CIVIL CONSULTANTS MEMORANDUM

TO: **Mr. Keith Trefethen – Town Manager, Town of Berwick**

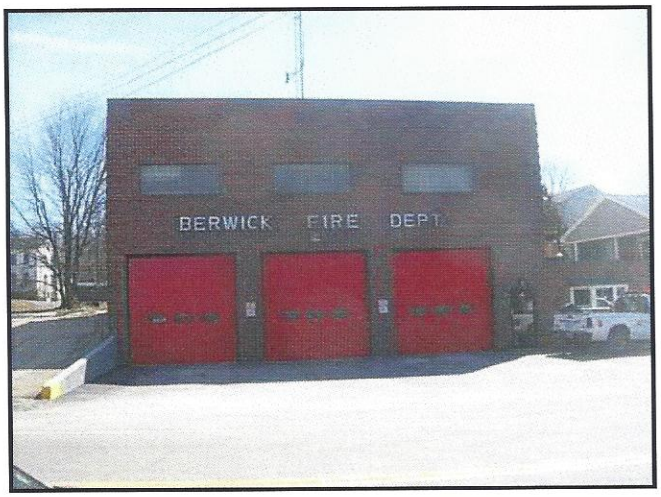
FROM: **Geoffrey R. Aleva, PE – Structural / Sr. Project Engineer**

SUBJECT: **Structural Evaluation of Town of Berwick Fire Station**

DATE: **APRIL 12, 2011**

PROJECT: **10-225.00 TOWN OF BERWICK / FIRE STATION**

Civil Consultants (CC) has completed a structural evaluation of the Town of Berwick Fire Station, located at 10 School Street, Berwick, ME. The information used in this analysis was obtained through site visits performed by Geoffrey R. Aleva, PE and Neil J. Rapoza, PE of Civil Consultants, South Berwick. CC staff performed visual inspections of the building condition and framing members. No destructive testing was performed, as it was determined not to be needed to evaluate the structural systems. CC also developed floor plans that provide dimensions, as wells as details of the existing building framing.



The Fire Station structure is a two story masonry block building with large door openings along the front (west elevation) for emergency vehicle access. This elevation has a brick façade, the remaining three sides are comprised of exposed masonry block. The foundation system is poured in place concrete. The second floor is framed with timber joists and steel beams. The flat roof is framed with horizontal chord timber trusses spaced approximately 6 feet on center. A single story radio room addition is located off the southern elevation of the building. Construction plans for the structure were not available.

The exact age of the structure is not known, but based on the construction type; the building is approximately 40 to 50 years old. This type of structure was usually designed for a service life of approximately 50 to 60 years. The concrete block masonry and wood frame exhibit stress and age cracks throughout the building perimeter and roof system. The structure is nearing the end of its design life as exhibited by the structural concerns outlined below.

Evaluation of the building structural systems was performed using published standards and engineering opinion. For analysis, building loads were generated using the 2009 International Building Code. The timber framing analysis was performed using the requirements of the 2005 NDS for Wood Construction. The computer analysis of the roof trusses was performed using StaadPRO structural modeling software.

GENERAL STRUCTURAL SYSTEMS:

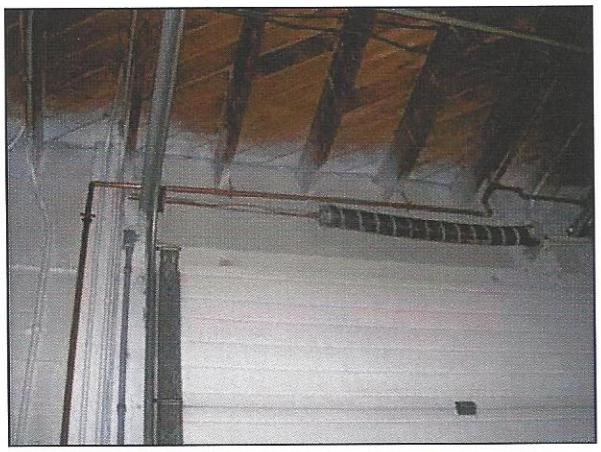
A visual inspection of the exterior of the building reveals that the windows and associated flashing are not performing well. There are indications of water infiltration into the walls in several areas. The exterior bearing walls are of concrete masonry construction. Deterioration of mortar joints is prevalent, and paint spalling was common along the exterior walls.

