DIRIGO ENGINEERING
2 Dirigo Drive Fairfield, Maine 04937 (207) 453-2401 Fax: (207) 453-2405

January 14, 2014

Mr. Newell Graf, Selectman
Town of Skowhegan
225 Water Street
Skowhegan, Maine 04976

RE: Evaluation of Skowhegan Fire Station

Dear Newell and Members of the Board of Selectmen:

Dirigo Engineering has completed an evaluation of the Town of Skowhegan's Fire Station. Our evaluation included a general overview, a detailed structural evaluation of the roof, a detailed conditional assessment of the above grade masonry façade, and an evaluation of the foundation. Dirigo Engineering performed the general overview and evaluation of the foundation under the entrance bay of the building. Dirigo Engineering contracted with sub-consultants EXP of Fredericton, Canada for the structural evaluation of the roof structure and Building Envelope Specialists out of S. Portland, Maine for the Masonry Evaluation. This report provides our findings. We have attached the Structural Evaluation Report and the Masonry Evaluation Report as well as a cost estimate to rehabilitate the building.

General Overview

Our general comments on the building and its use as a fire station are as follows:

- The building is of brick construction with a stone and masonry foundation. The building rests on bedrock on the street end and it is not clear what the foundation bears on in the rear although bedrock does not appear to be very deep based on evidence seen on the river bank. The building appears to be generally square and plumb from the exterior.
- There is a basement level housing heating and mechanical equipment as well as some fire related apparatus. The 100 year flood elevation is reported to be above the first floor elevation so it is likely that any equipment in the basement and first floor would be damaged or destroyed in a flood event.
- The street is very busy and often traffic is stopped right in front of the station. Due to sight distance concerns an additional traffic light cannot be added on the street to facilitate access. Ingress and egress by fire trucks requires flaggers.

- The original building was constructed in 1904 for use as a fire station before the use of internal combustion engines. The bays are very narrow and the doors are not even 10 feet wide (a typical residential garage door width).
- The hose tower is showing signs of settlement and degradation from weather.
- Granite Steps have settled and there is a gap for water to enter
- Due to the narrow width, there is insufficient room around the vehicles to move safely, clean the vehicles and apparatus, make minor repairs, etc.
- The main level floor was upgraded in 1978 with steel columns and a reinforced concrete slab. The numerous columns restrict use of the basement.
- The foundation is crumbling under the bay doors.
- The heat plant is at least 30 years old and very inefficient.
- The generator appears to be very old.
- Some of the wiring in the older sections of the building is in need of modernization. There appears to be some abandoned wiring in parts of the building.
- The windows are over 30 years old.
- Only the first floor is considered accessible to people with disabilities.

Below is a list of improvements Dirigo recommends for the general building system.

- Heavy duty bollards should be added to the exterior of the building at the bay doors to protect the structure.
- The foundation under the front end of the bay access should be replaced with concrete walls. The addition of approach slabs in front of the building may help to reduce lateral loads on the foundation wall.
- Replace the heating system.
- Upgrade the generator.
- Bring electrical system up to code.
- Replace windows.
- Reinforce & weatherize the hose tower structure.
- Repair the steps.
- Provide access to the second floor of the station in accordance with the Americans with Disabilities Act.

Roof

The roof is a wood framed roof with masonry and wood bearing elements. The roof has a synthetic liner with a center draining system. The roof structure is showing signs of its age and is in disrepair. There are signs of water damage, joists are splitting, and settlement of the roof has occurred. Attached is a detailed description and evaluation of the roof structure.

From the evaluation the following recommendations were made for the rehabilitation of the roof:

- Repair/replace notched joists where the depth of the notch exceeds code
- Reinforce cracked joists
- Replace joists that have mid-span cracks
- Install solid blocking between joists at bearings.
- Reinforce truss top chord.

Masonry Facade

The masonry façade is composed of water-struck, Brick-Clay Masonry units. This masonry façade is in disrepair and in need of significant repair. The condition of the masonry is a product of its age and exposure to water, freeze thaw cycles and acid compounds in the rain reacting with the mortar. This level of deterioration is typical for masonry of this age in Maine. Attached is a detailed evaluation of the Brick façade.

