TIREY & ASSOCIATES, P.C.
CONSULTING STRUCTURAL ENGINEERS

November 6, 2009

Mr. Bob Veloski
Town Administrator
Town of Sanbornton
PO Box 124
Sanbornton, NH 03269

RE: Sanbornton Highway Garage Evaluation, Sanbornton, NH

Dear Mr. Veloski:

At your request, I visited and examined the existing Sanbornton Highway Garage on October 28, 2009 to visually evaluate its structural condition. John Thayer and Dave Nickerson were at the building and accompanied me during my examination, providing some background information in response to my questions. For purposes of this report, the side of the building containing the four overhead doors will be called the south side.

The highway garage is a single story building, 50' x 60' in size, constructed in about 1962. There is a small addition on the north side, east end. The building is partially buried on its north, east and west sides, as grade rises around the building from low at the south side to high at the north side. The foundations of the building are concrete, with foundation walls extending 4'-0" above the interior floor slab at all sides of the building. Masonry block walls are constructed on top of the concrete foundation walls. There is one interior load bearing masonry block wall that divides the 60' east-west length of the building into two sections of 1/4 and 3/4 of the total length. The roof is framed with precast concrete double tees for the long span and precast concrete plank for the short span. The roof membrane is a ballasted, EPDM rubber roof with no internal roof drains.

The precast concrete plank and double tee roof framing of the building is generally in good condition. There is little to no sign of water infiltration or deterioration of the concrete.

The roof membrane is estimated by John Thayer to be at least 10 years old. It is believed that there is not much insulation beneath the membrane, perhaps 1" or 2" of rigid insulation. The roof plane is general flat, with no slope to provide drainage for water. This leaves standing water on the roof, as was observed on the day of my visit. Over time, this can lead to water infiltration as the roof membrane ages and seams degrade. Someone tried to partially address this situation by cutting the top of the metal roof fascia panels at five locations on the north roof edge and folding down the metal to let water run off the north side of the roof. This has created a much larger problem, with deterioration of the wall where water has run down the wall face. Water has been absorbed into the masonry, cracking joints, corroding reinforcing steel, eroding the masonry face shells and permitting moss to grow in the mortar joints. The removal of water from the roof should be addressed in such a way as to not damage other portions of the building, as it does now. There are at least two different ways to address water removal, either with internal roof drains and piping or a properly designed external drainage system that does not dump water on the walls.

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The masonry block walls are in good to very poor condition, depending on which wall is being examined. It is clear from selected areas where block has been damaged, that there is no vertical reinforcing steel existing in the masonry walls, classifying the building as an unreinforced masonry block structure. There is horizontal wire reinforcing in the mortar joints. As an unreinforced masonry structure, the building is brittle and will not perform well in a dynamic lateral load event, such as an earthquake. This is an important consideration, given the occupancy and usage of the building.

The masonry walls have no vertical control joints in them to limit cracking resulting from normal longitudinal thermal movement of the block. This leads to crack locations in the block at weak locations in the walls.

The south wall of the building has three 4'-0" high concrete piers with concrete masonry block piers on top, running up to the band beam that runs around the entire building at a height of 12'-0" above the floor. These three piers are located between the four overhead doors. Neither the concrete nor the masonry of these piers is reinforced with vertical steel bars. There are short wall returns at the east and west ends of the south wall.

The easterly of these three piers has been hit by a vehicle or equipment, breaking off the base of the concrete part of the pier and pushing it inward about 2". This amount of lateral movement is evidence of the lack of vertical reinforcing steel in the pier. The horizontal joint between the top of the concrete and the bottom of the masonry has also cracked, forming a hinge at the joint. The top of the masonry portion of the pier at the underside of the band beam is also severely cracked and partially displaced. **This pier has failed structurally and is both unstable and unsafe. It is in immediate need of replacement.** See attached photos 036, 022A, 023, 024 and 026.