Existing framing plans were created to evaluate the capacity of the structure. The second floor framing was observed to be 2x10 joists at 16" on center, supported by W18x35 steel beams. The roof is supported by timber trusses with 2x6 chords and webs, with a truss spacing of 6'-0" on center. The second floor and roof decking is composed of 1 ½" timber planks.

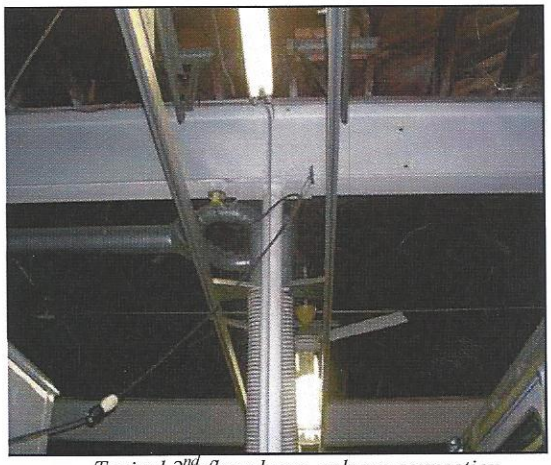
SECOND FLOOR FRAMING:

Analysis of the second floor joists indicates a maximum safe floor live loading of 38-40 psf (pounds per square foot) in the open function/classroom area.

Using current building code standards, the area is assumed to be a heavily loaded classroom and should be capable of supporting 50 psf. Inspection of the joists does not indicate any failed members. It was observed during the inspection that the floor exhibits noticeable flexing under normal use due to the long spans.



Typical 2nd floor joist bearing at CMU wall.



Typical 2nd floor beam-column connection.

The steel beams supporting the joists have adequate capacity to support the minimum live load, but are not connected to the supporting pilasters. This lack of connection is unacceptable and should be addressed through the installation of anchors or brackets having a secure connection to the pilasters and/or CMU wall.

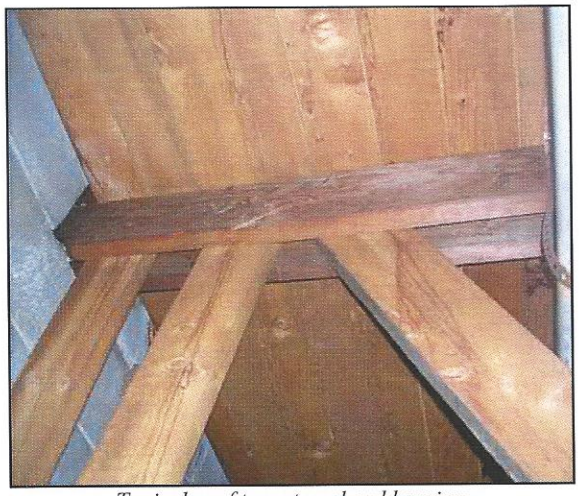
ROOF TRUSSES:

The review of the roof trusses reveals several issues that are of significant concern. The wood trusses are fabricated with dimensional lumber bolted and nailed together with doubled top and bottom chords. The department staff indicates that during winter months when snow is on the roof, large cracking and popping sounds are heard.

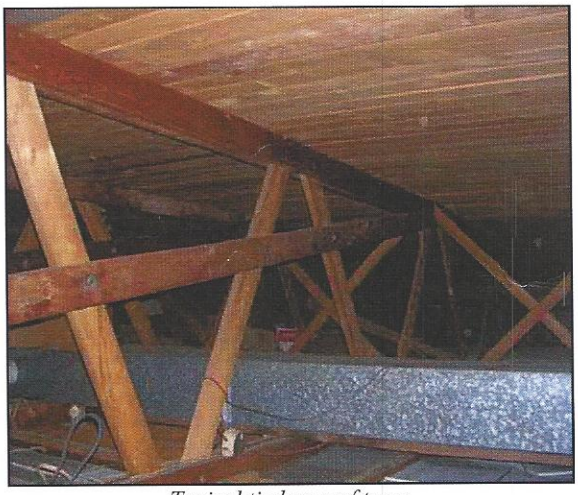
Review of eight of the twelve trusses reveal damaged and failing connections. The wood members are cracked through connections in several locations. These cracks compromise the load capacity of the truss members and roofing system. See the photographs and plans attached for details of the damaged truss members.