Summary

The Town has worked very hard over the years to maintain and upgrade the fire station that was originally constructed to support horse drawn fire equipment. The Town is limited on the type, style and size of equipment that can be utilized from this location. Due to its age, the Town will likely need to perform significant repairs to the roof structure, the foundation, electrical system, masonry façade, replace windows, and upgrade the HVAC and emergency power systems. The building is also inefficient from an energy perspective due to the type of construction and materials used.

In addition, only the main floor is considered ADA accessible. If the Town chooses to invest significant money in the station to rehabilitate it, the Town would be required to make all possible efforts to make the second floor ADA complaint, OR, to relocate all activities currently occurring on the second floor. It is important to note that to comply with the Americans with Disabilities Act, the Program (all included functions, facilities, services), needs to be accessible. And since this is a fire station, employment is part of the Program meaning employees need to have access to all aspects of the Program.

The Town would likely need to install an elevator, either exterior to the building or interior, or, a platform wheel chair lift to comply with the ADA.

Preliminary Cost Estimate

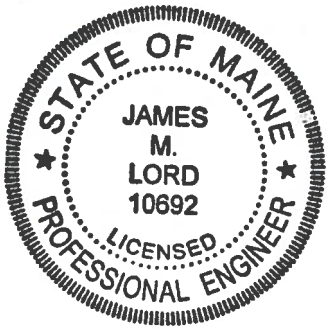
Attached is a detailed cost estimate for all recommended improvements. Below is a summary of the costs:

General Building Repairs/Improvements	$207,000
Roof System Rehabilitation	$75,000
Masonry Façade Rehabilitation	$71,300
Other Costs (engineering, contingency, permitting, etc.)	$101,500
Total Estimated Fire Station Rehabilitation Costs	**$454,800**

Closing

We hope this provides you with the Information you need. We would be happy to meet with you to discuss these findings further.

Sincerely,
Dirigo Engineering



James M. Lord, P.E.
Project Manager

enclosures

DIRIGO ENGINEERING
2 Dirigo Drive • Fairfield, Maine 04937 • 207-453-2401

01/14/14
#42504

Preliminary Project Cost Estimate
Fire Station Rehabiliation
Town of Skowhegan

Construction Costs:

NO.	ITEM		TOTAL
General Building			
1	New Heating System		$25,000
2	New Generator		$20,000
3	Foundation Repairs		$15,000
4	Electrical System Upgrades		$40,000
5	Window Replacement Allowance		$20,000
6	Bollards		$4,000
7	Hose Tower Reinforcement & Weatherization		$5,000
8	Granite Step Repair		$3,000
9	ADA Accessability Allowance		$75,000
		Sub Total - General Building	**$207,000**
Roof System			
1	Structural Improvements to Joist System		$40,000
2	New Roof Liner		$30,000
3	Roof Drainage System Improvements		$5,000
		Sub Total - Roof System	**$75,000**
Masonry Façade			
1	Façade Repair		$57,800
2	Roof Flashing Repairs		$3,500
3	Chimney Rebuild		$10,000
		Sub Total - Masonry	**$71,300**
		Sub Total - Construction Costs	**$353,300**
Other Costs			
	Engineering		$64,000
	Contingency		$35,000
	Permitting		$2,500
		Sub Total Other Costs	**$101,500.00**
		Total Estimated Project Costs	**$454,800.00**

DRAFT 2

2013.12.20 FRE-00215834-A0

Mr. Randy Butler
Dirigo Engineering
2 Dirigo Drive
Fairfield, Maine, 04937

Re: Skowhegan Fire Station

Dear Mr. Butler:

1.0 INTRODUCTION

At the request of Dirigo Engineering, exp Services Inc. was retained to conduct the following scope of work for the Skowhegan Fire Station:

- Review photos, data and documentation relating to the fire station as provided by Dirigo Engineering and comment on observations made.
- Comment on the building in relation to current building code.
- Structural evaluation of existing building roof framing.
- Provide recommendations.
- Written report summarizing the above.

The building was constructed in 1904 and in general consists of a wood framed roof with masonry and wood bearing elements.

