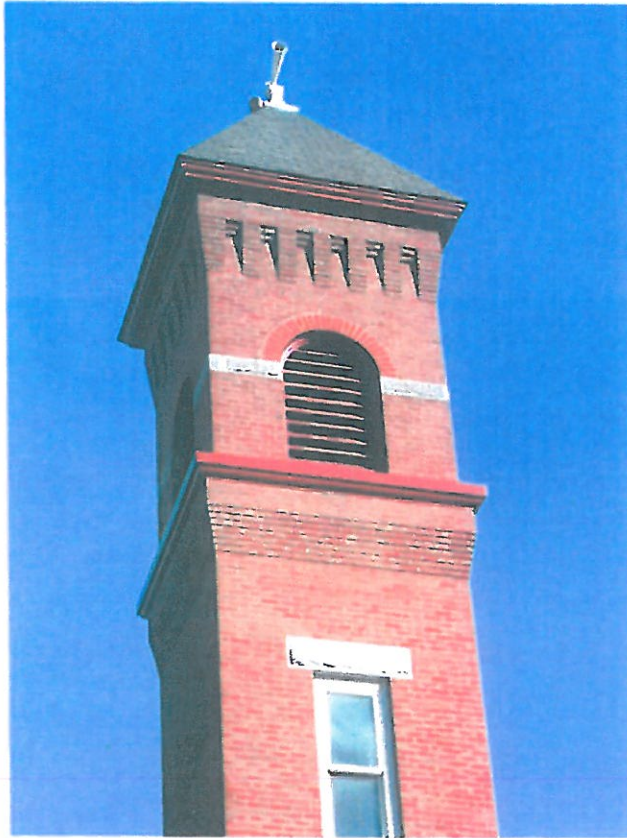


# Westborough Fire Station

Westborough, Massachusetts

## Building Structure - Limited Condition Survey

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Prepared for:  
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## Building Structure Limited Condition Survey

### A. Introduction

BVH Integrated Services, Inc. (BVH) has been commissioned by Jacunski Humes Architects, LLC to investigate and assess the condition of the structure of the Westborough Fire Station. BVH has visited the building to perform a limited visual inspection of the structure and gather available information related to repairs and additions to the structure. This report concentrates on the structure of the building and does not attempt to address architectural, MEP, code or life safety related items.

### B. Building History

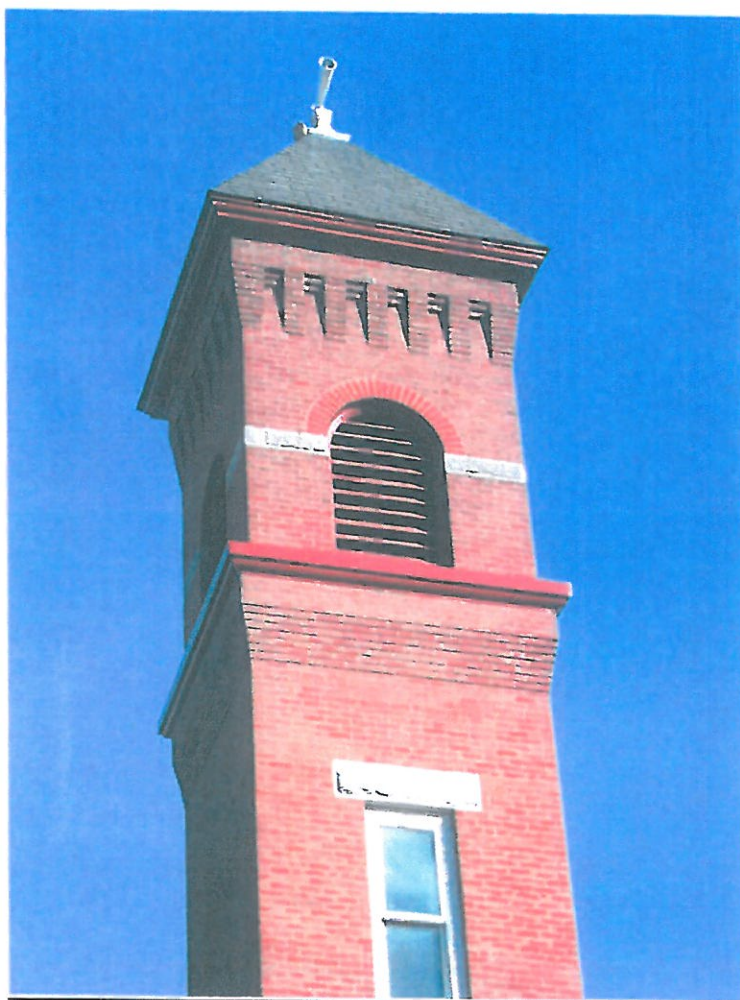
The original Fire Station structure was built in 1888 and is at the Southeastern corner of the present facility located at 42 Milk Street in Westborough, Massachusetts. The original structure includes load bearing, unreinforced brick masonry walls with a heavy timber framing for the second floor and roof. The ground floor apparatus bay framing appears to have been replaced with a cast-in-place concrete joist structure in the early 1900's. The basement walls are constructed with mortared stone rubble. The exterior masonry walls appear to be 3 brick wythes thick up to the second floor and 2 brick wythes above the second floor. Decorative dentil corbelling is detailed at the top of the wall.