Analysis of the roof framing indicates that the existing 2x6 trusses are not adequate to support the current code minimum snow load. The capacity of the trusses has been further reduced due to cracking and splitting caused by poor timber quality and excessive stresses. Several truss members have failed and are no longer capable of carrying load, resulting in greater stresses in adjacent members and instability of the truss as a whole.

As noted in the previous report, moisture staining was observed in many areas of the roof framing, with the majority of truss members at the CMU wall exhibiting signs of exposure to water. While significant damage of the bearing ends was not evident, the presence of moisture has reduced the capacity of the timber in these locations.

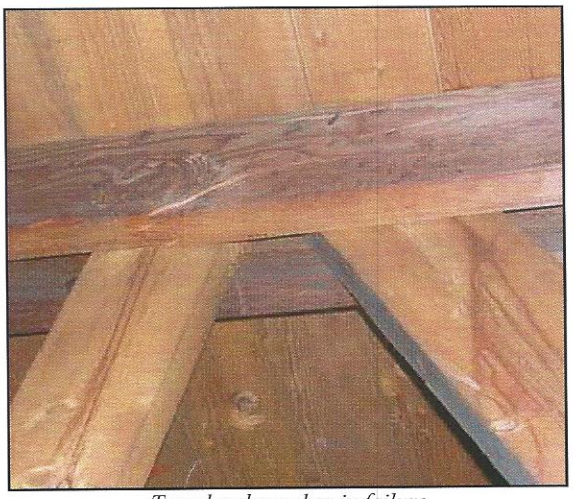


Typical roof truss top chord bearing.

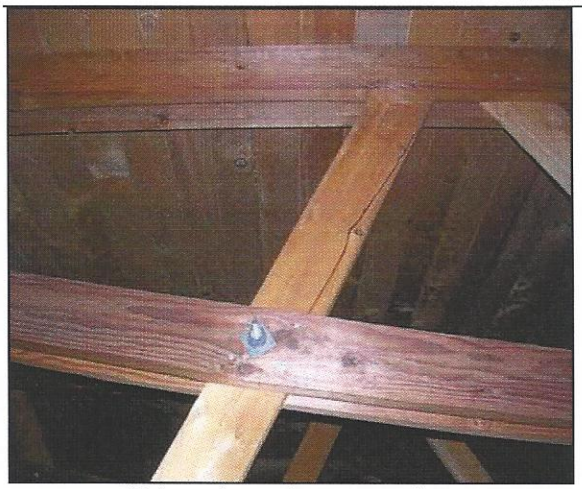


Typical timber roof truss.

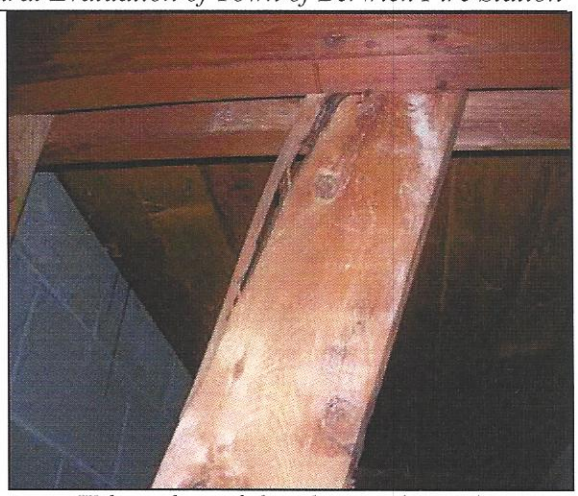
Bottom chord member in failure.