2.0 REVIEW PHOTOS, DATA AND DOCUMENTATION

A review of roof framing photos supplied by Dirigo was carried out. Refer to Photos in Appendix A. The following observations were made:

- There appears to have been water previous leakage as staining was noted on joists in several photos (Photos 1-2).
- Many of the joists notched at bearing points are split (Photos 3-4).
- Many joists are warped at bearing points due to lack of solid blocking between joists (Photo 5).
- One joist has an interior span split nearly completely though the joist (Photo 6).
- Some truss top chords are severely checked (split) due to drying shrinkage (Photo 7-8).

3.0 EXISTING BUILDING IN RELATION TO CURRENT BUILDING CODE

It is not known if the fire station was designed and constructed according to any building code, however given the age of the building it is unlikely. Existing building structures are governed by IBC 2009 Chapter 34 - Existing Structures. The chapter covers additions, alterations or repairs to existing

structures. The Chapter states that existing structures do not have to comply with current building code except for the following conditions:

- Change of use or occupancy.
- Alterations that would increase the seismic force by more than 10% or decrease seismic force resistance by more than 5%.
- Building addition that would increase the seismic force by more than 10% or decrease seismic force resistance by more than 5%.
- Additions or alterations that would increase the force in any structural element by more than 5%, unless the increased forces are still in compliance with the code for new structures.
- Repairs to deficient individual structural elements. These repairs have to be done according to current code requirements.

It also should be noted that many older structures, especially timber and/or masonry framed buildings such as the fire station do not have a defined lateral load resisting system (LLRS). However, walls not intended to act as part of a LLRS may in fact be doing so, therefore even minor modifications such as putting penetrations through walls could be considered as triggering an evaluation and a possible code upgrade.

4.0 STRUCTURAL EVALUATION OF EXISTING ROOF FRAMING

The building roof framing as-built is per field information gathered by Dirigo Engineering and is shown on Dirigo drawings 1-4 found in Appendix B.

The structural analysis was conducted using the following assumptions:

- Roof dead load:
  - Roof membrane 1.0 PSF
  - Insulation 2.0 PSF
  - 7/8” wood deck 3.0 PSF
  - Joists @ 16” cc 4.0 PSF
  - Misc. 2.0 PSF
  - **TOTAL** **12.0 PSF**

- Lumber species – Spruce and pine (per Dirigo).
- Ground snow load, p_g = 90 PSF (per Dirigo).
- Building code – International Building Code (IBC) 2009.
- Timber design code – NDS 2005, ASD Method.
- Timber design data per NDS for Spruce-Pine-Fir #1/#2 species combination.
- Risk Category per Table 1.5-1 of ASCE 7-10 *Minimum Design Loads For Buildings and Other Structures:* **IV - Essential Facility**.

Four design criteria checks were done for each joist – Bending, Shear, Deflection and bearing. The results of the design check for the roof joists are as follows:

CRITERIA	JOIST (SPF)					
	R1	R2	R3	R4	R5a	R5b
SIZE	1 7/8 " X 10 3/4"	1 7/8 " X 10 3/4"	1 7/8 " X 10 3/4"	1 7/8 " X 10 3/4"	3" X 11 3/4"	3" X 11 1/2"
BENDING	85.0%	88.0%	87.0%	87.0%	92%	96%
SHEAR	40.0%	82.0%	*	*	43%	44%
DEFLECTION	42.0%	44.0%	43.0%	43.0%	60%	64%
BEARING	31.0%	32.0%	31.0%	31.0%	31%	31%

* - Indicates notch depth at bearing exceeds code allowable of 25% of joist depth.

Note: Values 100% or less are acceptable, values greater than 100% are not acceptable.

Joists R1 – R5 are below their stress limit with respect to bending, deflection and bearing. Joists R3 and R4 exceed the code limit for allowable depth of notch, which is 25% of depth maximum. Joists R1, R2 and R5 are within acceptable limits for notching and shear.

The results of the design check for the roof truss timber members indicate all members are within acceptable design limits except for the 7 ½" H x 7 ½" top chord members at each end of the truss. These members are overstressed in bending at 137%. Truss deflection is within acceptable limits. Note that truss connections were not evaluated.

