortar.

The cracked and broken window lintels and sills are a result of long-term water exposure and deferred maintenance. The lintel stones and sills are a porous stone, and long-term water exposure causes the stone to deteriorate. The peeling paint and rotted wood trim are the result of age-related deterioration, weathering, and deferred maintenance. The bulging stone at the bottom of the stained glass window on the east elevation is a result of long-term deterioration, deferred maintenance, and improper maintenance (improper tuck-point) of the stone mortar and lintels which is causing the stone to fail. The mortar behind the stone elevation holds the stones in place and is deteriorated. The bowing of the east elevation below the stained glass window and the deteriorated mortar is a structural concern and should be addressed to prevent the potential of collapse of the wall. The pile of deteriorated and washed out stone and mortar below the windows on the east elevation is the result of age-related deterioration, improper maintenance (improper tuck-point), and deterioration of construction materials.

The water intrusion, efflorescence, and cracks in the church's east and north walls, and the west altar wall are the result of precipitation entering into the cracks and gaps in the mortar, cracked and spalled stones, and rotted wood trim in the church elevations. The presence of historical repairs throughout the interior of the church and the degree of deterioration of the wood trim indicates that water intrusion is an historical and ongoing issue and not the result of any single weather event.

Summary of Conclusions

In summary, based on what is known at this time, I am of the opinion that:

- The open cracks, gaps, and spalling are caused by water penetrating the exterior wall as a result of age-related deterioration of construction materials, deferred maintenance, and improper maintenance (improper tuck-point).

- The spalled stone around the windows are the result of age-related deterioration of construction materials and deferred maintenance.

- The spalling of the stone and cracking of the mortar joints are a long-term and ongoing maintenance issue and are not the result of any single weather event.

- Lime mortar should be repaired and tuck-pointed with lime mortar.

- The cracked and broken window lintels and sills are a result of long-term water exposure and deferred maintenance.

- The peeling paint and rotted wood trim are the result of age-related deterioration, weathering, and deferred maintenance.

- The bulging stone at the bottom of the stained glass window on the east elevation is a result of long-term deterioration, deferred maintenance, and improper maintenance (improper tuck-point) of the stone mortar and lintels which is causing the stone to fail.

- The pile of deteriorated and washed out stone and mortar below the windows on the east elevation is the result of age-related deterioration, improper maintenance (improper tuck-point) and deterioration of construction materials.

- The bowing of the east elevation below the stained glass window and the deteriorated mortar is a structural and safety concern and should be addressed to prevent the potential of collapse of the wall.

This report is based on relevant information known to Donan at the time the report is issued. Donan reserves the right to amend or supplement this report if additional relevant information becomes available.

Church Insurance Company of Vermont
Claim Number: 35080
May 23, 2017
Page 8

We appreciate your confidence in our professional services.

Sincerely,

DONAN ENGINEERING CO., INC.

Joseph W. Malo, P.E.
Forensic Engineer
Maine P.E.: 13953
Expires: December 31, 2017

Photograph 1: The front of the church faces east toward Chestnut Street.

Photograph 2: The north (side) elevation of the church, the altar is north of the bell tower.

Photograph 3: The mortar is cracked throughout the church elevations.

Photograph 4: The mortar is cracked throughout the church elevations.

Photograph 5: The mortar is both light and gray in color.

Photograph 6: Piles of deteriorated and washed-out mortar and stone are below the bottom windows on the east elevation.

Photograph 7: The stone surrounding the crawlspace window on the east elevation is deteriorated and missing.

Photograph 8: The wood trim along the top of the stained glass window on the east elevation is cracked and deteriorated.

Photograph 9: A gap and deteriorated wood is around the crawlspace windows on the east elevation.

Photograph 10: The stone approximately 3 feet below the stained glass window on the east elevation is bowing outward.

Photograph 11: The stone surrounding the stained glass window on the east elevation is cracked and deteriorated.

Photograph 12: The roof step-flashing on the sides of the altar are loose and a gap is between the flashing and the north elevation of the church.

Photograph 13: Sections of the concrete on the north elevation is removed and being replaced.

Photograph 14: White stains are on the stones on the east elevation below the bell tower.

Photograph 15: Water is leaching out of the stone on the east elevation of the bell tower.

Photograph 16: The stones around the bell tower's east elevation window are cracked, displaced, and deteriorated.

Photograph 17: The wood trim on the west elevation of the altar is rotted and a gap is between the wood and the stone.

Photograph 18: White substance and stains on the east wall of the church around the stained glass window.

Photograph 19: White substance and stains on the east wall of the church around the stained glass window.

Photograph 20: White substance and stains on the north wall of the church.

Photograph 21: White substance and stains on the west wall of the altar.

Photograph 22: White substance and stains on the altar's east wall, the reported bell tower's floor drain is within this wall.

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
- Roofing Options
- AACE International Recommended Practice No. 18R-97 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS

July. 13, 2017

St. Thomas Episcopal Church
33 Chestnut St.
Camden, Maine 04843

Re: Exterior Envelope Assessment and Repair Documents.

Dear Carlos,
Thank you for the opportunity for Building Envelope Specialists, Inc. (BES) to submit a proposal for envelope consulting services on St. Thomas Episcopal Church in Camden, Maine.

As requested, BES is submitting a proposal for envelope consulting services in the form of an exterior envelope conditions assessment and a prioritized set of repair documents and specifications. The first phase of the project is a visual assessment of the condition of the east elevation exterior masonry façade that may be observed with the naked eye. From the information gathered during Phase 1, BES's design department will assemble a set of repair documents and specifications that will reflect the scope defined during the limited envelope assessment. Building elements addressed in our repair document package will include the masonry façade, flashings, wood trim and protective lenses over existing stain glass window units.

The project team is defined as:

- Scott R. Whitaker: Senior Envelope Consultant.
- Ray Hamlin: Envelope Tec.

The following proposal is broken down into the time and dollar value associated with an activity under a defined project phase. Miscellaneous project costs are included and defined within. Items highlighted in red are considered allowances and will be invoiced as net plus 10%. Please refer to the *Exclusions* section for items that are not included within this proposal. Building Envelope Specialist's fee for the outlined services is:

Assessment Phase

- 1 Day Building Assessment: BES Project Team. (Includes Travel Time) $3,190.00

Expenses Associated with Assessment Phase

- Mileage & Tolls: $92.65
- Project Supplies: $50.00
- Project Insurance Fee: $144.00
- Mortar Composition Test: $1,500.00
- 85' Lift Allowance: $1,200.00

Total Assessment Phase Fee: $6,176.65

Design Phase

- Design documents and specifications for East Wall only: Project Team. $12,000.00

Expenses Associated with Design Phase

- Project Supplies: $100.00
- Project Insurance Fee: $511.00

Total Design Phase Fee: $12,611.00

BES proposes a professional services fee of **$18,787.65** for the above scope of services based upon the hours allotted. This project will be scheduled after the return of the accepted proposal. Any services added to the outlined scope will be considered a change order to the contract and will be invoiced per an agreed upon sum.

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Exclusions:
- Consulting on the structural elements of the building.
- Testing for hazardous materials on building envelope.
- Assessment or upgrades to life safety systems.
- Subsurface investigations and design documents associated with the building's foundation.
- No interior repair documents included.
- No window restoration documents included.
- Bidding consulting services.
- Value Engineering.
- Construction administration services.
- Hazardous materials coordination during construction.
- Permits.

Invoicing Procedure Terms & Conditions:
BES will invoice on a monthly basis for our services based on the completion percentage of each task. These financial arrangements allow Net 30 for all invoices assuming orderly and continuous progress of the project through to completion. Unpaid invoices over Net 30 shall accrue interest at the rate of 1.5% per month plus any costs of collections for the unpaid balance.

Authorization:
This Proposal with Terms and Conditions constitute the entire AGREEMENT between you 'The Client' and Building Envelope Specialists, Inc. This Proposal will be open for acceptance for 30 days from the date of this proposal, unless extended by Building Envelope Specialists, Inc. in writing.

We look forward to the opportunity to provide professional consulting services to you on this important project. If this proposal satisfactorily sets forth your understanding of our agreement, please sign and return a copy of this letter to us.

If you have any questions, please call my office at 207-400-0086.

Regards,
Scott R. Whitaker
Scott R. Whitaker-President
Building Envelope Specialists, Inc.

Acceptance: ____ **Date:** ________________

All information contained in this proposal including attachment(s) is confidential information and is intended only for the exclusive use by 'The Client' mentioned above. Any disclosure, copying, distribution or use of the information contained herein is strictly prohibited and may be unlawful and constitute a breach in confidentiality laws without the permission of Building Envelope Specialists.

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
- Roofing Options
- AACE International Recommended Practice No. 18R-97 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS

July. 13, 2017

St. Thomas Episcopal Church
33 Chestnut St.
Camden, Maine 04843

Re: Summary of Condition of Exterior Masonry on East Elevation Gable End.

Dear Lisa,
As requested, the following is a summary of findings of the condition of the masonry on the east gable end of the St. Thomas Chapel located at 33 Chestnut St. in Camden, Maine.

The masonry assessment took place on September 29, 2017. Our visual assessment of the elevation took place from the ground and with the aid of a 120' aerial lift to reach the upper wall sections. The weather was sunny with temperatures in the high 70's.

Summary of observations:

- The masonry assembly is made up of 24" of Quincy Granite wall stones with limestone highlights at the window surrounds, buttress caps and wall caps stones.
- Original mortar appears to be natural cement which is a naturally hydraulic cement quarried in America from 1880 to around 1930. Historically, this cement is susceptible to deterioration from acid rain and the interaction with the salts in Portland Cement. Excessive fractures, cracks and deterioration of original setting mortar was observed. A mortar test of the original mortar has been ordered to determine its composition.
- Repair mortar appears to be Portland Cement based. Excessive fractures, cracks and deterioration of existing repair mortar was observed. The non-porous nature of Portland cement based mortars is not allowing moisture with in the wall to weep out through the joints, thus trapping the water with in the wall cavity. This is creating freeze/thaw damage to the masonry as well as causing additional deterioration to the original mortar.

  RECOMMENDATION: All Portland Cement based mortar MUST be removed from the masonry and repointed with the original mortar.
- Large separations between the wythes of the wall's stone veneer were observed. They present as bulges in the face-plane of the exterior wall surface. These bulges are located around the upper and mid-section section of the tracery window unit as well as directly under the tracery's window sill. The separation between the exterior veneer and the next masonry wythe measured 5". The gap between the stones is void of any masonry material. At the time of the investigation, the upper bulges appear to be stable, but the bulge under the window sill was not. Exterior stone were easily removed. Wall damage below the window appears not to be limited to the exterior wythe, but has indeed moved deeper into the wall assembly. This is evidenced by the cracks on the interior face of the plaster wall within the chapel's Nave.

  RECOMMENDATION: As part of the repair of this elevation, masonry at the bulges need to be disassembled and rebuilt with the original mortar.
- The masonry buttresses are in poor condition due to excessive mortar deterioration. This damage goes deep into the buttresses core and will force the features to be rebuilt in their entirety.

  RECOMMENDATION: As part of the repair of this elevation, damaged buttresses need to be disassembled and rebuilt with the original mortar.

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- The masonry walls directly adjacent to the buttresses are damaged at varying degrees as well.

  RECOMMENDATION: As part of the repair of this elevation, damaged wall sections need to be disassembled and rebuilt with the original mortar.
- There were many surface spalls and chips were observed on the existing limestone features. These were primarily caused by pointing mortar that exceeds the tensile strength of the adjacent limestone. This is a common problem with many buildings and is easily remedied.

  RECOMMENDATION: As part of the repair of this elevation, damaged should be patched and a correct joint treatment be installed.

As outlined within the bulleted items, the existing masonry assembly on the east elevation of the chapel is in poor condition. It needs extensive repairs to reestablish the wall's structural capacities, weather tightness as well as visual appearance. Repairs will include rebuilding sections of the masonry wall bulges exist, rebuilding stone buttresses and any adjacent damaged wall assemblies, removing all existing Portland Cement based mortar and replacing it with new to match original, and repairing damage to all limestone features.

In today's masonry market, this work can be completed over the winter months in Maine. An enclosed staging structure wrapped with insulated blankets will create an environment conducive for a good quality masonry restoration. However, the masonry contractor chosen MUST have extensive knowledge in resetting masonry with natural cement as well as experience in winter masonry. BES can assist you in that selection.