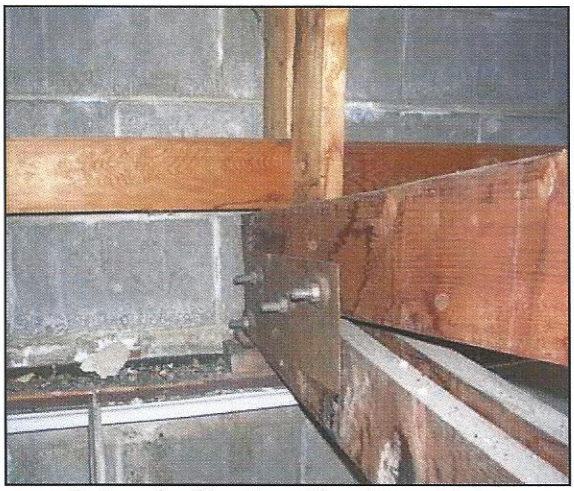
Top chord member in failure.



Web member with severe cracking.



Web member in failure due to timber quality.



Bottom chord bearing with moisture staining.

The renovation to the trusses will be expensive. The redistribution of the stress due to the damage truss members has significantly reduced the load capacity. The probable renovation strategy is truss replacement. This renovation work needs to be balanced with other code required improvements.

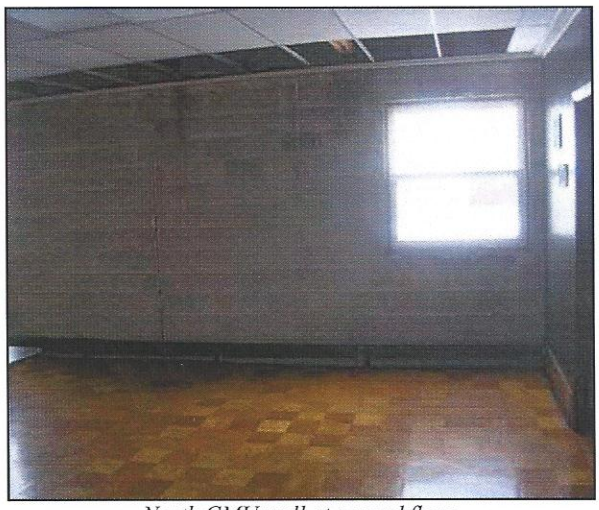
CMU / EXTERIOR WALLS:

Non-destructive testing using a James Instruments Reinforcing Data Scanner indicated that no vertical reinforcing steel is present in the walls. There was an indication that horizontal "ladder" type reinforcement had been installed at 16" on center. Although this is not out of the ordinary for this age of construction, the lack of reinforcing is not acceptable for an essential structure such as the fire station. The reinforcing provides lateral support to resist high winds and seismic loadings.

The visual inspection of the building from the main floor level reveals numerous vertical and staggered cracks along the masonry walls and concrete foundations. These types of cracks are characteristic of a building of this age. Typically, buildings of this age and type have minimal reinforcing in the concrete block walls. Over time, due to age, weather and settlement, the mortar

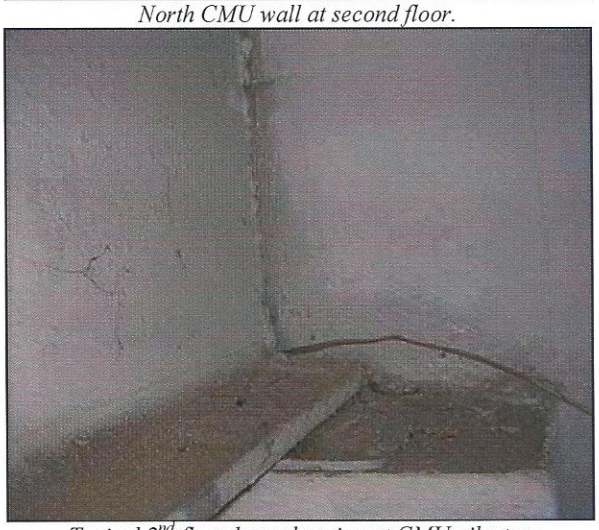
joints can deteriorate. This deterioration allows moisture to enter the building which leads to an accelerated decline in the stability of the concrete block wall system. This deterioration is evidenced by cracks in the mortar joints, staggered joints and delamination of the block. Once the block has reached this stage of deterioration, the rehabilitation costs can be prohibitive.