5.0 RECOMMENDATIONS

1. Notched joists which are within code allowable notch depth but have cracked will need to be repaired.

2. It is recommended that notched joists which have not cracked be reinforced to prevent possible future cracking.

3. Notched R3 joists which are beyond code allowable notch depth will need to be repaired/reinforced.

4. Joists which have mid-span cracks, as noted in above observation of photos will need to be replaced.

5. Install solid blocking between joists at bearings.

6. Joists R1, R2 and R3 are near 100% stress in bending.

7. The truss top chord end members require reinforcement.

6.0 CLOSING

Trusting the above has addressed your requirements to this stage. If you would like to meet to discuss this report further, please contact me any time.

Sincerely,

Mark McCormick, P. Eng.
Structural Engineer/Project Manager

exp Services Inc.

Enclosures: Appendix A – Photos

Building Envelope Specialists
SPECIALIZED BUILDING CONSULTANTS

January 10, 2014

Dirgo Engineering
2 Dirgo Drive
Fairfield, Maine 04937

Re: Skowhegan Fire Station *Findings Report.*

Dear Mr. Butler,
As per your request, Building Envelope Specialists, (B.E.S.) has performed an assessment of the above grade masonry façade on the Skowhegan Fire Station. The visual assessment took place on December 16, 2013. The assessment was performed from the ground with the aid of 40x binoculars to view the upper sections of the building. No aerial lifts were used to access upper sections of the building, no material was removed during the assessment, and no material from the building was tested as part of this report.

The purpose of this assessment was to determine the condition of the masonry assembly, define areas of concern within a *Findings Report* and include budget for proposed repairs.

The conclusions drawn within this report are based upon visual observations only. No laboratory testing aided in the formulation of the conclusions. Additional material testing and forensic exploration may be necessary in future phases to better define a scope for masonry assembly repairs.

Basic Building Information:

- Circa: 1904
- Foundation: Rough split granite below grade from Norridgewock, Maine.
- Base Course: Stippled finished salt & pepper granite from Norridgewock, Maine.
- Façade: Water-struck, Brick-Clay Masonry Units. 7 ¾" long x 2 ¼" high x 3 ¼" thick.
- Face Brick Pattern: Running bond with Row Locks every 8 horizontal courses.
- Face Brick Mortar: Brownish tint, soft & porous.
- Sub-surface Brick Mortar: White in color, hard, less porous.
- Joint Width: ¼" +
- Wall Thickness: +- 12 ¼" or 3 wythe with two 1" collar joints within wall assembly. The only location that varies from this is the recessed area of masonry below the upper roof over hanging soffit. The wall is only 2 wythe thick in this location.

Observations:

- The mortar joints within the brick assembly adjacent to the granite base course along the front of the building are deteriorated as evidenced in **Plate #1.** This is due to differential moisture absorption values between the clay brick masonry and the granite base. As moisture infiltrates the brick assembly during weather events, it migrates downward through capillary action allowing some reduction through normal evaporation. The moisture migration slows greatly when in comes in contact with the granite base course, thus creating a "head" or "reservoir" of moisture within the brick assembly. The rate of evaporation is far less than the moisture being added into the assembly thus creating a higher concentration of moisture against the granite base. Concentrations of moisture within a masonry assembly will produce moisture heads with enough hydrostatic pressure to continue the wetting process. Along the eastern half of the United States, this moisture is laden with sulphurous acids from fossil fuel burning plants to the west, natural salts such as Sodium Sulphate that were absorbed by the evaporation

of ground water or Potassium Carbonate found in fly ash in the atmosphere. As these contaminates enter into the masonry assembly, their interaction with the assembly's setting mortar have a varying degree of negative effects. The most common result of this interaction is the deterioration of the lime component of existing setting mortar. When sulphurous acid comes into contact with 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. As 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. The actions and reactions described have caused the mortar to weaken under the pressures of material deterioration. Freeze/thaw pressures during seasonal changes aggravate the process. As the moisture slowly leaches out or its vapor migrates out of the assembly, the joint to falls because the components are no-longer one.