Historical costs of projects of a similar nature have run from $350,000 to $750,000 depending on interior impact. Once the drawings are complete, BES will provide projects budgets to you for planning and funding activates.

This assessment was based on limited visual observations of readily-accessible portions of the building exterior. Our findings and recommendations are based on observations of these representative conditions at the referenced facility at the time of our assessment. Other conditions may exist, or develop over time, which were not found during our investigation. BES reserves the right to modify our findings should additional information become available. Our recommendations and/or opinions are presented for consideration by the trustees and do not represent a design or specification for repairs.

If you have any questions, please call my office at 207-400-0086.

Regards,

Scott R. Whitaker

Scott R. Whitaker-President
Building Envelope Specialists, Inc.

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
- Roofing Options
- AACE International Recommended Practice No. 18R-97 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
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Building Envelope Specialists
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January 10, 2018

St. Thomas Episcopal Church
33 Chestnut St.
Camden, Maine 04843

Re: Summary of Mortar Analyses.

Dear Lisa,
As requested, the following is a summary of findings for the mortar analyses of St. Thomas Chapel located at 33 Chestnut St. in Camden, Maine.

Sample Information:
During the inspection of the East Elevation Gable End of the chapel, BES' field team collected 3 large samples of the **ORIGINAL** mortar from the rubble core of the wall, behind the face stones, just below the large window unit. This is an area with large bulging in the masonry assembly. The samples collected were bagged and labeled for shipment to Highbridge Materials Consulting, Inc. However, only one sample bag was shipped to Highbridge.

To determine the physical characteristics of the mortar samples and understand their aging process, the sample underwent petrographic and chemical analysis to identify constituents, estimate component proportions, and evaluate overall condition. An acid digestion to extract a sand sample for description and gradation is also included, and the extracted sand sample is returned to BES for record purpose.

Summary of Findings:
The examined sample contains gray portland cement, a minor lime gauging, and a high content of broadly graded sand. The binder is estimated to be cement-rich with roughly one-tenth part of lime added to enhance plasticity. These binder proportions are quite typical for mixes employed in the early twentieth century.

The mortar has a high sand content with a binder to aggregate ratio estimated around 1: 4 by volume. This creates a very porous mixture which will allow moisture to absorb into the mortar because of high permeability. During seasonal temperature changes, static moisture within the mortar may freeze, thus causing damage to the mortar.

In its current condition, the mortar has a uniform appearance with a light gray color. It is compact and well consolidated with an original air-void content estimated at 3%-5% by volume. Despite the cement-rich composition, the cured product has a moderately soft paste with a high permeability.

The binder paste has been leached and undergone a bicarbonation reaction. There is also a moderate abundance of cracking as well as carbonate lining the cracks and filling air-voids. The crack characteristics and secondary mineralizations are consistent with freeze-thaw distress of the hardened mortar.

Discussion of Findings:
First, we must recognize that originally at the time of construction, the same mortar recipe was used for the both the setting mortar and pointing mortar. This was typical of heavy stone masonry construction in Maine during the 1800's and early 1900's. Considering this is the case, the high permeability of the original mortar mixture would allow moisture to absorb into the mortar joints during normal rain. The condition is worsened during wind driven rain events, which are typical along the Maine coast. Once moisture has absorbed into the mortar, it remains static until the evaporation cycle begins. The start of this cycle will vary depending on outside temperatures. If additional moisture saturates the masonry assembly, the existing moisture head is pushed deeper into the assembly.

Once moisture is present within the masonry assembly, it becomes the catalyst for masonry wall deterioration. The cause for this deterioration falls under one or more of the following categories: salt crystallization, acidic rain, and frost action.

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Salt Crystallization:
The following list is common types and sources for salt that cause deterioration in lime materials within mortar.

- Sodium Sulphate: soil, some clay-fired bricks by action of polluted air on sodium carbonate, and processed solid fuels.
- Sodium Carbonate: masonry cleaners, and fresh cement-based mortars.
- Magnesium Sulphate: some clay-fired bricks polluted by rain-wash from dolomitic limestone.
- Potassium Carbonate: fresh cement based mortars, fuel ash, and ash mortars.
- Potassium Sulphate: some clay-fired bricks by action of polluted air on potassium carbonate.
- Sodium Chloride: deicing salts, and soil.
- Calcium Sulphate: gypsum base wall plasters.

A solution of salt or a mixture of salts in rainwater can transfer through the natural pours of the stone or mortar. Under dry conditions, the water evaporates, and the salts are deposited on the surface of the masonry, within its pours, or both. A salty growth (*florescence*) appearing on the surface is called *efflorescence*. Crystallization that occurs within the pores of the masonry is called *sub-florescence.* It is very common to have both forms occur together.

Efflorescence is unsightly but harmless to the masonry. However, sub-florescence causes some pressure to be exerted on the walls of the pores and cavities within the masonry. This pressure will cause damage to the host and adjacent material; reducing it strength and creating additional openings to trap future moisture. The repeated cycles of direct wetting (moisture infiltration) and drying leads to a re-dissolving and re-crystallization of the salts continually. This deterioration cycle will repeat itself until this process is stopped.

Additionally, this cycle may be aggravated by another source of moisture. This source is humidity. *Hydroscopic* salts occur when the relative humidity falls low enough for moisture to form. The re-crystallization cycle is repeated as outlined above. This cycle is difficult to stop.

A third way re-crystallization occurs is through temperature changes. As the temperature rises within the wall, re-crystallization slows. Conversely, as the temperature drops, salts crystal growth increases due to the relationship between temperature, type of salts, and optimum growth conditions. This cycle is difficult to stop but and be reduced by installing insulation and vapor barriers.

Acid Rain: (Common of the East Coast)
Another cause for masonry deterioration is its exposure to acid rain. The sources for the acid within rainfall occurs naturally and as we know from air pollution, but the effects are the same, the growth of gypsum crystals. The explanation below is simplified but effectively explains this type of deterioration.

The “acid” component of Acid Rain is Sulphurous acid and when combined with oxygen creates sulphuric acid. When sulphuric acid comes into contact the lime (calcium carbonate) in mortar the end result is a chemical compound called Calcium Sulphite ($CaSO3$). This new compound replaces the calcium carbonate in the mortar thus reducing the mortar’s strength and bonding capacities. When this compound combines with oxygen, gypsum crystals form and grow much like the sodium crystals do. However, unlike sodium crystals (which singularly exert damaging pressure) Gypsum crystals expand up to 200% of their original size (creating adjacent voids in the mortar,) then dissolve with the contact of additional acid rain. This elimination of the gypsum makes the mortar weaker, less resistant to loading, reduces is bonding capacity to adjacent masonry, and leaves behind additional voids to trap moisture.

Drying out the existing masonry system and buttoning up the exterior façade against moisture infiltration can slow this condition.

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Frost Action: (Common in the Upper Tier States)
Frost attack differs from damage caused by salt crystallization and air pollution in two ways: frost damages only the parts of the building that can become frozen and when wet, and the damage is very dramatic.

Frost action is simple process. The forces exerted on masonry by the expansion of freezing moisture crush or crack the hosting material or adjacent material. In the chapel's case, this could mean the veneer stone, accent stone or mortar.

Interpretation of Findings:
It is BES' opinion, the deterioration of the existing masonry wall assembly is a result of the not one, but all the factors previously outlined. However, concentrating on the scientific cause of the deterioration misses the root issue as uncovered during the mortar analyses. The permeability of the original mortar is the root cause, allowing moisture to infiltrate the masonry assembly causing, salt crystallization, acidic rain, and frost action deterioration. During construction, this permeability allowed moisture to absorb into the unprotected setting mortar. During seasonal temperature changes, the static moisture within the mortar froze, thus creating crack characteristics and secondary mineralizations consistent with freeze-thaw distress of the hardened mortar. Hence, the **root** cause of the masonry assembly's deterioration is the inherent characteristic of the building's original mortar and not a result of deferred maintenance.

Closing:
This assessment was based on limited visual observations of readily-accessible portions of the building exterior. Our findings and recommendations are based on observations of these representative conditions at the referenced facility at the time of our assessment. Other conditions may exist, or develop over time, which were not found during our investigation. BES reserves the right to modify our findings should additional information become available. Our recommendations and/or opinions are presented for consideration by the Trustees of St. Thomas Episcopal Church and do not represent a design or specification for repairs.

If you have any questions, please call my office at 207-400-0086.

Regards,
Scott R. Whitaker

Scott R. Whitaker-President
Building Envelope Specialists, Inc.

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
- Roofing Options
- AACE International Recommended Practice No. 18R-97 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

HIGHBRIDGE MATERIALS CONSULTING, INC.

404 Irvington Street
Pleasantville, NY 10570
Phone: (914) 502-0100
Fax: (914) 502-0099
www.highbridgematerials.com

MORTAR ANALYSIS REPORT

Client:	Building Envelope Specialists	**Client ID:**	BUIL006
Project:	St. Thomas	**Report #:**	SL1216-01
Location:	Not provided	**Date Received:**	10/26/17
Sample Type:	Mortar	**Report Date:**	12/04/17
Delivered by:	Client (S. Whitaker)	**Petrographer:**	J. Walsh
		Chemist:	H. Hartshorn
		Page 1 of 16	

Report Summary

- One mortar sample from the a project identified as "St. Thomas" is examined for this report.
- The examined sample contains gray portland cement, a minor lime gauging, and a high content of broadly graded sand.
- The binder is estimated to be cement-rich with roughly one-tenth part of lime added to enhance plasticity. These binder proportions are quite typical for mixes employed in the early twentieth century. Though the author is unaware of the original construction date, the microtextures of the cement are at least consistent with a product manufactured in this time period.
- The mortar has a high sand content with a binder to aggregate ratio estimated around 1 : 4 by volume.
- In its current condition, the mortar has a uniform appearance with a light gray color. It is compact and well consolidated with an original air-void content estimated at 3-5% by volume. Despite the cement-rich composition, the cured product has a moderately soft paste with a high permeability. The observed physical properties might be attributed more to the secondary condition of the mortar than to the original qualities of the mix.
- The binder paste has been leached and undergone a bicarbonation reaction. There is also a moderate abundance of cracking as well as carbonate lining the cracks and filling air-voids. The crack characteristics and secondary mineralizations are consistent with freeze-thaw distress of the hardened mortar.

1. Introduction

On October 26, 2017, Highbridge received one mortar sample from Mr. Scott Whitaker of Building Envelope Specialists. The sample is identified as having been taken from a project identified as "St. Thomas". At the client's request, a compositional analysis is performed on the mortar sample. The testing includes petrographic and chemical analysis to identify constituents, estimate component proportions, and evaluate overall condition. An acid digestion to extract a sand sample for description and gradation is also included, and the extracted sand sample is returned to the client.

2. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-15. Data collection is performed or supervised by a degreed geologist who by nature of his/her education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856-17.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-15. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

3. Standard of Care

Highbridge has performed its services in conformance with the care and skill ordinarily exercised by reputable members of the profession practicing under similar conditions at the same time. Interpretations and results are based strictly on samples provided and/or examined.

4. Confidentiality Statement

This report presents the results of laboratory testing requested by the client to satisfy specific project requirements. As such, the client has the right to use this report as necessary in any commercial matters related to the referenced project. Any reproduction of this report must be done in full. In offering a more thorough analysis, it may have been necessary for Highbridge to describe proprietary laboratory methodologies or present opinions, concepts, or original research that represent the intellectual property of Highbridge Materials Consulting and its successors. These intellectual property rights are not transferred in part or in full to any other party. Presentation of any or all of the data or interpretations for purposes other than those necessary to satisfy the goals of the investigation are not permitted without the express written consent of the author. The findings may not be used for purposes outside those originally intended. Unauthorized uses include but are not limited to internet or electronic presentation for marketing purposes, presentation of findings at professional venues, or submission of scholarly articles.

5. Petrographic Findings and Discussion

5.1 - General Summary

The examined sample contains gray portland cement, a minor lime gauging, and a high content of broadly graded sand. The binder is estimated to be cement-rich with roughly one-tenth part of lime added to enhance plasticity. These binder proportions are quite typical for mixes employed in the early twentieth century. Though the author is unaware of the original construction date, the microtextures of the cement are at least consistent with a product manufactured in this time period. The mortar has a high sand content with a binder to aggregate ratio estimated around 1 : 4 by volume. In its current condition, the mortar has a uniform appearance with a light gray color. It is compact and well consolidated with an original air-void content estimated at 3-5% by volume. Despite the cement-rich composition, the cured product has a moderately soft paste with a high permeability. The observed physical properties might be attributed more to the secondary condition of the mortar than to the original qualities of the mix. The binder paste has been leached and undergone a bicarbonation reaction. There is also a moderate abundance of cracking as well as carbonate lining the cracks and filling air-voids. The crack characteristics and secondary mineralizations are consistent with freeze-thaw distress of the hardened mortar.