Decorative Dentil Corbelling at South Elevation of the Original 1888 Building



The Hose Tower was constructed with the original building and is built with similar materials and details.



Hose Tower

#### 1978 Addition

An addition that included an ambulance bay and maintenance bay was constructed around 1978. The addition was constructed with load bearing concrete masonry units (CMU) with steel bar joist roof framing and metal roof deck. The roof framing for the addition is connected to and supported on the exterior wall construction of the original fire station.

Based on discussions with various Fire Station personnel, the original masonry arch construction at the East elevation of the original fire station was reconstructed to accommodate larger apparatus. The wall appears to have been reconstructed with 8" CMU backup with a brick veneer and granite lintels. The lintels span across an opening that accommodates two apparatus bays.

### 1988 Addition

A final addition that included an apparatus bay and dispatch on the ground floor and a training room and offices on the second floor was constructed in 1988. The addition was constructed with load bearing CMU exterior walls with a brick veneer. Floors were framed with 8 inch precast concrete planks supported on load bearing exterior walls and cast-in-place concrete beams supported on cast-in-place columns at the apparatus bay doors and apparatus bay. The roof was framed with dimensional lumber supported on a structural steel truss. A portion of this addition was constructed over the 1978 addition and required cast-in-place concrete beams to support the new construction. These beams are supported by and attached to the exterior load bearing masonry walls that were part of the original 1988 construction. As part of the 1988 construction an areaway was added to the South elevation of the 1888 building and basement slab on grade was placed in the original 1888 building.



Concrete Beam at Maintenance Bay



Concrete Beam and Roof Deck at Ambulance Bay



### C. Previous Reports and Repairs

In 2001, the Maguire Group was retained to assess the condition of the exterior envelope of the original 1888 building and addressed the "bulging" masonry observed on the East elevation. The Maguire investigation included several exploratory cores, exploratory probes and investigated several repair options. The report concluded that water intrusion had allowed the mortar to disintegrate due to the leaching action of the lime in the original mortar. The areas that were identified as critical and in immediate danger included two areas of the dentil corbel and a portion of the Hose Tower. In these areas, the mortar was completely disintegrated and the bricks could be removed by hand. Other areas of the South wall were identified as progressing towards a dangerous condition.

Repairs that were investigated ranged from a temporary fix that removed the loose bricks and rebuilt the areas with the original bricks to a more long term solution that required the total removal and replacement of the wall. Based on the understanding that the building was to be replaced, Maguire prepared documents that included reconstruction of the critical areas, repointing of the South elevation and portions of the Hose Tower, new gutters, leaders and flashing and installation of drilled in masonry ties. The repairs were performed by Monaco Restorations, Inc and based on a review of the requisitions, it appears that all work was performed in a satisfactory manner and that a decision to not install the masonry anchors was made.