The second floor steel beams bear on steel columns in the truck bay and on CMU pilasters at each end. There was no connection observed at the beam/pilaster location, making the beams susceptible to lateral movement.



North CMU wall at second floor.

Cracking visible at front CMU wall.



Typical 2nd floor beam bearing at CMU pilaster.

Typically, buildings of this type of construction were not planned with seismic (earthquake) loading as a design consideration. This appears to be the case with this structure, as exhibited by the lack of vertical wall steel or anchorage of the frame to the exterior wall.

Non-destructive testing was inconclusive for the presence of reinforcement in the bond beams at truss bearing points, due to interference from nearby joint ladder type reinforcement. However, it is assumed that at least minimal steel was installed in these locations per common practice.

The Fire Chief indicates that the building experiences significant moisture leaks along the northeastern corner of the building during most rain events. He indicates that this section of the

building is unusable for several days and department staff cleans the area to prevent mold growth due to the water infiltration. It is our understanding that interior remediation work was completed. The exterior of the building and window penetrations should be addressed or this damage could occur again.

At some point the expansion joints were filled with mortar instead of flexible sealants. This rigid system does not allow the CMU system to expand and contract during thermal changes. This can lead to additional cracking and deterioration of the wall system. The control joints should be repaired while the building is continued to be used as the fire station. The thermal changes in the masonry are visible by the changes in the gap between the south chimney and the exterior wall.

The CMU cracks along the main entry door are typical for an under reinforced masonry wall. The cracks are caused by stress increases due to the floor framing and support of the main overhead doors.

The exterior brick work show signs of distress along the similar location of the interior block masonry. The cracks should be repaired to prevent further moisture intrusion. The repair should involve removal of the damaged mortar and replacement.

The exterior of the windows and flashing need to be addressed to reduce the potential for moisture infiltration. This can be accomplished through removal of the existing windows, installation of proper flashing, reinstallation of the windows and caulking the perimeter. This should be accomplished on the north elevation first since this side of the building experiences the majority of the moisture infiltration.

The exterior block surfaces should be scraped, loose and cracked mortar repaired and covered with a flexible breathable paint. This work should be considered a temporary measure until a long term solution is decided.

BUILDING CODE IMPLICATIONS

Per the 2009 International Building Code (IBC) this structure is considered an Essential Facility due its use as the fire station. This designation requires an additional increase in design loading to ensure that the facility remains operational during natural disasters and other emergencies. In order to renovate the existing building to meet these requirements, several major items need to be addressed as listed below.

- The exterior bearing wall needs to be rehabilitated to achieve the capacity to allow for the transfer of design wind and seismic forces. This would most likely require the design and installation of a supplementary steel frame on the interior of the building, potentially reducing usable space and creating interference with the existing floor plan and building utilities.

- The roof framing system would need to be replaced. This would require a new framing system to be installed over or in place of the existing. The new framing would then need to bear on the new appropriately designed wall/frame. It is not recommended that an attempt be made to repair the existing trusses, as analysis has shown that they were not adequate to carry the current code loading prior to the damage that is evident at this time.

- The second floor framing needs to be supplemented. Most likely this would be achieved by the installation of steel frames between the existing beam lines, along with the necessary pilasters and foundations for end bearing.

- Existing second floor beams need to be anchored to the exterior wall bearing locations. This would also include a closer investigation of the receiving pilasters to ensure their ability to support the new anchorage.

- The building needs to be updated to provide a more complete building envelope. There are currently many areas that could be improved in order to create a more efficient fire station structure.

Taking into account all of the repairs and modifications that would be necessary to bring the building up to current code standards and provide for a safe and reliable emergency response facility, a preliminary budget cost may be substantial (approximately $475,000 to $550,000). It is our recommendation that other options be explored and evaluated against rehabilitation in order to ensure that the Town obtains the most economical and safest facility.

Please refer to the attached plans and photographs for a detailed representation of observed issues and general condition of the existing building.

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