- Many mortar joints at the granite window-sills are missing or open as shown in **Plate #2.** These opening are allowing moisture to infiltrate into the brick assembly below the window units causing damage to the mortar component of the wall.
- As evidenced in **Plate #3**, some areas of mortar deterioration may be caused by heat-loss through variations in the wall assembly in and around penetrations or openings. Heated atmospheres contain a level of moisture. As the interior face of the brick assembly warms, the heat will migrate toward the exterior face of the wall. At the point in the assembly where the warm interior mass is adjacent to the cold exterior mass condensation will form. This condensation added to the inherent level of moisture within the interior space and storm related moisture infiltration from exterior sources creates a similar head of moisture as described under Plate #1. If the assembly is a given area varies in some micro fashion from adjacent assemblies, deterioration to the mortar as well as other building material may spike. This seams to be a logical explanation for this isolated damage.
- **Plate #4** highlights an area of the masonry assembly that has fractured at the mortar joints. The wall thickness is only 2 wythes in this area. As the mortar at the collar joint ages, it shrinks and becomes unbounded to adjacent masonry. Because the collar joint is 1" wide, any shrinkage is exaggerated within the cavity, thus its evidenced by failure at the wall's weakest point…the mortar joint. This type of failure is also present at the building's diagonally opposite corner.
- The short knee wall at the left entrance stairs is in poor condition as evidenced in **Plate #5**. The assembly is leaning and rolled away from the plain of the building wall. Additionally, the mortar along the wall's base to the left of the knee wall is deteriorated due to the conditions outlined under Plate #1.
- **Plate #6** highlights area of the assembly on the building's north elevation that has fractured. This damage was caused by the expansion of the clay masonry units at the window infill. All clay brick units spend a life absorbing moisture. Units of different ages absorb moisture at different rates. The rule of thumb is the new the unit, the higher the rate of absorption. As the clay units absorb moisture, they will expand in size vertically as well as horizontally. Although this growth is slight, is does exert pressure on adjacent materials and assemblies. If this pressure cannot find relief at an expansion joint, it will find relief at the wall's weakest point. In the case of this building, this point is the aging mortar. Hence, the result is the fracture that is present within the area indicated.
- **Plates #7 & 8** highlight areas on the building that have deteriorated pointing mortar due to the exposure of the masonry profile. Features such as belt courses, keystones and window arches that create a horizontal plain to the mortar joint profile all show deterioration.

- **Plate #9** highlights an area of masonry at the base of the hose tower that has fractured. This fracture appears to be caused by moisture infiltrating into the assembly at or below grade, thus causing damage to the mortar component of the assembly and allowing the driving force for damaged caused by freeze/thaw action. The exterior face pointing is in poor condition on the balance of the wall's face, thus reducing the wall's ability to impede further moisture infiltration.
- **Plate #10** documents the gap that existing between the granite door threshold and the bituminous coating on the entrance ramp. The gap is approximately 3/8" wide and is allowing moisture to infiltration into the basement space, which is causing damage the concrete floor slab. Additionally, the **Plate #10** shows the original coal shoot cover, which there is evidence of moisture infiltrating around and through it as well.

Approximate Repair Budgets:

• Conditions similar to **Plate #1:** 4 conditions total:	$1,000.00
• Conditions similar to **Plate #2:** 4 conditions total:	$500.00
• Conditions similar to **Plate #3, 7 & 8:** 2,000 sf total:	$36,000.00
• Conditions similar to **Plate #4:** Stitch & repoint 2 corners total:	$3,000.00
• Conditions similar to **Plate #5:** Rebuild 40 s.f. total:	$3,000.00
• Conditions similar to **Plate #6:** Stitch & repoint 80 s.f. total:	$4,800.00
• Conditions similar to **Plate #9:** Stitch & repoint 2 sides total:	$5,000.00
• Conditions similar to **Plate #10:** Install gap Filler 3 locations total:	$4,500.00
• Roof Flashing Repairs:	$3,500.00
• Rebuild Chimney:	$10,000.00
Repair Budget Estimate:	$71,300.00
Project Contingency @ 10%	$7,130.00
Total Project Budget:	**$78,430.00**

Exclusions:

- Foundation work.
- New roofs & flashings.
- Repair Documents & Specifications.
- Project Management.

Note: The budget prices included in this assessment are intended to provide the client with "best-guess" budget pricing for planning purposes. They are not intended to reflect an actuarial estimate for the scope outlined. In order to receive more accurate estimates, BES would need to develop detailed repair drawings and specifications.

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.

Plate #1

Mortar deterioration due to differential moisture absorption values between the clay brick masonry and the granite base.

Plate #2

Many mortar joints at the granite window sills are missing or open.