5.2 - Materials

The aggregate is a siliceous natural sand consisting mostly of granitic particles and fewer micaceous metasedimentary grains. The granitic component contains quartz, feldspar, and granite particles with a minor abundance of strain. The micaceous metasediments include metaquartzites and schists. Mica, amphibole, and pyroxene are detected as accessory minerals in the metasedimentary grains and as individual particles. There are also trace ironstone and opaque minerals. No clay coatings or friable materials are detected, and the sand is considered hard, non-porous, and durable for use in masonry mortars. An aggregate sample was extracted from the mortar through acid digestion. The extracted material is moderately variegated, semi-opaque to semi-translucent, and light gray in color overall (Munsell code approximately 2.5Y 6.5/0.75). The variegation is mostly due to a low abundance of coarser grains on the No. 4 mesh and a mixture of light gray, dark gray, and fewer white opaque grains against a more uniform background.

The sand is somewhat sharp-textured. It consists of mostly equidimensional particles that are subangular to subrounded in shape. There are only rare anisotropic particles with aspect ratios near 4 : 1. The particle size distribution is estimated through a quantified gradation analysis of the extracted sand after it was passed through a standard sieve stack. Details of the gradation are presented in Section 7 below. The aggregate is broadly graded with a nominal top size at the No. 4 mesh, a peak abundance between the No. 50 and No. 100 sieves, and a moderate fines content. Despite the broad gradation, the aggregate is not compliant with modern requirements for masonry sand gradations as specified by ASTM C144-11.

The binder is identified as an ordinary gray portland cement with a small lime gauging. No pozzolan or pigment additions are detected. The binder matrix is homogeneously developed with a high capillary porosity. All of the calcium hydroxide from the initial cement hydration has been depleted from the binder paste. Residual portland cement grains are present in moderate abundance on average throughout the binder matrix. The cement is fully hydrated, and the residuals are present as agglomerates of former calcium silicate that are only defined by the skeletal framework of interstitial iron-bearing ferrite that remains. The ferrite indicates the cement is a gray variety, and this is confirmed by the measured SiO_2/Fe_2O_3 ratio of 8.7. Most of the cement grains are up to and retained on the No. 200 sieve though very rare particles are detected up to the No. 100 mesh. Given the extreme hydration of the cement, it is difficult to discern the extent to which the observed cement residuals are representative of the original cement microtextures. However, the lack of coarse cement grains is most consistent with a product manufactured no earlier than the early to mid-twentieth century.

There are no clearly discernible lime grains observed in the examined mortar sample. There is only one potential lime grain detected in the thin section, and this particle is internally nondescript and approximately 75 µm in size. Though undispersed lime grains are rare at most, there are traces of burned mica and silicates. These residuals represent impurities in the original source rock that were burned during the lime manufacturing process. Still, it is clear that the mortar was certainly cement-rich with only a minor lime gauging at most.

5.3 - Component Proportions

Chemical analysis was performed on the mortar sample, and the results are summarized in Section 6 below. The binder is cement-rich with only a minor lime gauging. It is estimated to contain roughly one-tenth part lime for each part cement by volume. The mortar is oversanded with a binder to sand ratio near 1 : 4 by volume.

Given the secondary alteration in the mortar, these proportional ratios are calculated based on several assumptions. First, it is assumed that the lime is a dolomitic variety so that the measured MgO content can be used to constrain the proportion of lime in the binder. After a proportional amount of CaO is attributed to the lime (assuming a CaO/MgO ratio of 1.4 that is typical for dolomitic limes), the remaining chemistry has a CaO/SiO_2 ratio of 2.2, which is low for a portland cement. The anomalous cement chemistry is attributed to the leaching of calcium from the binder since there are signs of bicarbonation in the examined sample. In order to calculate the binder proportions, some CaO is mathematically added back to the measured chemistry in order to have a more typical portland cement with a CaO/SiO_2 of 3.0. If the initial assumption is incorrect and the lime is a high-calcium variety, then it is possible that the material could have had a much higher lime content and lower sand content. However, the petrographic observations are at least consistent with the presented proportions, and the mortar appears to have been densely sanded with only a minor lime gauging at most.

Since there is no significant amount of lime or any other type of plasticizer incorporated into the mixture, the mortar would not comply with any modern mortar mixes specified by ASTM C270. However, this kind of mixture would have been typical for masonry use in the early twentieth century. It is quite common to find mortars from this time period with either pure cement binders or cement-rich binders with only a minor lime gauging for plasticity. In fact, a popular mixture of the first few decades of the twentieth century used a cement to lime ratio of 1 : 0.1 by volume. Though the laboratory is not aware of the original construction date for this mortar, the cement microtextures are at least consistent with an early twentieth century vintage.

Still, a very low content of lime would be considered a substantial deficiency if this mortar were to be prepared today. It is almost always inadvisable to replicate such a portland cement-rich mortar especially given the high strength and elastic modulus of the portland cement available today. Though it is outside of the laboratory scope to specify repair materials or recommend strategies, some general commentary may be offered. The identification of a mortar of this composition means that there is a wide range of possible repair mixes that would be softer, more elastic, and more vapor transmissive than the original mixture. Of course, it should also be noted that the examined mortar sample has undergone secondary alteration that has resulted in a weaker, more permeable material than the original mix. The laboratory is not aware how widespread this condition might be across the building or how this will be addressed in the repair plan. The specifier would need to determine whether a repair mix is appropriate for the type, condition, and exposure of the masonry.

5.4 - Condition and Service Performance
Based on the examined sample, the mortar components were well mixed with no sand streaks. There is a single centimeter-scale cement streak in the piece examined. The incorporation of the original mix water cannot be evaluated, due to the moisture infiltration in the sample. Still, there is no evidence for inappropriate late retempering. Despite the high sand content, the mortar is compact and well consolidated with a total air content estimated at 3-5% by volume. Of course, this estimate includes only the subspherical voids from the original consolidation of the mortar. It does not taken into account the void space added by any secondary cracking in the sample.

The original mortar clearly would have been hard, indurate, and rather impermeable based on its composition. It is possible that some of the mortar remains in this condition in other areas that are deeper within the joints or less susceptible to water infiltration. However, this particular sample appears softer and more permeable than expected for the composition. Though the piece is intact, the paste is moderately soft and rapidly water absorptive. It is more likely that these features are due to secondary service effects in the sample.

A bicarbonation reaction appears to have occurred in the examined mortar sample. The bicarbonation reaction tends to occur when the cementitious matrix is already relatively porous, often due to a high original mix water content, and when much of the calcium hydroxide has been depleted. The depletion of calcium hydroxide results in a lower pH in the binder paste. This allows the pore water to be sufficiently acidic in order to leach calcium from the calcium silicate hydrate in the matrix and precipitate secondary calcium carbonate as patches of carbonation that have a "popcorn-like" texture. In this sample, all of the crystalline hydroxide from the initial cement hydration has been completely consumed, and the binder matrix is isotropic with fine patches of recrystallized carbonate throughout. These textures are consistent with a cementitious matrix that has undergone a bicarbonation reaction.

There is also a moderate abundance of cracks that are spaced roughly a millimeter apart, and the characteristics of this cracking are consistent with freeze-thaw distress. Most of the cracks are oriented parallel to one another, meander through the paste, and deflect around aggregate. There is also some secondary carbonate that has been precipitated in the open pore space. It is found lining cracks and filling air-voids. These kind of secondary mineralizations are typical where water movement and freeze-thaw distress has occurred.

6. Chemical Analysis

Table 6.1: Chemical Analysis Results

Sample ID	**Mortar**
Component (wgt. %)	
SiO_2	3.96
CaO	9.13
MgO	0.85
Al_2O_3	1.26
Fe_2O_3	0.46
Insoluble residue	74.61
LOI to 110°C	0.99
LOI 110°C-550°C	1.85
LOI 550°C-950°C	7.26
Measured Totals	**100.36**

Table 6.2: Calculated Components

The presented proportions assume that the lime is a dolomitic variety and correct the measured chemistry for some calcium leaching from the binder paste. The correction does not alter the estimated proportions much. However, if the lime was a high-calcium rather than dolomitic variety, the original mixture could have potentially been more lime-rich with a lower sand content. Still, the minor lime gauging and high sand content presented below are more consistent with petrographic observations and are considered to be a reasonable assessment of the mix proportions.

Sample ID	**Mortar**
Component	
Portland cement (wgt. %)	21
Natural cement (wgt. %)	Not detected
Lime expressed as dry hydrate (wgt. %)	1.0
Pozzolans (wgt. %)	Not detected
Pigment (wgt. %)	Not detected
Sand (wgt. %)	82
Cement : lime ratio (by volume)	1 : 0.12
Binder : sand ratio (by volume)	1 : 4.1

Notes:

1. A portion of the measured MgO is attributed to the portland cement assuming that all SiO_2 belongs to the cement and the SiO_2/MgO ratio in cement is assumed to be 7. The remaining MgO is attributed to a dolomitic lime. Sufficient CaO is deducted from the measured value to satisfy a purely dolomitic lime with a CaO/MgO ratio of 1.4. The CaO and MgO are reported as their respective dry hydroxides through molecular weight conversion. This presents the weight percentage of lime in dry hydrate form. The remaining chemistry results in a portland cement with an anomalously low CaO/SiO_2 ratio of 2.2. Given the secondary effects observed in the sample, this is attributed to the leaching of CaO from the binder due to moisture infiltration. To correct for this error, the calculated amount of SiO_2 in the cement is then used to calculate the CaO in the cement assuming a CaO/SiO_2 ratio of 3.0 in the original portland cement. The cement content is calculated assuming that the calculated SiO_2, CaO, and MgO as well as the other two measured oxides represent 95% of the total cement weight. The cement, lime, and sand weights are then normalized to 100% to return the materials to a dry weight basis. Volumetric ratios are calculated assuming bulk weights for portland cement, hydrated lime, and damp, loose sand of 94 lbs./ft.^{3}, 40 lbs./ft.^{3}, and 80 lbs./ft.^{3} respectively.

7. Aggregate Sieve Analysis

Aggregate analysis is performed by digesting the sample in an acid sufficient to dissolve the binder. The fines are examined petrographically to ensure that all recovered material represents sand rather than undigested binder components. In this case, most of the fines below a No. 325 sieve consist of hydrous silica gel from the incomplete digestion of the portland cement binder. This material is excluded from the gradation analysis below. The exclusion of any traces of fine silt intermixed with these fines is considered a negligible error. A qualitative description of the sand is given in the discussion above, and the recovered sample is returned to the client. The sample size is significantly smaller than would be required to perform a sieve analysis on fresh aggregate materials as per ASTM C136, and some small errors should be expected.

Table 7.1: Acid Digestion Data

	Retention (g)	Cumulative passing (%)	Cumulative retained (%)
No. 4	1.15	91.4	8.6
No. 8	0.89	84.6	15.4
No. 16	1.46	73.7	26.3
No. 30	1.72	60.7	39.3
No. 50	2.51	41.9	58.1
No. 100	2.84	20.6	79.4
No. 200	2.17	4.3	95.7
Pan	0.58	0.0	100.0
Fineness Modulus			**2.27**

Respectfully submitted,

Heather Hartshorn
Chemist/ Staff Scientist
Highbridge Materials Consulting, Inc.

Appendix I: Visual Description of Sample as Received

Sample ID	**Mortar**
Description	The sample consists of one large mortar piece, several smaller mortar fragments, and a low abundance of loose powder weighing a total of 51 grams. Though the orientation of the mortar pieces with respect to the assembly is not clearly discernible, the large piece has dimensions of approximately 0.75" x 2.25" x 2.5".
Surfaces	No tooled surfaces are included, and no formed bed surfaces are clearly discernible in the sample. All of the surfaces of mostly compact and sandy-textured.
Hardness / Friability	The paste is moderately soft, and the mortar is nonfriable.
Appearance	Freshly exposed surfaces have a slightly subvitreous luster and light gray in color (Munsell code approximately 2.5Y 7.5/1.25).
Other Details	There is a series of parallel hairline cracks running perpendicular to the largest face of the largest mortar piece. The cracks extend through the entire 0.75" thickness of the piece and are spaced approximately 0.25" apart. There is a low abundance of white mineral deposits much less than one millimeter in diameter throughout the mortar sample. There are trace white inclusions up to two millimeters in diameter. A single, very light brown streak is observed on one surface and is roughly five millimeters thick and two centimeters long. All of the mortar surfaces are rapidly water absorptive.