Repaired Decorative Corbel and New Rain Gutter/Leader

In 2005, the Maguire Group, Inc. was retained to investigate the cast-in-place Apparatus Bay floor of the original 1888 building to address the spalled concrete that was identified in the basement area below the Apparatus Bay. Investigation included cores through the slab, field observation, structural analysis, chloride ion testing and petrographic analysis of the concrete. The investigation concluded that the quality of the concrete was poor with very high water to cement ratio, soft cement paste with poor aggregate bond and low strength (1,900 to 2,200 psi). The poor quality of the concrete combined with the poor workmanship, that was made apparent by the excessive honeycombing and inadequate concrete cover over the reinforcing, was determined to be the root cause of the concrete deterioration. Chloride ion testing indicated that heightened chloride levels were found in the 3 inch topping slab that was identified in the core samples. Maguire's structural analysis concluded that a floor construction had sufficient capacity to support the required apparatus bay loads provided the concrete deterioration was halted. Based on their investigation and analysis, Maguire recommended a repair program that included removal loose/spalled concrete, application of a protective coating on exposed reinforcing, epoxy injection of cracked concrete, application of a specialized patching compound to spalled areas and placement of a protective urethane coating system to the surface of the apparatus bay floor. The spall repairs were performed by Monaco Restorations, Inc. The urethane protective coating was not applied to the apparatus bay floor.



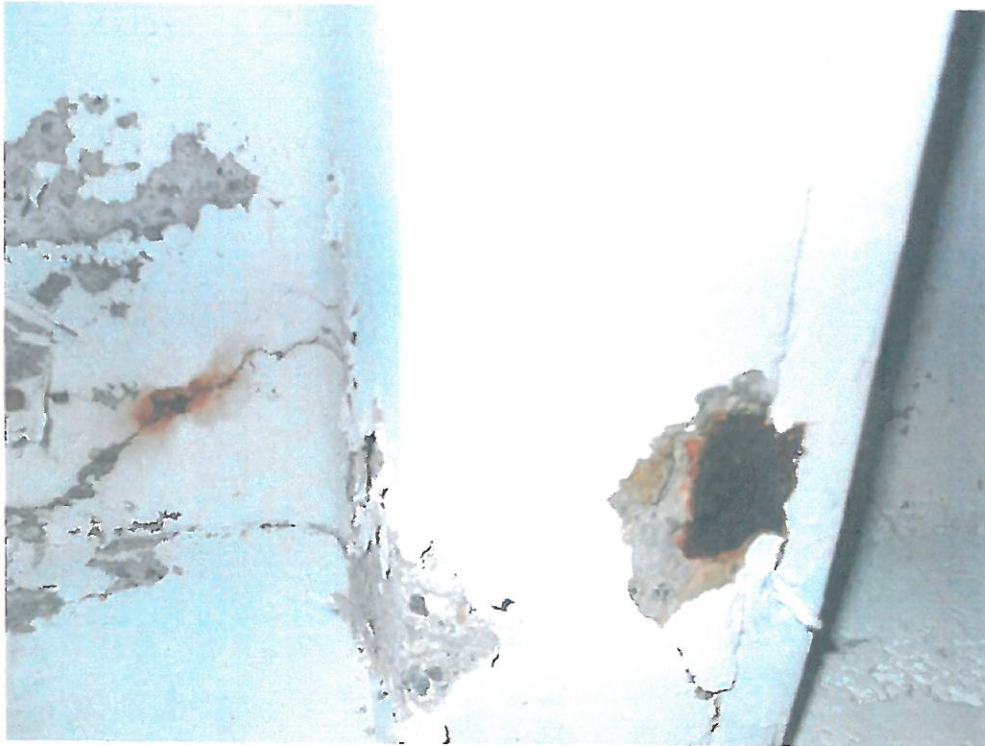
Repairs to Underside of Floor Structure



#### D. Visual Observations

BVH visited the site on November 16, 2010 and December 7, 2010 to perform a visual assessment of the existing structure. A review of the attic framing revealed no signs of structural overstress, deterioration or water infiltration. The second floor framing in the original 1888 building was not visible, but no signs of excessive floor deflection, floor bounce or wall cracking were apparent. The second floor and roof framing above the new apparatus bay, maintenance bay and ambulance bay was visible and there were no apparent signs of overstress, cracking or deterioration of the structure.