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

Plate #3

Mortar deterioration may be due to differential heat loss out of the building in and around penetrations or opening.

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

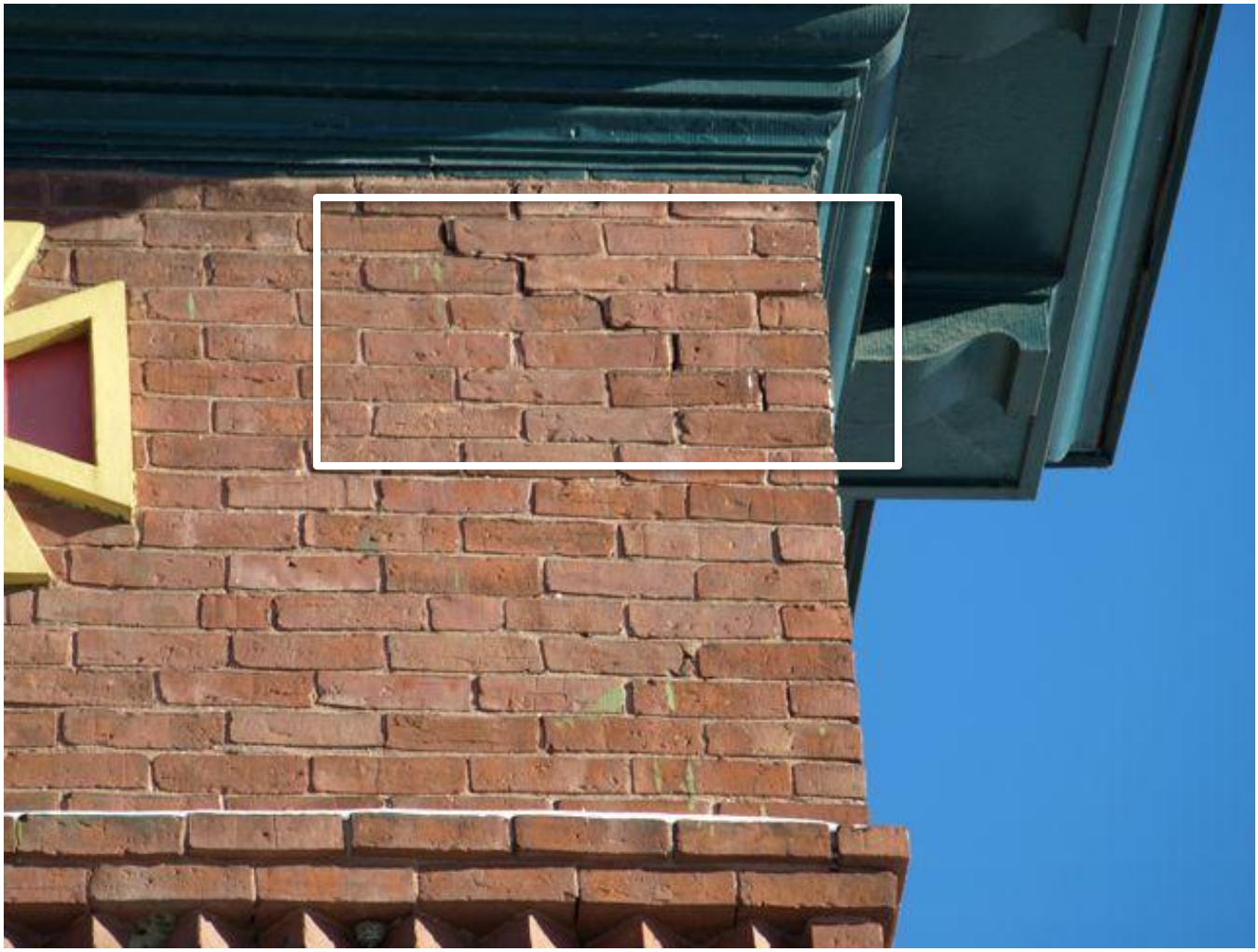


Plate #4
A fracture in the upper brick assembly is caused by the aging of the mortar within this 2 wythe wall section.

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

Plate #5
The short knee wall at the left exterior entrance stairs is in poor condition.

Plate #6
The assembly within this area is fractured due to the difference of expansion values between the original masonry and the new window infill.