Appendix II: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic reflected light microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The overlays presented in the photomicrographs (e.g., text, scale bars, and arrows) are prepared as layers in Adobe Photoshop and converted to the jpeg format. Digital processing is limited to those functions normally performed during standard print photography processing. Photographs intended to be visually compared are taken under the same exposure conditions whenever possible.

The following abbreviations may be found in the figure captions and overlays and these are defined as follows:

cm	centimeters	PPL	Plane polarized light
mm	millimeters	XPL	Crossed polarized light
µm	microns (1 micron = 1/1000 millimeter)		
mil	1/1000 inch		

Microscopical images are often confusing and non-intuitive to those not accustomed to the techniques employed. The following is offered as a brief explanation of the various views encountered in order that the reader may gain a better appreciation of what is being described.

Reflected light images: These are simply magnified images of the surface as would be observed by the human eye. A variety of surface preparations may be employed including polished and fractured surfaces. The reader should note the included scale bars as minor deficiencies may seem much more significant when magnified.

Plane polarized light images (PPL): This imaging technique is most often employed in order to discern textural relationships and microstructure. To employ this technique, samples are milled (anywhere from 20 to 30 microns depending on the purpose) so as to allow light to be transmitted through the material. In many cases, Highbridge also employs a technique whereby the material is impregnated with a low viscosity, blue-dyed epoxy. Anything appearing blue therefore represents some type of void space (e.g.; air voids, capillary pores, open cracks, etc.) Hydrated cement paste typically appears a light shade of brown in this view (with a blue hue when impregnated with the epoxy). With some exceptions, most aggregate materials are very light colored if not altogether white. Some particles will appear to stand out in higher relief than others. This is a function of the refractive power of different materials with respect to the mounting epoxy.

Crossed polarized light images (XPL): This imaging technique is most often employed to distinguish components or highlight textural relationships between certain components not easily distinguished in plane polarized light. Using the same thin sections, this technique places the sample between two pieces of polarizing film in order to determine the crystal structure of the materials under consideration. Isotropic materials (e.g.; hydrated cement paste, pozzolans and other glasses, many oxides, etc.) will not transmit light under crossed polars and therefore appear black. Non-isotropic crystals (e.g.; residual cement, calcium hydroxide, calcium carbonate, and most aggregate minerals) will appear colored. The colors are a function of the thickness, crystal structure, and orientation of the mineral. Many minerals will exhibit a range of colors due to their orientation in the section. For example, quartz sand in the aggregate will appear black to white and every shade of gray in between. Color difference does not necessarily indicate a material difference. When no other prompt is given in the figure caption, the reader should appeal to general shapes and morphological characteristics when considering the components being illustrated.

Chemical treatments: Many chemical techniques (etches and stains typically) are used to isolate and enhance a variety of materials and structures. These techniques will often produce strongly colored images that distinguish components or chemical conditions.

Figure 1: Photograph of the examined mortar sample provided to Highbridge for examination. The mortar has a uniform appearance with a light gray color. The cured product is cohesive, but the paste is moderately soft and highly permeable. There are also some hairline cracks visible in the sample piece.

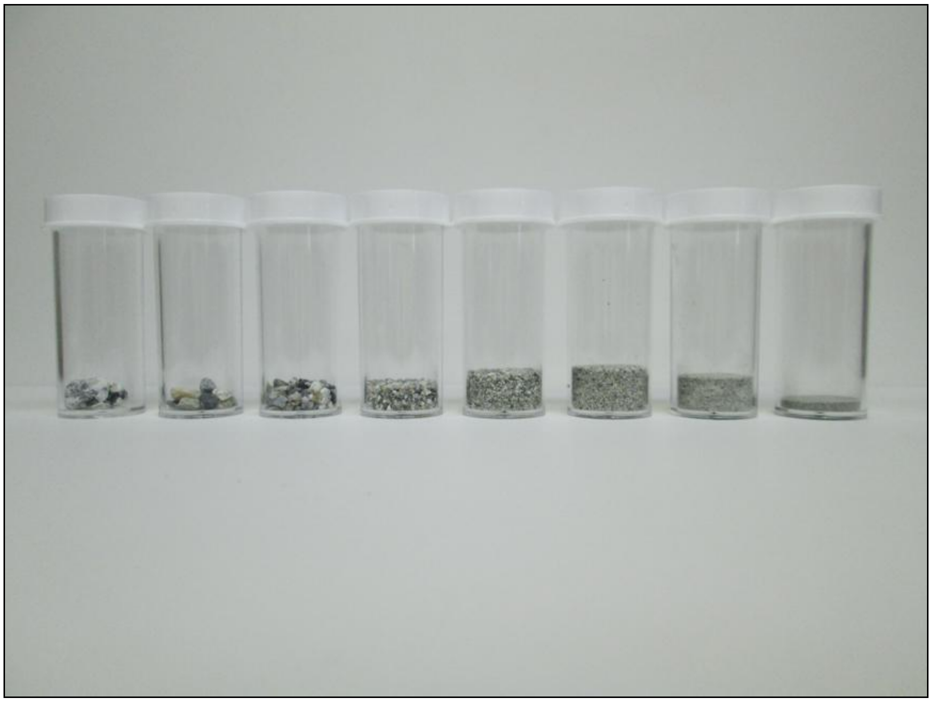


Figure 2: Photographs of the sand sample extracted through acid digestion. (Upper image) The complete extraction is shown. The sand has a moderately variegated appearance consisting of semi-translucent to semi-opaque grains with a light gray color overall. (Lower image) The extracted sand is shown after gradation through a standard sieve stack. The aggregate is broadly graded with a nominal top size at the No. 4 mesh and a peak abundance between the No. 50 and No. 100 sieves. Despite the broad gradation, the aggregate is not compliant with the limits specified by ASTM C144 for modern masonry sands.

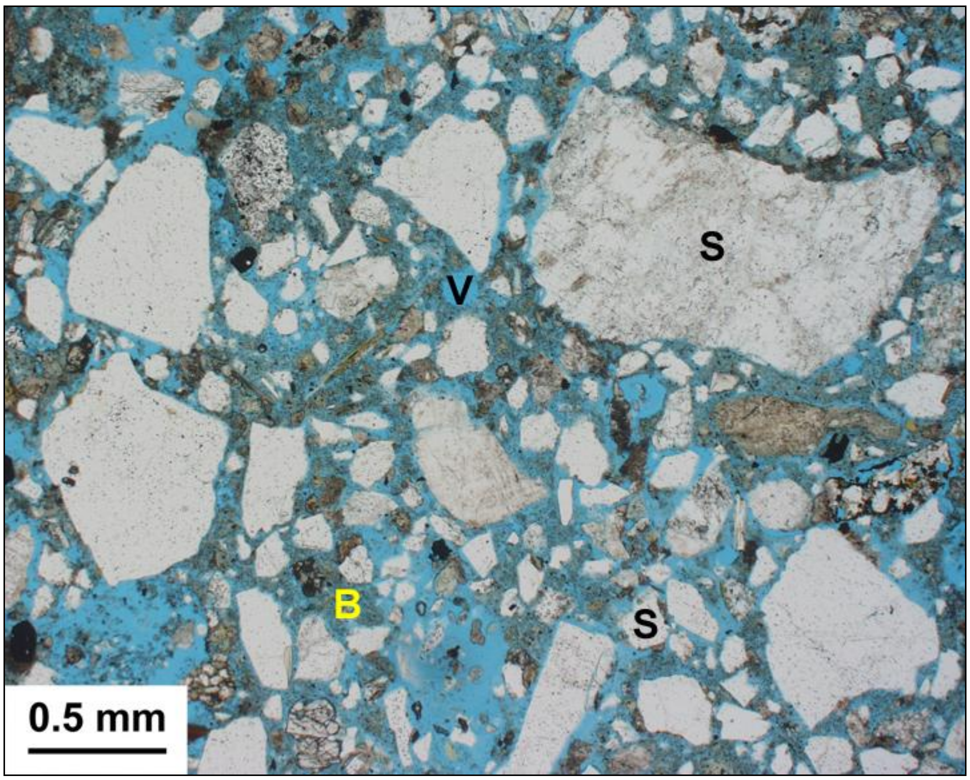


Figure 3: PPL photomicrograph illustrating the overall microtexture of the mortar. The sample is impregnated with a low-viscosity, blue-dyed epoxy in order to highlight cracks, pores, and voids. The binder matrix (B) is homogeneously developed with a high capillary porosity as indicated by the absorption of the dyed epoxy. The sand (S) is somewhat sharp-textured and densely distributed throughout the binder matrix. The mortar is compact and well consolidated with a total air-void content (V) estimated at 3-5% by volume.

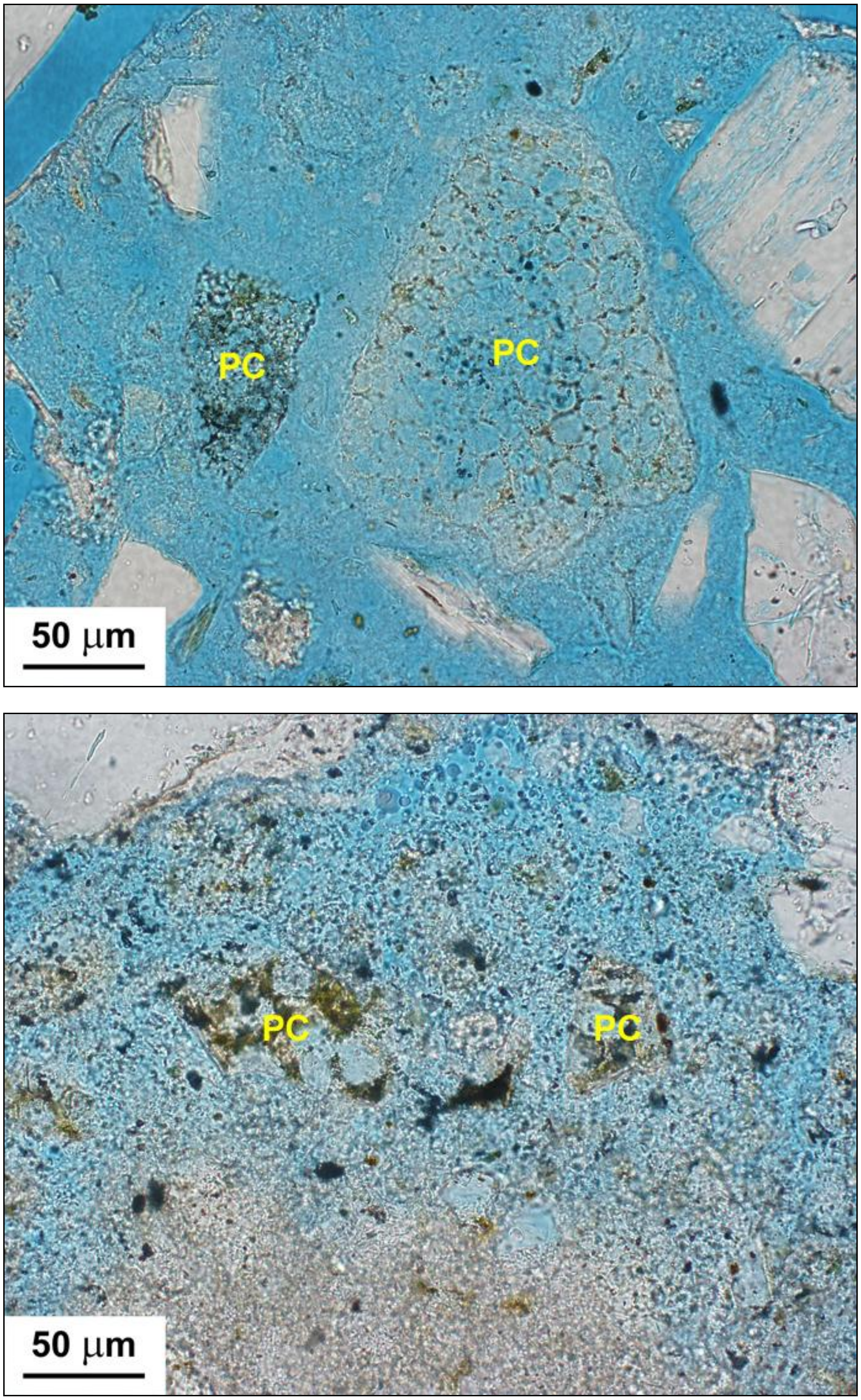
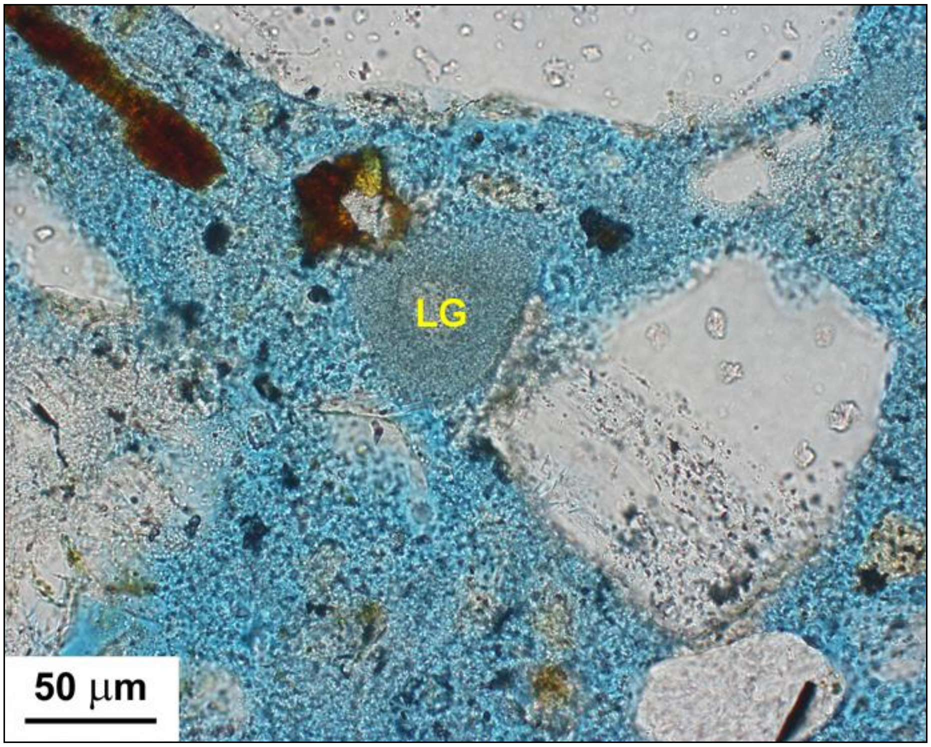