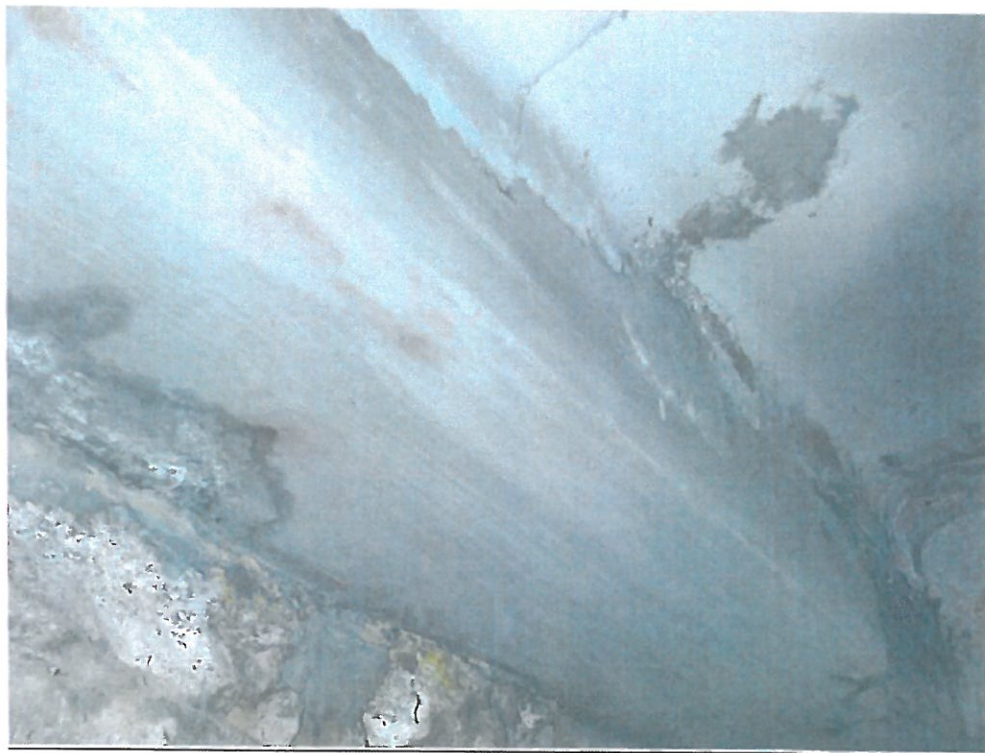
A review of the underside of the Apparatus Bay floor in the original 1888 building revealed honeycombing, minor cracking and minor spalling that was similar to the conditions noted in Maguire's 2005 report with no significant increase in the deterioration of the concrete structure.



Cracked and Spalled Concrete at Underside of Apparatus Bay Floor Slab

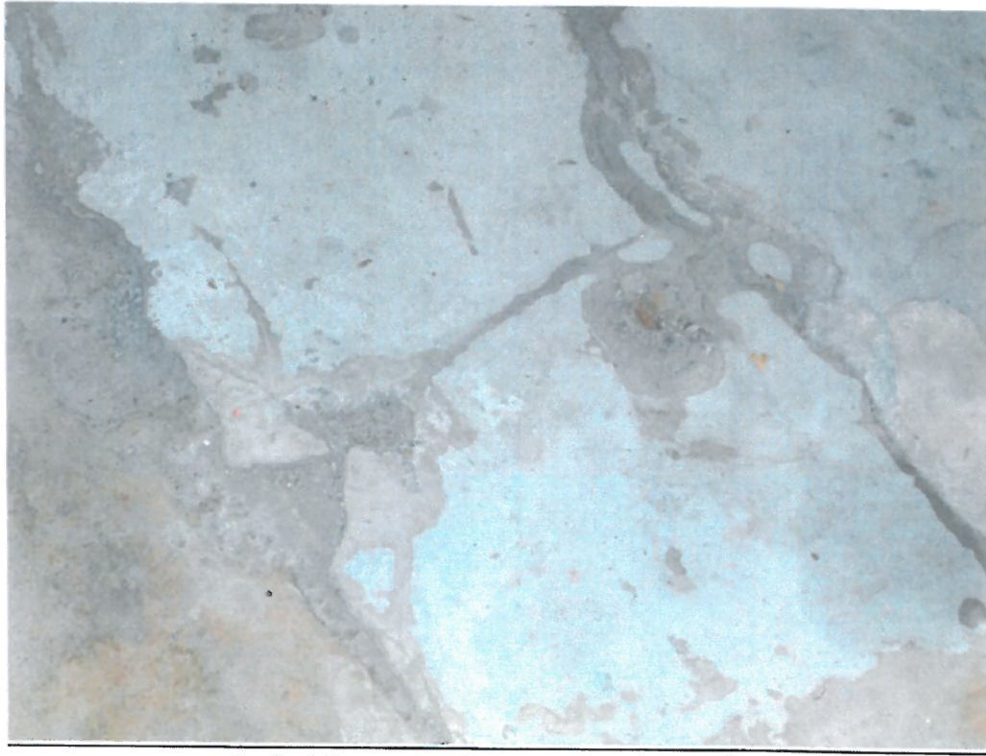


The repairs to the previously spalled concrete appeared to be performing well with no signs of additional concrete deterioration or spalling.