Plate #7 **Plate #8**

The mortar joints within the highlighted pictures are deteriorating due to their protruding exposure from the plain of the adjacent masonry.

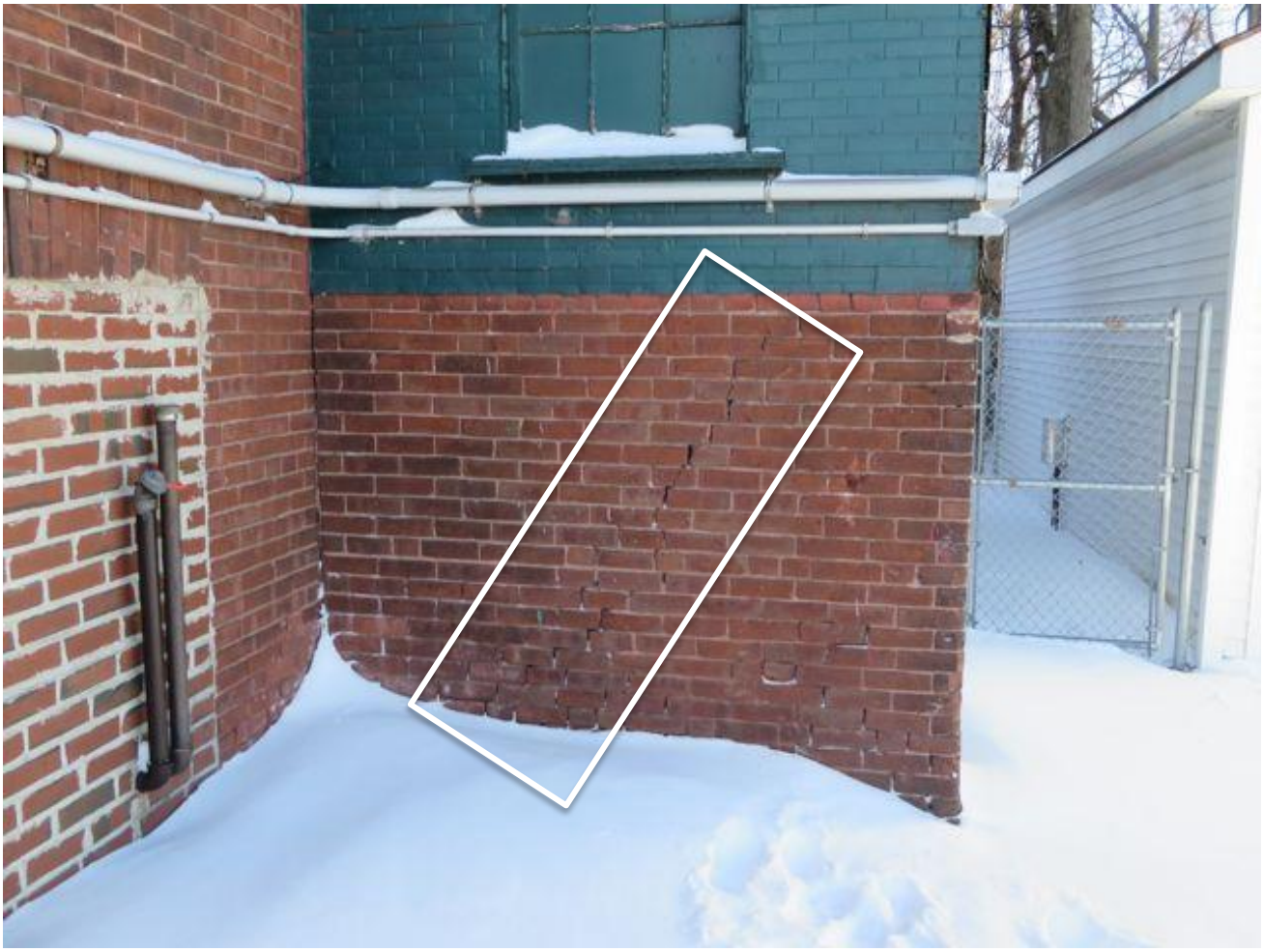


Plate #9
The assembly within this area is fractured due to moisture infiltration at or below grade.

Plate #10
The assembly within this area is fractured due to the difference of expansion values between the original masonry and the new window infill.