Figure 4: PPL photomicrographs illustrating the binder residuals in the examined mortar. The binder is cement-rich, and residual portland cement grains (PC) are present in moderate abundance. The cement is fully hydrated with residuals present as former calcium silicate agglomerates that are mostly defined by the interstitial iron-bearing ferrite. The ferrite identifies the cement as a gray rather than white variety. The medium grind of the cement is most consistent with an early to mid-twentieth century product.



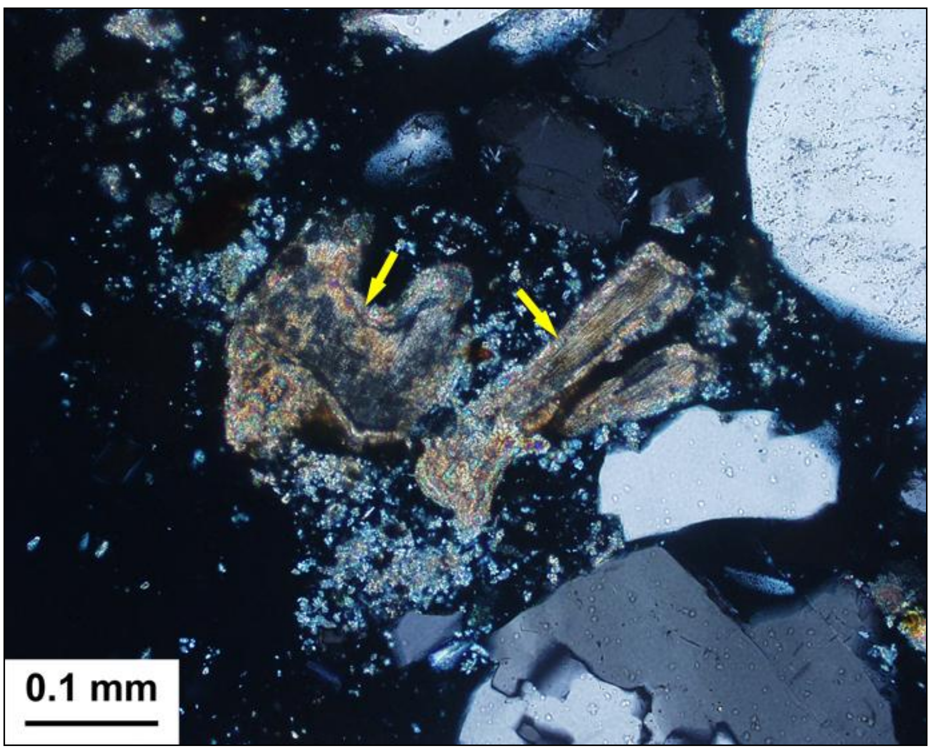


Figure 5: Photomicrographs illustrating the binder residuals in the examined mortar. (Upper PPL image) Though there are no clearly discernible undispersed lime particles, there is a single potential lime grain (LG) detected in thin section. This is internally nondescript and approximately 75 μm in diameter. (Lower XPL image) There are also trace residuals of fired silicates (arrows) dispersed throughout the binder matrix. These represent impurities in the original source rock that were burned during the lime manufacturing process.

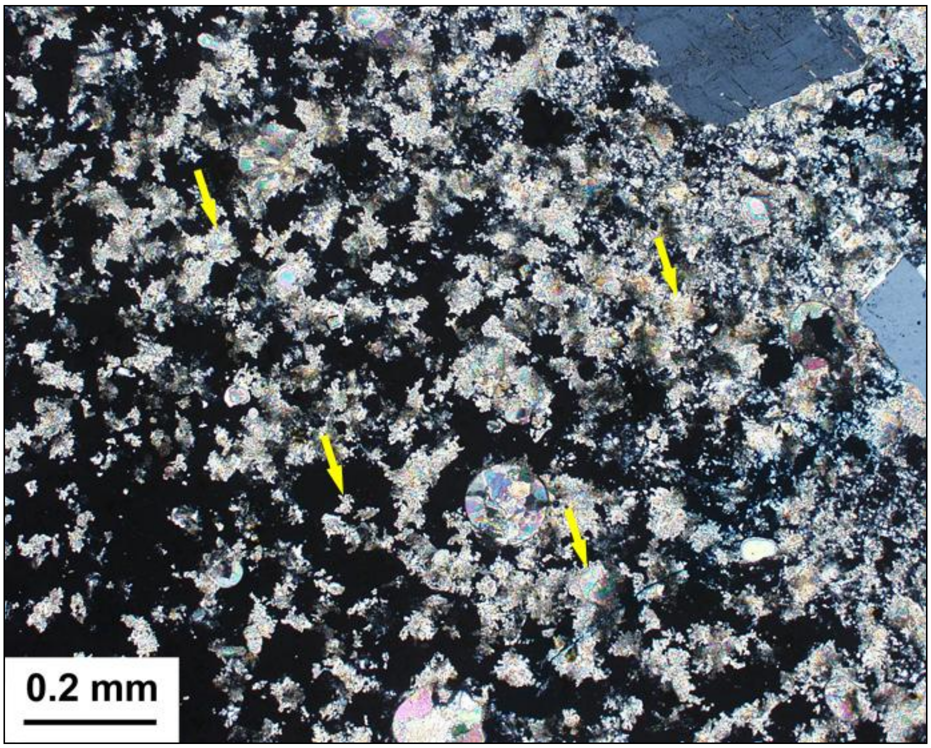
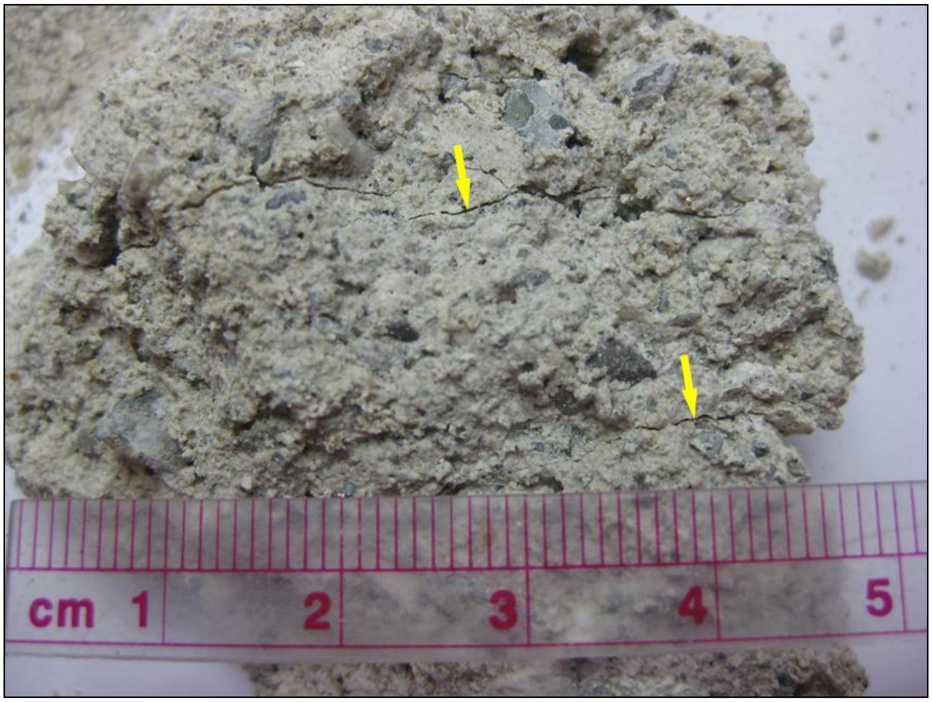


Figure 6: XPL photomicrograph illustrating secondary service effects in the mortar sample. A bicarbonation reaction appears to have occurred, resulting in an isotropic binder matrix with patchy, "popcorn-like" areas of carbonation (arrows). This typically occurs when the binder paste is relatively porous and calcium hydroxide has been depleted, allowing for the movement of more acidic pore water that digests calcium from the matrix and precipitates it as patches of calcium carbonate.



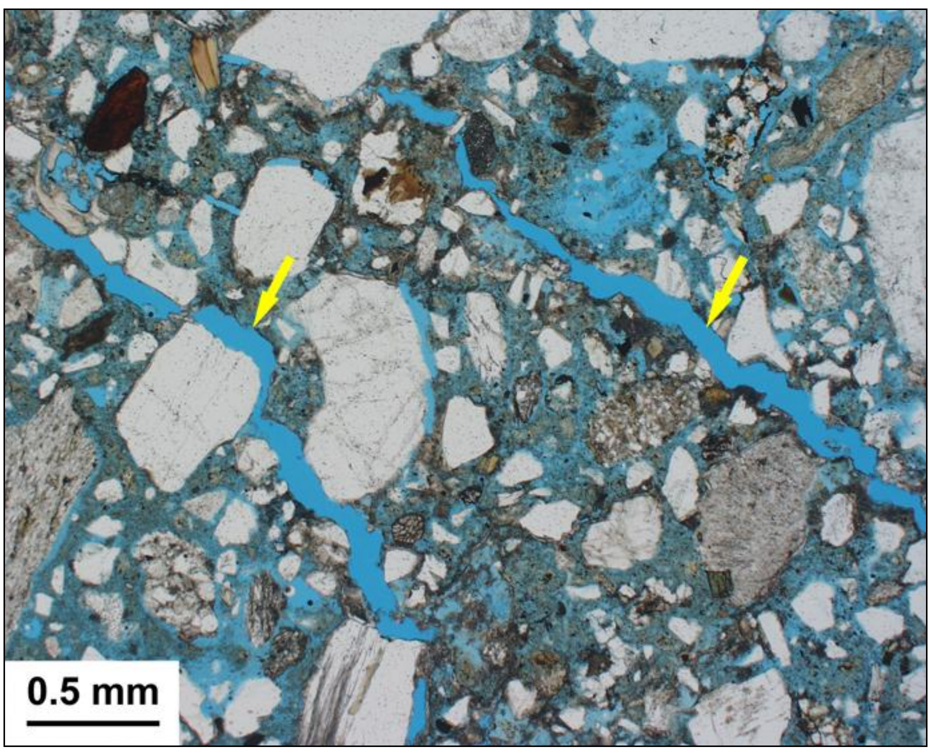


Figure 7: Images illustrating secondary cracking in the mortar sample. (Upper photograph) The cracking (arrows) is visible in the hand sample at as parallel cracks spaced at the centimeter scale. (Lower PPL photomicrograph) When viewed at the polarized light microscope, the cracks (arrows) are present in moderate abundance and sometimes spaced roughly a millimeter apart. These are mostly parallel to one another and meander through the paste, deflecting around aggregate particles. The characteristics of these cracks are consistent with freeze-thaw distress.