Concrete Repair

Deterioration and spalling of the floor surface of the Apparatus Bay was noted in several areas. The areas of slab surface that were patched to repair previous problems appeared to exhibit the most deterioration. Based on concrete cores that were part of Maguire's study, it appears that the surface deterioration is occurring in the 3" non-structural topping slab.



Spalled Concrete at Apparatus Bay Floor Surface

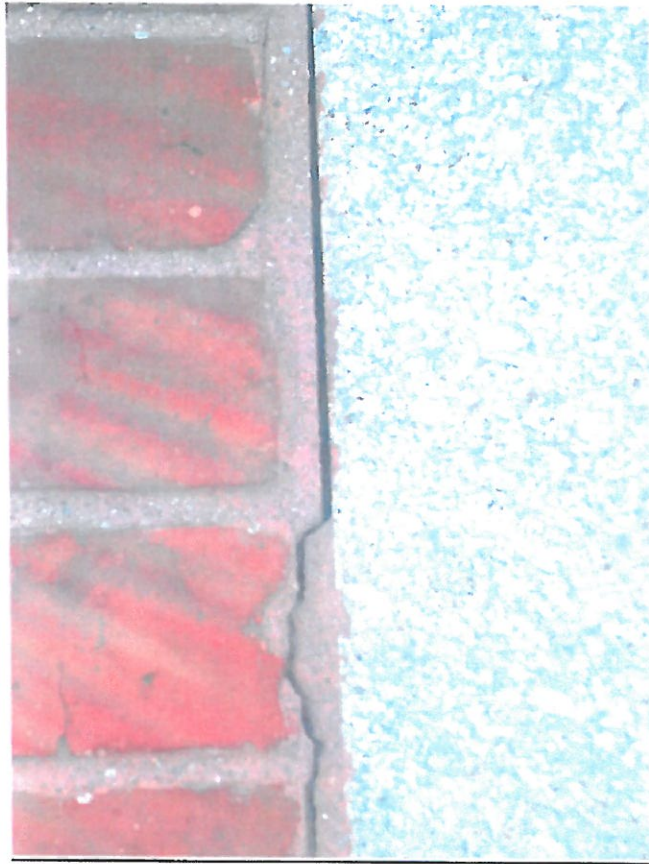
It was noted by Fire Station personnel that the trucks are now washed down outside prior to being parked in the building. This wash down procedure will help to minimize the potential for additional chloride ion infiltration and help to prolong the life of the structure.