The center of the three piers has also been hit by vehicles or equipment, although the damage is not as severe as the easterly pier. The exterior face shell of the lower two courses of masonry block, at the top of the concrete pier, are severely damaged, with loss of cross section that reduces the strength of this pier. The block is cracked at the top of the pier, with some lateral movement visible. The base of the concrete pier at the level of the floor slab is also cracked through the entire thickness of the pier, although lateral movement is only about 1/8". This pier is also in a state of structural failure and should be replaced as well. See attached photos 028, 029 and 033.

The westerly of the three piers, between the two westerly overhead doors, has also been struck by vehicles and equipment, creating cracks at the interface between the concrete and masonry block. Some of the lower courses of the block have large chips out of the surface. This pier has been slightly damaged structurally, making it much more vulnerable to future damage from impacts by vehicles or equipment.

The top of the masonry wall above the large west overhead door has a deteriorated mortar joint at the bottom of the top course of block. Because the concrete plank that forms the roof is at about the same elevation as this course of block, it is likely that the block is not the full width of the wall, but may be a “soap” course, or partial width, non-load bearing block. This course may also have a poor connection to the remainder of the wall, making it more susceptible to movement once the mortar joint has cracked and allowed moisture infiltration.

The north wall of the building has been damaged by water running off the roof and down the masonry wall. This condition has existed since the last re-roofing was completed. The water is being absorbed into the face shell of the block as well as the mortar joints. Freeze-thaw action is cracking the mortar joints and spalling the face shells of the block. The wall at each of the “scupper” locations has algae and moss growing either on the wall or in the mortar joints. The concrete band beam just to the east side of emergency egress hatch door, has had spalling of the concrete resulting from water corroding the reinforcing steel which has insufficient concrete cover to protect the steel. It appears there is less than ½" of concrete cover over the steel, when there should be at least 1½". As the exposed reinforcing steel continues to corrode with cycles of wetting and drying, it will exfoliate layers of expanding corroded steel, which will further crack and spall the concrete of the band beam.

While the north wall is not a gravity load bearing wall, since the roof framing spans parallel to it, the wall does provide lateral load resistance for forces applied in an east-west direction. The deterioration of the wall reduces its strength and therefore its load capacity.

The east and west masonry walls have some cracking in them, but the cracks do not significantly decrease the vertical load carrying capacity of the walls. At the west wall, the top course of block along the south half of the wall is cracked at the bottom mortar joint of the course and has pushed or moved outwards up to about ½". This top course is at about the same elevation as the precast concrete roof plank supported by the west wall. It is likely that this top course of block is a thin “soap” course, located on the end of the plank to visually finish the top of the wall, without carrying any load. There may be little or no attachment of the soap course to backup material to limit its movement. While the top course carries no load, its movement outward will lead it to become a falling hazard, a safety issue which will need to be addressed.

The overall structural condition of the building is fair, on a scale of poor, fair, good or excellent. While portions of the structure are in relatively good condition, other portions are in poor, failed and unstable condition.

As you work through your overall assessment of the building, there are other issues and factors to consider- some structural in nature and others not.

You have indicated that there is a desire to improve the thermal performance of the building to reduce heat loss and heating bills. If insulation is to be added to the roof, either from below or above the roof structural elements, please bear in mind that lower heat loss will lead to more snow accumulation on the roof due to less melting. More accumulation means higher seasonal loads, which may be greater than the original design capacity of the roof. This could lead to an overload and failure of the roof. Given that this building was designed and constructed before the first oil embargo of the late 1970's, its design roof snow load would likely not be as high as the values used today. The change in approaches to insulating buildings following that first oil embargo have resulted in re-evaluation of design snow loads and general increases in their values.