Index

Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS

Date: March 19, 2018

Project: St. Thomas Episcopal Church-Budget Numbers

BES Project Number: 020.0-17

The following budgets reflect the repair work outlined in BES Building Envelope Repair Docments dated 2-16-2018. Prices are good for 60 days. If project is delayed past November of 2018, an updated building assessment will be needed to document additional damage due to freeze/thaw and to define any increase of scope. Undated estimates will be needed at that time.

Project Duration: 4 months. (16 weeks)
Project Season: Spring, summer and fall.
Winter Conditions: None.

PROJECT DELIVERY METHOD:
BES has priced this project in three different project delivery methods. They are defined below and each have their advantages for the trustees. Please review and select the project delivery method that you prefer.

- **CM at Risk:** BES holds all the contracts and carries all the risk in the project by owning the project contingency and pulling funds to cover the costs of unforeseen conditions.
- **Owner at Risk:** The Trustees holds all the contracts and carries all the risk in the project by owning the project contingency ** and pulling funds to cover the costs of unforeseen conditions.
- **Shared Risk:** BES holds all the contracts and the BES and the Trustees share the risk in the project by co-owning the project contingency * and pulling funds to cover the costs of unforeseen conditions. Remaining project contingency funds at the end of the project are split 50/50.

	CM at Risk (5 yr. limited warrenty)	**CM Shared Risk** (2 yr. limited warrenty)	**Owner at Risk** (1 yr. limited warrenty)
General Conditions:	$43,209.00	$43,209.00	$15,000.00
BES Project Managament: ($2,866.00/wk.)	$45,856.00	$45,856.00	$45,856.00
Masonry:	$242,200.00	$242,200.00	$242,200.00
Sub-Total:	**$331,265.00**	**$331,265.00**	**$303,056.00**
Contingency @ 15%:	$49,690.00	* $49,690.00	* * $49,690.00
CM Fee @ 7%:	$23,189.00	$23,189.00	$0.00
Project Total:	**$404,144.00**	**$404,144.00**	**$352,746.00**

P.O. Box 2589. South Portland, Maine 04116
Tele: 207-400-0086

Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS

Exclusions:
Construction permit fees.
Temporary power hook up and delivery.
Temopary water hook up and delivery.
Roofing work and associated flashings.
Interior plaster wall repairs.
Stainglass window removal and restoration.
Hazardous materials consulting.

If you have any questions, please call my office at 207-747-7104.

Regards,

Scott R. Whitaker

Scott R. Whitaker-President
Building Envelope Specialists, Inc.

Index

East Elevation

- Church Insurance – Engineer's Inspection Report
- Building Envelope Specialists – Assessment and Proposal
- Building Envelope Specialists – Summary of Exterior Masonry Condition
- Building Envelope Specialists – Summary of Mortar Analysis
- Highbridge Materials Consulting – Mortar Analysis Report
- Building Envelope Specialists – Project Budget
- Gnazzo – Masonry Repair Budget

Bell Tower

- Building Envelope Specialists – Findings Report
- Building Envelope Specialists – Masonry Tower & Roof Assessment and Design Documents
- Building Envelope Specialists – St. Thomas' Tower Repair Options
- Gnazzo – Tower Restoration Option 00
- Building Envelope Specialists – Tower Wrap inspections

Bell Tower & Roof (Campbell & Cordjia)

- Bell Tower Repair Opinion of Probable Cost
- Roofing Options
- AACE International Recommended Practice No. 18R-97 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

JOSEPH GNAZZO COMPANY INC.

Joseph Gnazzo Company Inc. 1053 Buckley Highway Union, CT 06076 TEL 860.684.2334 FAX 860.684.1306 www.gnazzo.com office@gnazzo.com

March 12, 2018

Scott Whitaker
Building Envelope Specialists
159 Front Street
South Portland, ME 04106

RE: All Exterior Repairs per Building Envelope Repair Documents Shown on Drawings TS, AO, A1 and A2

The following is a proposal to perform the work items listed below at selected areas of the St. Thomas Episcopal Church, Camden, ME.

1. Erect all scaffolding with stair tower exterior elevations.
2. Number, photograph all rebuild areas.
3. Remove stone and rebuild to original locations.
4. Rake and repoint remaining stone mortar joints.
5. Patch limestone trim shown on drawings.
6. Install helical wall ties shown on repointing areas.
7. Install weather cap at capstones.
8. Install backer rod and sealant as required.

Labor, Staging and Material $ 237,600.00

Alternate 1: Allowance to install through flashing front window between frame and limestone surround. Labor and Material $4,600.00

Note:

1. All applicable sales tax is not included in price.

_______________________ Accepted Signature

_______________________ Date

Joseph Gnazzo Company, Inc.

Gary G. Gnazzo, President

Index

East Elevation

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Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS
1 Madison Street South Portland, ME 04106
(207) 400-0086
admin@building-envelope-specialists.net

FINDINGS REPORT

CLIENT **St Thomas Episcopal Church**
33 Chestnut Street
Camden, Maine

PURPOSE OF SITE VISIT(S)

This report is a summary of observations, conclusions, and recommendations for the remaining masonry on the nave, tower, side entrance, organ room, sacristy, as well as various roof assemblies on St. Thomas Chapel located at 33 Chestnut St. in Camden, Maine **(See Photo Plate #1)**

Our conditions assessment took place on April 25, 2019 primarily from the ground and was visual in nature. Upper sections of the tower were accessed with a 32' foot extension ladder. No building materials were removed during our assessment however, at some locations of the masonry, loose mortar was removed for a closer examination. The weather was sunny with temperatures in the high 50's. Our assessment included interior observations of the same areas including accessing the bell chamber of the tower and the adjacent roof cricket. The upper roof of the tower as well as the bell deck platform were inspected as part of this assessment.

PROJECT TEAM

- Scott Whitaker – Principal in Charge and Project Executive
- Tim Dean P.E. – Sr. Envelope Consultant
- Ray Hamlin – Envelope Consultant

OBSERVATIONS

Masonry

The masonry assembly is constructed of 6" to 8" thick Quincy Granite wall stones that face an 18" to 24" thick masonry rubble bearing wall. Integrated into the assembly are limestone and cast stone highlights at the window surrounds, buttress caps and wall caps stones. Repair mortar is Portland Cement based. Past re-pointing projects installed the mortar at the incorrect depths and incorrect profiles as evidenced by the pervasive mortar failure **(See Photo Plate #21).**

Overall, the condition of the stone masonry façade varies. While some areas are in fair condition, only needing repointing with the correct mortar recipe, other areas need full restoration to include rebuilding wall sections. Many areas of masonry have been repointed previously, but often the mortar mix is noticeably different than most of the existing adjacent mortar joints and in some instances, the masonry units themselves do not match the existing adjacent original masonry. Mortar joints are heavily deteriorated, and in a few locations are completely absent. Excessive fractures, cracks and deterioration of existing repair mortar was observed; this has allowed moisture to enter the core of the wall assembly. The non-porous nature of Portland cement-based mortars is not allowing moisture within the wall to weep out through the joints; thus, trapping the water within the wall cavity. This is creating freeze/thaw damage to the masonry, as well as causing additional deterioration to the original mortar **(See Photo Plates #5- 6).**

Large separations between the wythes of the tower wall's stone veneer were observed. They present as bulges in the face-plane of the exterior wall surface. These bulges are located around the upper and mid-section section of the tower. There are separations between the exterior veneer and the next masonry

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wythe. The gap between the stones is void of any masonry material. At the time of the investigation, the upper bulges on the tower appear to be stable, however we did not test these areas. Wind driven moisture enters this structure through the bell chamber windows that have bird screens but are otherwise open to the outside **(See Photo Plate #7).**

Slate Roof Assembly

The slate roof has a steep 15”/12” pitch and appears to be original weathered New England slate. It has a full color range from green to gray to buff. Overall, the slate roof is in poor conditions with missing or damaged slates, missing or damaged flashing and isolated repairs that have failed. Observations reveal sections of the slate are loose due to aging attachment nails. There is impact damage to the slates leaving the assembly vulnerable to moisture infiltration. Rust stains on the surface of the slates reveal either the oxidation of steel hanger nails or iron is leaching out of the slate itself. Discolored slates at and around the base of the chimney have been coated with grime from the boiler exhaust. This coating may have discolored the slate permanently. Copper features, such as, the ridge cap, step flashings, gutters & downspouts are patinaed, but appear to need selective replacement **(See Photo Plate #22).**

Flat Copper Roofs

Overall, the flat solder seam copper roofs at top of the tower and the bell platform are in poor condition as evidenced by broken solder, punctures, deteriorating patches and damaged counter flashing. The existing roof framing members pocketed in the exterior walls of the masonry tower were water-stained and wet at the time of our investigation. This suggests moisture is infiltrating the copper roof assembly as well as the masonry in multiple locations **(See Photo Plate #23-24).**

Other Observations

Most of the concrete/limestone surrounds are weathered and have some surface cracking. A few showed significant cracks **(See Photo Plate #9-10, 27).**

The wood trim at the window jambs are generally deteriorated and have cracks, have separated from the masonry opening and some have peeling paint. The wooden trim at the window heads are in fair condition **(See Photo Plate #25).**

The interior plaster walls have numerous cracks at the windows under the sills **(See Photo Plate # 26).**

CONCLUSIONS

The Chapel / Bell Tower has significantly deteriorated masonry with noticeable changes evident from this past winter. The upper 1/3 of the tower exhibits the most moisture damage on all 4 sides. The corners are beginning to displace outward. The east wall needs to be rebuilt full height. Most mortar joints have cracked or are missing. There is damage, some severe, to the limestone cornice, water tables, window surrounds, caps, and crenellations. There is water actively seeping out of joints. The wood roof joists are saturated in the vicinity of the masonry walls. The soldered copper roof at the top of the tower has some cracks in the soldered joints but does not appear to be the major source of water damage. However, since it is supported by the masonry walls and the roof joist ends are damaged, it will need to be replaced. The interior of the masonry in the bell chamber has a parge coating that is severely damaged and should be removed. The floor of the bell chamber/chapel roof is a soldered copper roof with an internal drain that appears to be in good condition and is allowing any water reaching the floor to properly drain. The bell support frame is supported with sleepers on this floor and is independent of the tower walls. The bells and frame will need to be temporarily removed or possibly protected in place during renovations. The interior of the chapel has plaster damage on the west side of the apse. This interior wall will need repairs.

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Otherwise, the chapel interior appears to be a lower priority. The East window surround of the chapel deteriorated quite significantly over the winter and the basement window and surrounding ceiling also have significant water damage. The south tower wall to roof joint is another source of moisture infiltration that will need to be addressed.

The slate & copper roofs are severely weathered and have exceeded their intended lifespan. The area closest to Chestnut Street on the Wood Street side, has had sealant applied to the joints in the slate to stop active moisture intrusion. There are slate tiles missing and damaged in several locations, the worst being above the organ room. The valley between the organ room and sacristy has some bad solder joints. There are a few open nail holes in the flashing near the south wall of the tower. The interior wood deck in the nave appears to still be in good condition. The repairs in the vicinity of the organ, organ flower room, and the east end of the nave must be considered high priority, but we have designated the remainder as medium-high. The most economical strategy is to repair the whole roof at the same time, rather than patch high priority areas and then come back and complete the whole roof. Staff indicated a desire to replace the slate with a more economical synthetic product, but this needs to be reviewed for compliance with the historic district requirements and aesthetic preferences. If allowed, this could represent a substantial savings. Included with the roof are the masonry repairs to the chimney, which are primarily repointing.