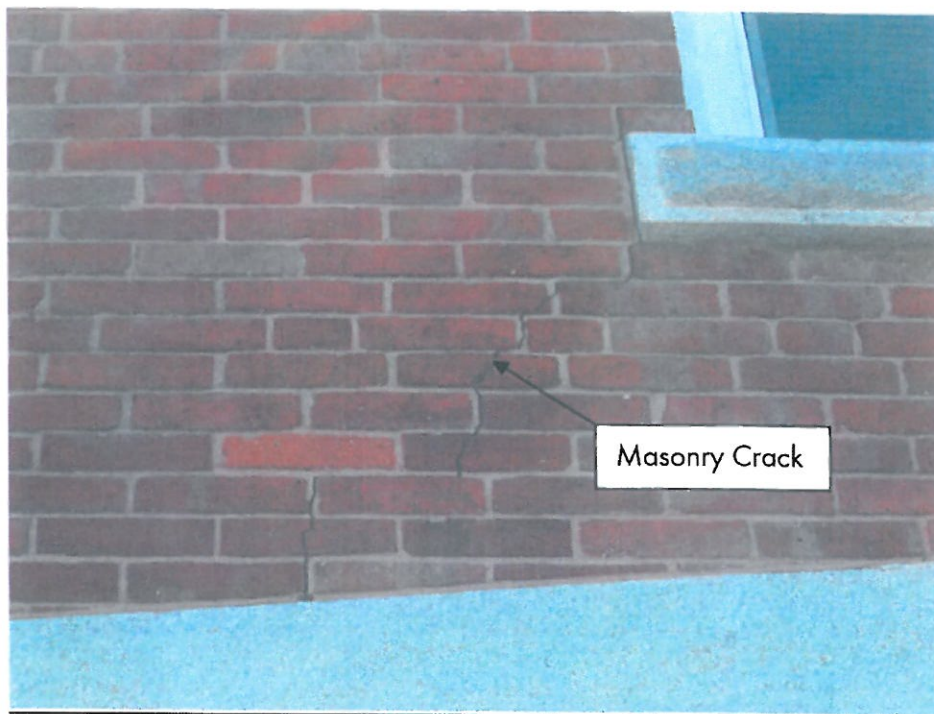
A review of the exterior of the buildings revealed several cracks in the exterior brick veneer. Cracks of significant size, up to 3/8", were noted on the East façade. The larger cracks have occurred at the jambs of the apparatus bay doors for the original 1888 building and the 1988 addition. The cracks extend horizontally over the head of the apparatus bay doors and extend diagonally to a window jamb or other opening in the wall construction. Smaller cracks were noted on the North and West elevations of the 1988 addition. All of cracks in the masonry veneer appear to be caused by lateral movement of the masonry veneer due to temperature changes and the absence of control joints in the veneer. Properly spaced control joints in the veneer would accommodate and control where the movement of the veneer occurs. Since no control joints were included, the reconstruction of the East elevation of the original 1888 building and no control joints were included in the construction of the 1988 addition the masonry has cracked where the stresses associated with the thermal variations are highest. At present, the cracks do not pose an immediate structural concern, but if left unaddressed the intrusion of water and potential freeze/thaw action could create a situation where the façade could be compromised.



Cracking and Separation at Precast Lintel of the 1988 Addition



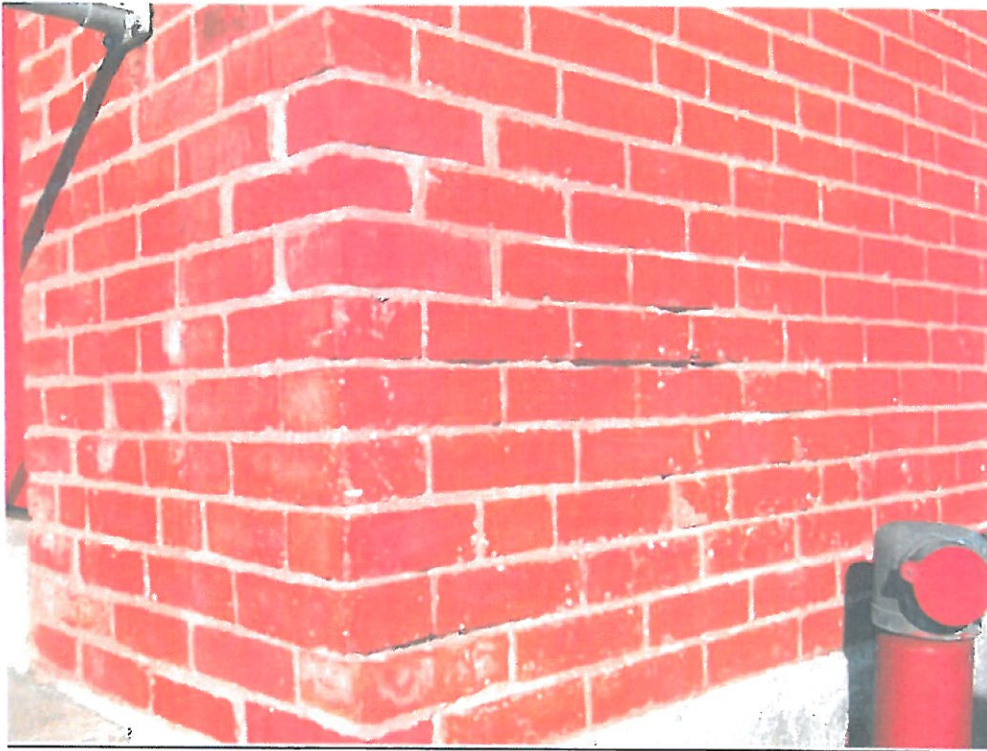
Crack at East Façade of Original 1888 Building



Masonry Crack at East Façade of Original 1888 Building



The repairs to the South elevation and Hose Tower masonry appears to be holding up well and show no signs of distress. At the Southwest corner of the South elevation a small area of the wall may have some minor deterioration of the mortar joints or the repointing in this area may not have been as complete as the surrounding areas.