You have indicated that there is a proposal being considered to re-locate some of the piers between the overhead doors so that wider doors can be installed. Relocating the piers at a wider spacing will increase the bending forces and deflections of the concrete beam spanning over the door openings. If the reinforcing steel size and quantity and concrete strength can be determined for the concrete beam, an analysis will yield whether it is feasible to relocate the piers without major reinforcement or replacement of the concrete beams. Without knowing the reinforcing steel and concrete strength, it would not be prudent to just move the piers. Further, possible splice locations in reinforcing steel within the beams, if those locations can be determined, may preclude moving the piers.

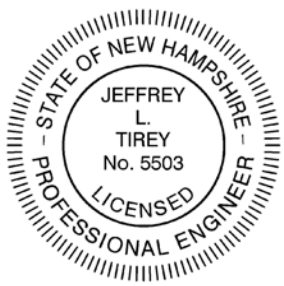
Another issue to consider is the use of the building relative to its existing construction. As stated above, the masonry block and at least some of the concrete, is not reinforced. This results in the building being brittle. It has little to no capacity to absorb dynamic loads, such as seismic loads, without significant damage and risk of total collapse. Many of the building collapses in the US during earthquake events have been of unreinforced masonry structures. Coupling this risk with the importance of the use of the building and its need to be available after such a seismic event, may lead your assessment to want a building more capable of surviving a dynamic load event without collapse.

There are numerous other factors which will play into your overall assessment of the building including ADA compliance, mechanical systems, ventilation systems, fire safety systems, space needs, roof water removal, to name a few. It is the combination of these additional factors with the structural condition of the building which will lead you to the decision of whether to salvage and renovate this building or replace it with one which meets today's design requirements and your needs.

Be advised that the south wall pier failures should be repaired/replaced immediately as they are unsafe and unstable. The concrete beam above the overhead doors on both sides of the piers should be temporarily shored to insure the short term safety of the structure until such time as structural integrity has been restored to the failed piers.

Please call if you have any questions or we can be of further assistance.

Truly Yours,



Jeffrey L. Tirey, P.E., SECB

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Enclosure

Photo 036: South face of garage building with 4 overhead doors. There is extensive structural damage to the concrete and masonry block pier between the two center doors and between the two right, or easterly, doors.

Photo 001: West wall of building. Note crack at bottom of top course of block, just below metal fascia, at southern half of wall. See detail photos 003 and 006.

Photo 007A: North wall of building, showing effects of water runoff from roof. See detail Photos 009, 010, 011, 012, 013 and 015. Note that the metal fascia has been cut and folded down at 5 locations (in red circles) to form scuppers for roof drainage.

Photo 017: East wall of building.

Photo 040: Typical precast concrete double tee roof framing bearing on masonry block wall at eastern 3/4 of building. Note concrete band beam two courses below bottom of tees.

Photo 047: Typical precast concrete plank shown at west exterior bearing wall. Note there are 3 full courses of masonry blocks above the concrete band beam plus a course of concrete masonry brick.

Photo 044A: General view of roof looking NW. Area of dark stone within yellow boundary has standing water on the roof.

Photo 003: Closer view of south half of west wall showing top, 4^{th} course of masonry above concrete band beam, cracked and laterally displaced to the outside from the wall below.

Photo 006: Close up of the west wall in Photo 003 showing about ½" of lateral displacement of the top course of masonry block. This course is located mostly at the thickness of the precast concrete plank roof inside.

Photo 009: Water damage to north wall of building where water is overflowing roof through "scupper" created through the metal fascia. Moss is growing in mortar joints which are cracked and permit water infiltration.