RECOMMENDATIONS

Based upon our visual assessment of St. Thomas Church, portions of the exterior façade are in stable and sound condition, while other areas need varying degrees of intervention. Rough budget pricing with a range of 35% is included. The degrees consider urgency of repair, safety factors, aesthetic uniformity and long-term durability of the building envelope.. Hence, the following conclusions and recommendations are categorized from High to Low, based upon the definitions we have established below in conjunction with the church's goals for the project. Priority Grading is as follows:

- **HIGH PRIORITY** (posing immediate concern for life safety, property damage or unacceptable façade performance)
- **MEDIUM PRIORITY** (affects long-term performance of the building envelope and may adversely affect tenant's comfort if not addressed promptly)
- **LOW PRIORITY** (non-immediate concerns that are not integral to life safety or building envelope uniformity and/or performance)

Highest Priority- Chapel / Bell Tower: The masonry work in the tower is estimated to involve the removal and resetting of approximately 1350sf of the outer wythe. This is most of the exposed stone façade. The 2 limestone horizontal bands and 5 window surrounds and decorative crown will require significant replacement with the remainder repaired. The upper roof, including wood framing, will be removed and replaced with the new flat roof using EPDM membrane instead of soldered copper. The bells are to be removed, stored, and reset. Bell restoration has not been included. Also excluded is any work to the chapel roof/ bell tower floor which appears to be in good condition. The cricket that ties the tower to the nave/sacristy roof will require new copper flashing and counter flashing. Including general conditions, a 20% contingency, and 12% for soft costs. Based on our experience with projects of similar nature, BES's opinion of probable cost for construction is approximately $680,000. Changing limestone replacement with cast stone could save around $60,000 in material costs.
Medium High Priority-Slate & Copper Roofs: The roof replacement costs will also be dependent on the material used. This work includes copper flashing and some gutter work. Excluded, is any work to the

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spire. Removing and replacing the roof with slate will cost about $400,000. Selecting an alternate material could provide significantly lower upfront costs but will also alter the church's appearance.

Low Priority- Nave, Entrance, & Sacristy Walls: The repointing and rebuilding of masonry for the entrance, nave and sacristy walls and repair/replacement of the window surrounds and adjacent woodwork is work that will cost about $150,000. This work may be scheduled over a longer time to better fit budgetary constraints.

Tower – East wall

Masonry joints mostly cracked; this wall was covered with Ivy. The window surrounds and limestone bands are all damaged. Moisture damage is increasing rapidly. Our estimate includes rebuilding this whole side

This assessment was based on visual observations of readily accessible portions of the buildings' exteriors. Our findings and recommendations are based on observations of these representative conditions at the referenced facility at the time of our assessment. Other conditions may exist, or develop over time, which were not found during our investigation. BES reserves the right to modify our findings should additional information become available. Our recommendations and/or opinions are presented for consideration and do not represent a design or specification for repairs.

Please contact us if you have any questions or comments regarding this report.

End of field report.

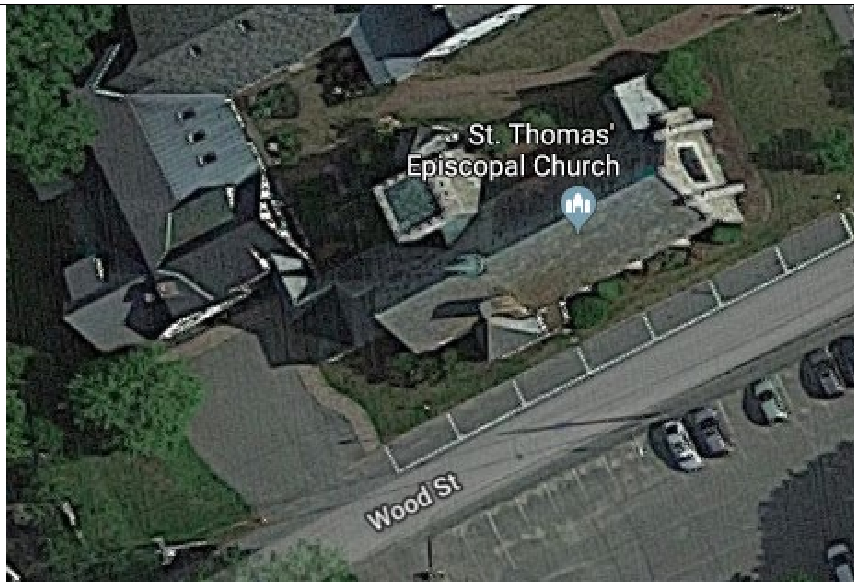
Report filed by:

Timothy Dean
Sr. Envelope Consultant
Building Envelope Specialists, Inc.

Report reviewed by:

Scott R. Whitaker
Project Executive
Building Envelope Specialists, Inc.

APPENDIX 1 – PHOTOS



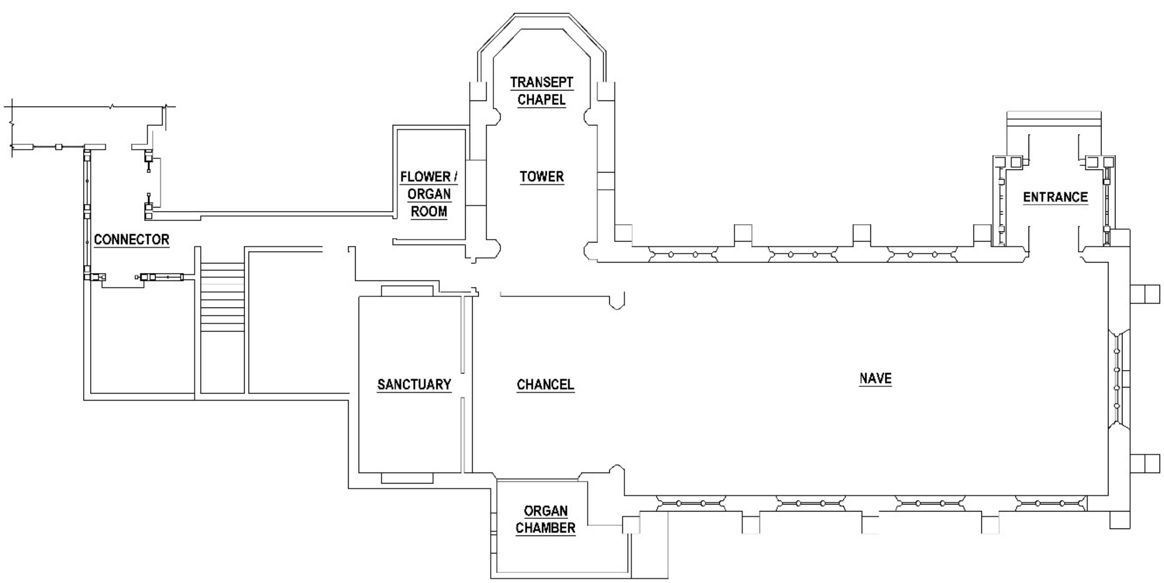


Photo 01
Overhead and plan view of church

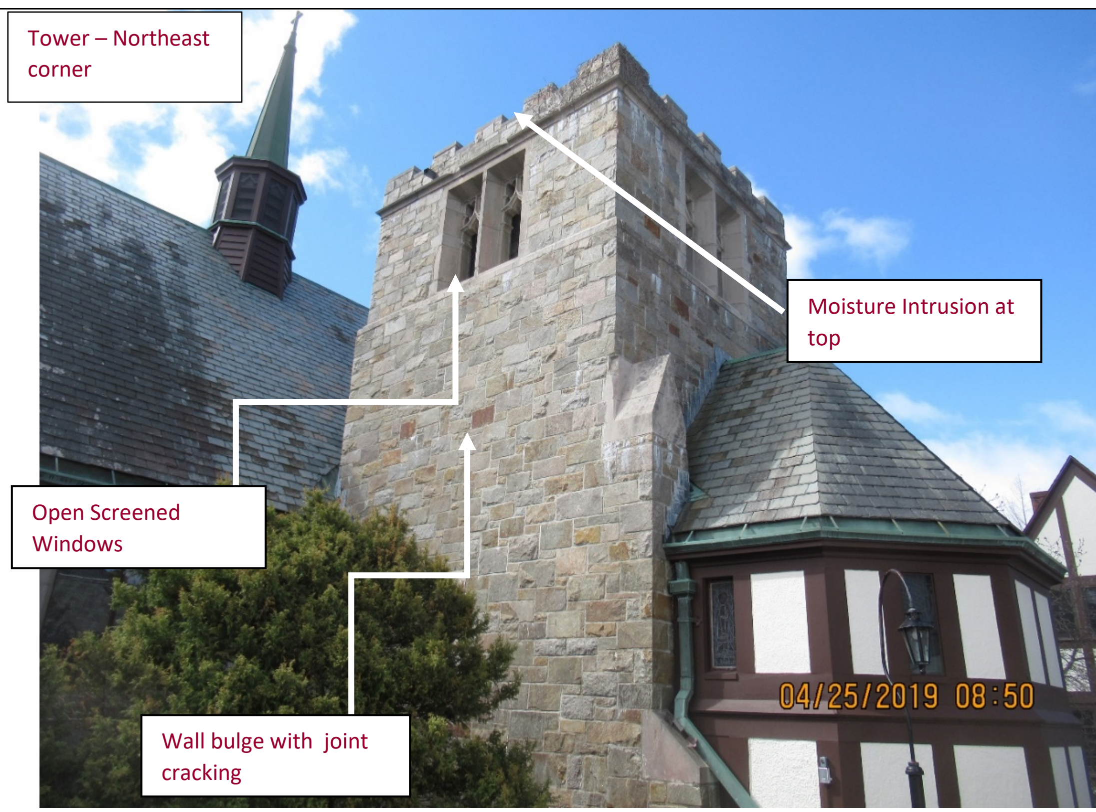


Photo 02
Northeast Tower

Photo 03
Middle of the East Tower

Photo 3A
Lower East Tower

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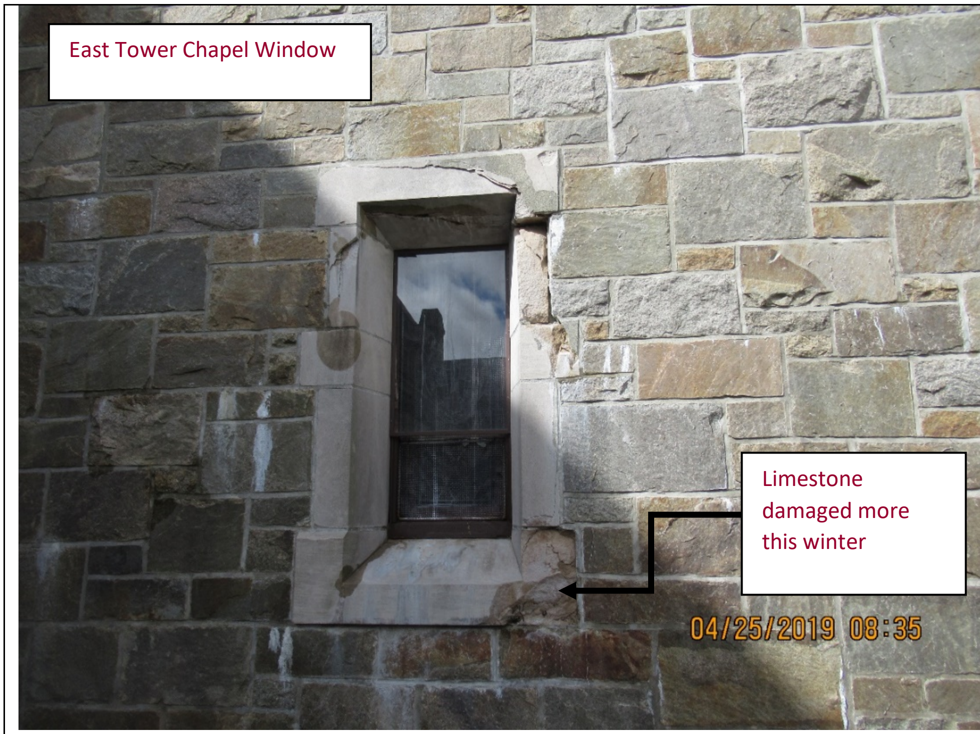

Photo 04
East Chapel Window

Photo 05
Mortar cracks at the SE corner of Tower, highlighted in red.