Masonry Repair at Southwest Corner

#### E. Conclusions and Recommendations

With the exception of the Apparatus Bay floor construction and the cracks in the masonry façade, the overall condition of the remaining structure and associated elements are in good condition and should provide a serviceable structure that will require ongoing maintenance. Some of the maintenance will include regular inspections and repointing of the masonry, monitoring and recaulking of joints in the exterior walls and monitoring and maintaining the roof.

The concerns with the Apparatus Floor structure include the poor quality of concrete, the poor quality of workmanship, the on-going intrusion/build-up of chloride ions in the concrete and the compromised floor surface. If no additional repairs or improvements are implemented, it is likely that the floor structure will require major repairs within 5 to 10 years. The major repairs could include partial or full replacement of the structure with a cost range of \$200,000 to \$350,000, not including the cost of temporary space to park the apparatus, temporary mechanical systems and disruption to the Fire Station. The service life of the floor structure could be extended to 20 years by repairing all of the honeycombing and deterioration, removal and replacement of the spalled/deteriorated topping slab, application of a heavy duty floor sealer and regular maintenance of the repairs. The cost to implement these repairs and improvements could range from \$75,000 to \$100,000.



The concern with the cracks in the masonry veneers is that if the cracks and the movement causing the cracking are not addressed, then the masonry veneer could become unstable and partially fail. A temporary repair would include sealing the cracks with caulk on a regular basis. This would only be a temporary repair and would likely need to be addressed on a 6 month interval. A more permanent repair would require the installation of vertical control joints in the masonry veneer to allow the thermal movement to occur at a controlled location. The control joints would be installed within 5 feet of a corner and at 20 foot spacing along the wall length and should be coordinated with the existing wall openings. Once the joints are in place, the cracks in the masonry would be routed out and repointed. The caulking of the control joints would likely need to be addressed on a 5 year interval. The cost for this work could range from \$40,000 to \$60,000.

The final item related to the building structure is the lateral stability of the structure. As was common for all buildings built at the turn of the last century up through the 1980's, there were no accommodations for extreme environmental loading (i.e. seismic or wind) and the ability of an essential facility, such as the Fire Station, to remain functional through an extreme event. As such, the structure of the original 1888 Fire Station and subsequent additions were not designed or detailed to resist extreme wind or seismic events. The Current Massachusetts Building Code, 780 CMR Eighth Edition, utilizes the 2009 International Building Code and requires compliance with the 2009 International Existing Building Code with Massachusetts Amendments for any alterations, repairs, additions or change of occupancy. These codes will require an upgrade to the structure to address an extreme event if a major renovation is proposed or if the existing structure is modified in a manner that increases the stress or if any portion of the structure is demolished. As discussed previously, all of the various additions are connected to and are supported on the original 1888 construction. By constructing the additions in this manner, the structural stability of each addition relies on the adjacent construction for vertical and lateral support. Therefore the partial demolition of any portion of the existing structure would also require an upgrade to the remaining structure. Upgrading the existing structure to meet the code requirements for Category IV - Essential Facilities would be impractical based on the existing construction and the increased requirements associated with Essential Facilities that are to remain operational in the event of extreme environmental loading from flood, wind or earthquakes.

MUST  
MEET THE  
CODE FOR  
CATEGORY  
IV - GIVEN  
TYPE OF  
CONSTRUCTION  
THIS CANNOT  
BE  
ACCOMPLISHED.

We would like to thank you for giving us the opportunity to assist you with this assessment. Please contact us to review the details of this report and to answer any questions you may have.

Sincerely,

BVH Integrated Services, Inc.



Karl F. Frey, P.E.  
Vice President

2011-21-11-005-Westborough Fire Station Structural Analysis