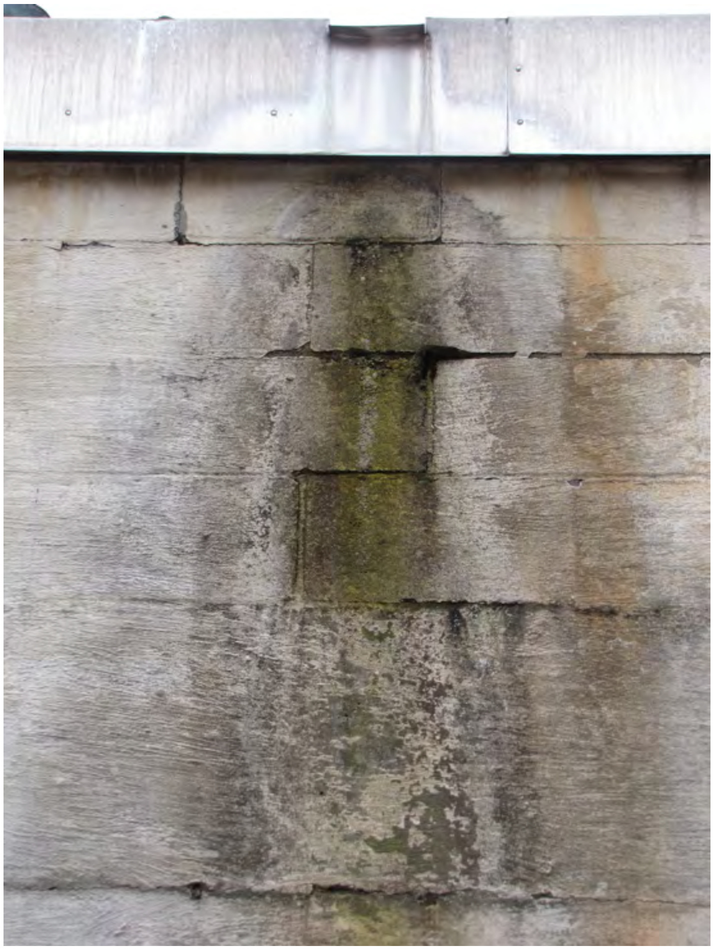

Photo 010: Water damage on north wall below "scupper" created through metal fascia. Algae and moss are growing on wall and mortar joints, respectively. Cracks in mortar joints permit water infiltration.

Photo 011: Significant water damage of north wall, on east side of emergency egress hatch door. Masonry is spalled and joints cracked. Note crack through concrete band beam.

Photo 012: Close up of Photo 011 at upper corner of hatch door. Masonry is so deteriorated a dull knife blade can push right through face shell. Note the bottom outside corner of the concrete band beam is spalled off (cracked and fallen off).

Photo 013: Close up of Photo 011 at the bottom of the crack in the concrete band beam. Reinforcing bar is visible where concrete has spalled off. There is insufficient concrete cover around the bar. Corrosion will cause continued cracking and concrete deterioration.

Photo 015: View of Photo 012 with knife removed. The masonry around the hole in the face shell crumbles in your hands.

Photo 018: North end of east wall showing cracked and loose block at corner.

Photo 021: Deteriorated masonry with hole in face shell of south end of east wall.

Photo 022A: South wall of building, looking west at pier between first two overhead doors. This pier was hit by a vehicle, cracking and dislodging the pier towards the inside of the building. Area in red circle has about 2" of movement.

Photo 023: Close up of Photo 022A showing extreme movement of concrete pier. This structure is unreinforced concrete. The pier is unstable and not safe.

Photo 024: Joint interface closeup of concrete to block, from Photo 022A. Note position of outside face of block of this pier relative to the pier beyond.

Photo 026: Top of masonry portion of pier between two eastern doors, as viewed from west side of pier. Cracking is severe, is not repairable, and must be replaced.

Photo 028: View of pier between two center overhead doors at top of concrete. Damage to masonry is likely due to impact by vehicles or equipment. Masonry has translated towards the inside of the building.

Photo 029: Crack in top of center pier between overhead doors, showing translation of block below top course.

Photo 033: Crack at bottom of concrete center pier at overhead doors. Shear crack results from lateral impact force on exterior face of pier.

Photo 038: SW corner of building showing deterioration of block and mortar joint at top course of block.