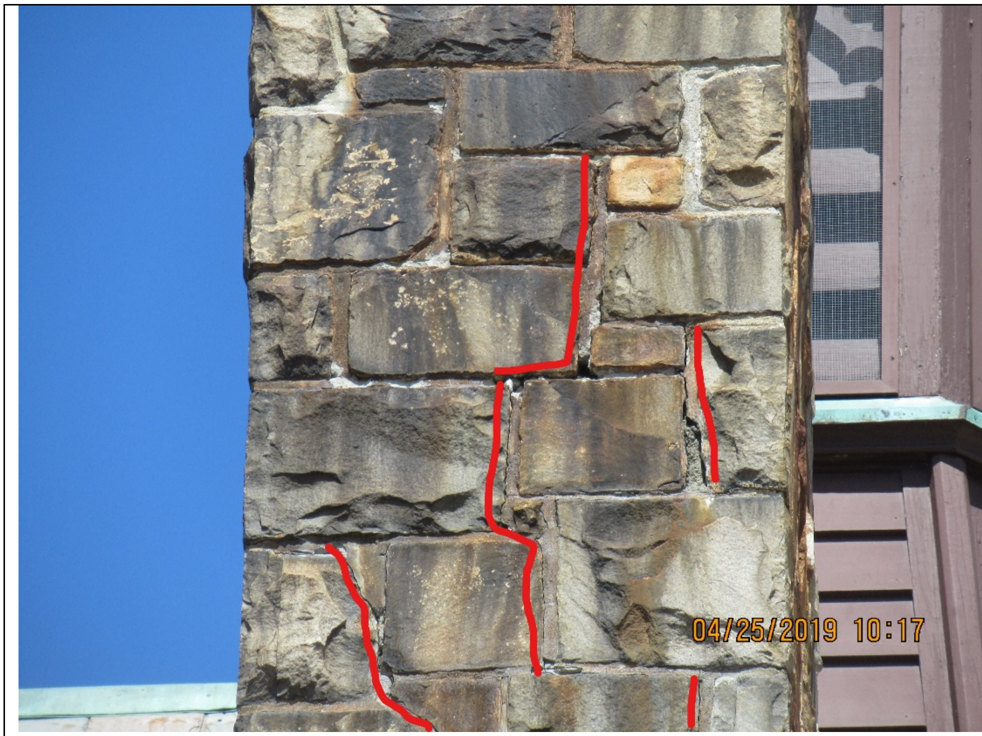	**Photo 06** South Chimney face mortar joint cracks, note variety of mortar colors and textures.
	**Photo 07** Window louvers have been removed on 3 sides allowing weather direct access to bell chamber.

Photo 08
Copper roof at scupper and view of crenellation caps. Note cracked mortar joints.

Photo 09
Nave window surround cracks and wood trim to stone joint gap.

	**Photo 10** Limestone window crack
 	**Photo 11** East Tower / Nave corner Note this area has interior plaster damage.

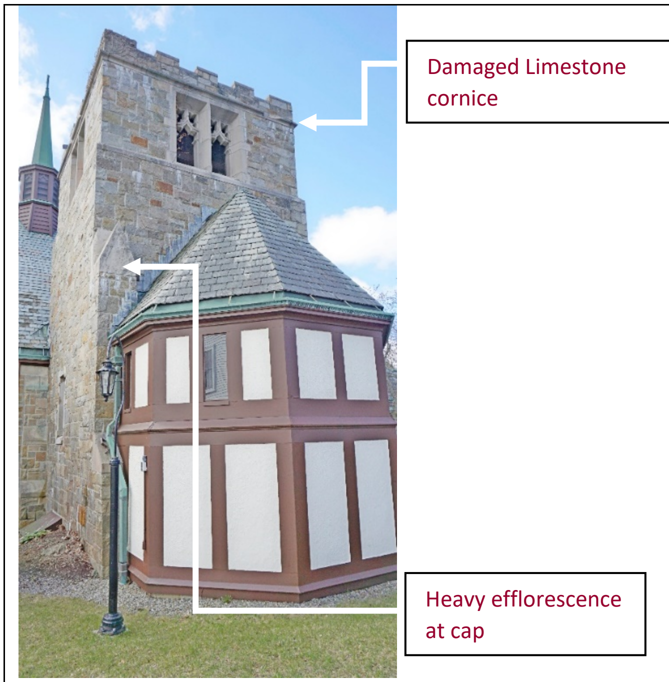

Photo 12
North Tower

Photo 13
West Tower

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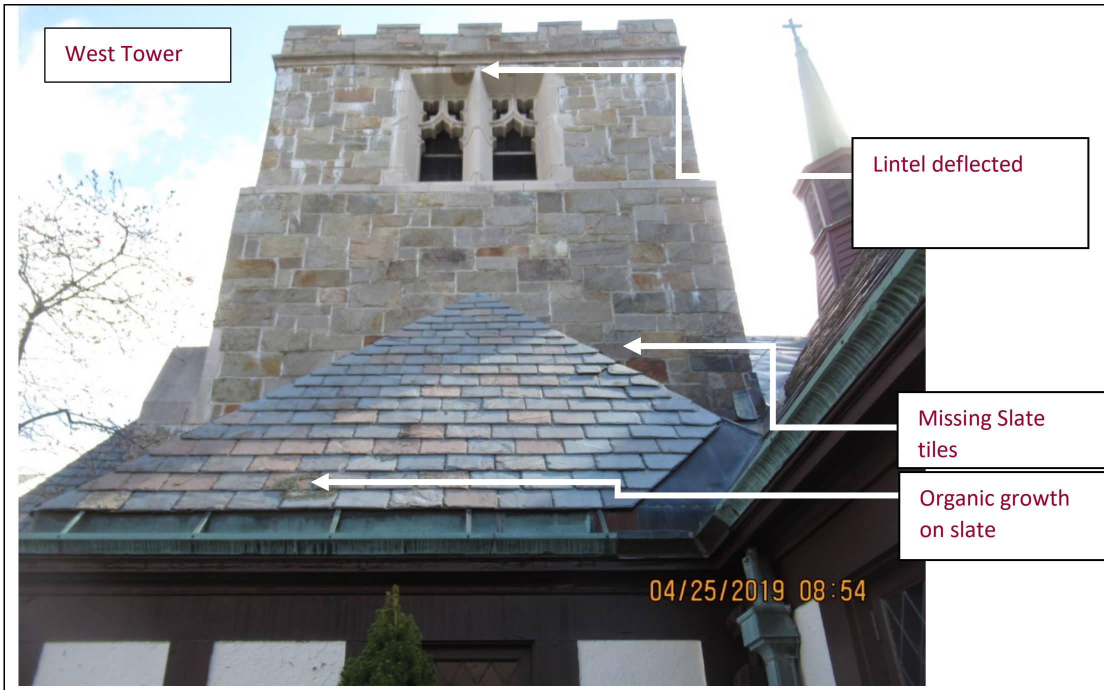
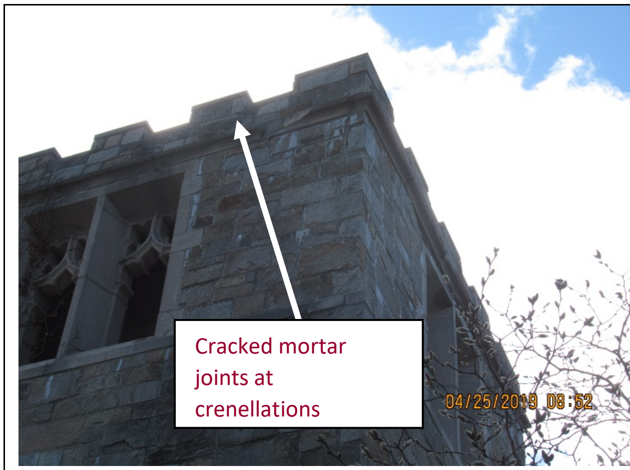


Photo 14
West Tower

Photo 15
West Tower Valley



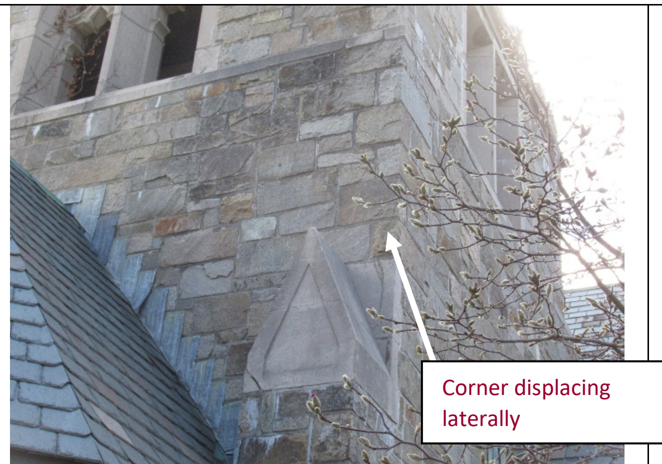


Photo 16
North Tower

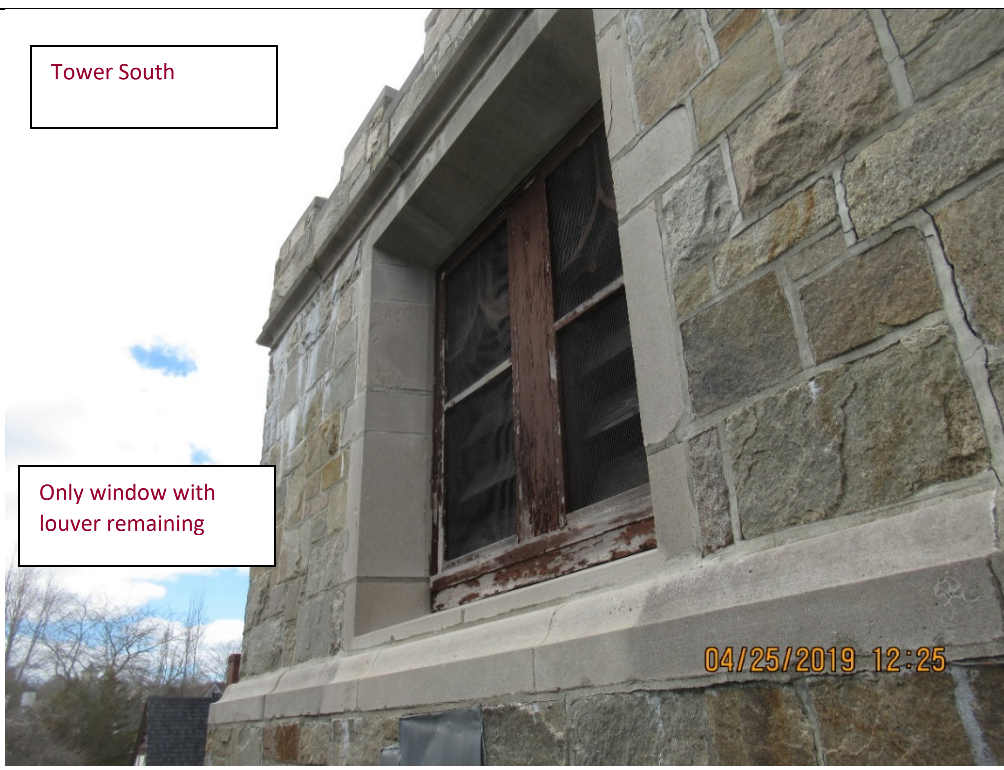


Photo 17
South Tower

	**Photo 18** Church entrance
	**Photo 19** Maintenance issue

 Loose mortar	**Photo 20** Entrance steps
 Poor Mortar joint repair	**Photo 21** Nave mortar repairs

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Repaired ridge cap with open nail holes and broken slate tile

Photo 22
Slate roof

Photo 23
Tower roof
Flat soldered copper

	**Photo 24** Tower roof flashing
	**Photo 25** Trim at window head is generally ok, ends and jambs near stone need work.

<table>
<tr><td></td><td><u>Photo 26</u>
Typical interior crack at windowsill</td></tr>
<tr><td></td><td><u>Photo 27</u>
Cracked Cap Stone</td></tr>
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