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April 22, 2012

Oyster River Cooperative School District  
36 Coe Drive  
Durham, NH 03824

Attn: Susan Caswell, Business Administrator

Re: Structural condition review and assessment  
Oyster River High School

Dear Ms Caswell;

Foley Buhl Roberts & Associates, Inc. (FBRA) has conducted a review of structural conditions at Oyster River High School, in accordance with our proposal to you dated February 29, 2012.

### **Executive Summary**

Two of the structural issues identified in the recent Facility Audit Report are not of any concern.

Generally, the remaining structural issues in the Facility Audit and the additional issues discovered in the course of this assessment are either secondary structural concerns or cosmetic in nature. With the possible exception of the snow load issues, the remaining concerns do not adversely affect the performance of the primary building structure.

Several of the remaining concerns relate to the installation of rooftop mechanical systems.

Further review of some of the conditions identified in this report should be conducted by appropriate parties other than a structural engineer. This work may include a building envelope consultant or a mechanical consultant, as appropriate.

In the case of the masonry wall cracks (observed at three locations), the services of a construction testing agency to install and monitor the cracks to detect any additional movement is recommended prior to undertaking repairs. This work is necessary, but not urgent.

Specific issues observed during the course of this review are described and discussed in this report.

At the request of the SAU #5 office, FBRA has also added commentary regarding roof snow load capacity to this report. Further assessment may be required to finalize that snow load evaluation. FBRA has included some initial maintenance recommendations as a result of the snow load evaluation work done for this report. These snow load issues are among the most important structural concerns described in this report.

In general, this review found no major or pervasive issues or concerns with regard to the condition or construction of the primary building structure. FBRA finds the concerns expressed in the Facility Audit Report pertaining to the structural quality of workmanship to be largely unfounded.

## **Background**

This review was requested by the District in response to observations, concerns and comments described in the Facility Audit Report completed in January 2012 by Acadia Engineers and Constructors (AEC). The AEC report was performed under the New Hampshire Local Audit Exchange Program developed by the NH Office of Energy and Planning. Accordingly the AEC report is an energy audit, and as such it deals primarily with building envelope and mechanical systems issues.

However, pages 33-34 of the AEC report identifies several "secondary observations", including several concerns of a structural nature that were observed within the school during the course of the audit. The report recommends review of these conditions by a structural engineer. This letter of report is intended to fulfill that recommendation.

## **Scope**

This review involved:

- Review of the AEC Facility Audit report.
- Discussion with school administrators and maintenance personnel.
- Review of the original structural construction drawings for the 2005 additions and renovations.
- Visual inspection of the building structure, involving two visits totaling approximately 7 hours on site. The areas of structural concern identified in the Facility Audit were specifically reviewed. Structural type and condition was also spot inspected throughout the building and compared with the original construction documents.
- Review of the available construction documentation on file at the SAU office.
- Roof snow load capacity was reviewed as an additional request made by the SAU office.

## **Review of AEC Audit Concerns**

1. AEC Audit, page 33, Figure 36 – "Structural Beam with Loose Bolted Flange Connection and No Fireproofing" and related text description on same page: This condition is not a concern. This condition and the photo are located at the northeast gym lobby (erroneously referred to as "west" in the AEC audit). The threaded rods are positional in nature and the corresponding holes in the beam flange are slotted. It is not necessary for the nuts in this connection to be torqued. Similar conditions exist elsewhere in the building where beams bear on masonry walls.

Fireproofing of this beam is not required. The building was designed under the 1999 BOCA Building Code as Type 3B Unprotected construction, with a fire suppression system.

2. AEC Audit, page 33, Figure 37 – "CMU Wall Plate with Missing Bolted Connections": This condition is not a concern. It appears there was an unresolved coordination issue between the architectural and structural plans. The structural plans indicate that the gym mechanical mezzanine was to extend northward over the northwest gym lobby. The architectural plans indicate that the northern limit of the mechanical mezzanine is south of this lobby. The masonry walls were evidently constructed in accordance with the structural plans, but the mezzanine was constructed per the architectural plans. These bearing plates were provided in this wall to support the mezzanine floor beams over the lobby area, per the structural drawings. When the mezzanine was shortened, these plates were abandoned in place. The plates have no detrimental effect on the wall construction.

3. AEC Audit, Page 33, third paragraph under "Structural Systems", regarding vertical wall cracks: FBRA is not certain which specific masonry wall crack location is referred to in this paragraph. This uncertainty may be caused by the apparent confusion over the compass orientation of the building. However, vertical masonry cracks fitting this description were observed by FBRA in the north wall of the gymnasium and also in the Athletic Trainer's office. These cracks may be due to minor settlement (as noted in the AEC Audit), or they may result from temperature and shrinkage stresses in combination with an inadequate control joint pattern. In either case, FBRA concurs with AEC that the cracks are most likely not moving or active at this time. The Facility Audit recommendation that the cracks be gauged and periodically monitored by a testing agency is appropriate. If this monitoring indicates that conditions are unchanged after a period of 1 to 2 years, then the cracks can be permanently repaired by re-pointing.

The crack observed in the north wall of the gymnasium occurs over the bleachers and extends upward to and through the fire alarm beacon on this wall. There is a vertical control joint in the masonry immediately adjacent to the crack, but the joint was ineffective at preventing the crack. It is likely that the horizontal wall reinforcement was extended across the control joint, rendering it ineffective.

Additional masonry wall cracking issues were observed by FBRA and are discussed later in this report.

4. AEC Audit, Page 33, last paragraph, AHU-4 framing: FBRA generally agrees with the AEC Audit comments. It appears that the dimensions of the rooftop steel frame were not coordinated with the dimensions of the mechanical unit. (This may have been due to a late change in the unit size or manufacturer). In any event, the longitudinal beams supporting the north and south sides of the unit were installed at a wider spacing than what was indicated on the steel shop drawings. This was done to correctly align those beams beneath the long sides of the rooftop unit. The cross beam at the west end of the rooftop unit was fabricated too short (it would have been too short even if the original spacing dimension between the longitudinal beams had been correct.) Ten framing connections were field modified to correct these conditions. Modifications to these beams included adding a 6" long welded-on web extension to the short cross beam. The ten affected framing connections were originally intended to be bolted, but the dimensional modifications required that the final connections be field welded.

The welded modifications described above are judged to be structurally adequate, but they are poorly done with regard to their cosmetic appearance and corrosion resistance. The cosmetic appearance may not be a major concern given the location of this unit.

However the steel plate that was used to extend the short beam was not galvanized material. That plate now exhibits surface corrosion. The framing connections were originally intended to be bolted (not welded) because welding destroys the galvanized finish on the steel, leaving it susceptible to corrosion. The field adjustments to the frame dimensions made welded connections necessary. Typically, field welding of steel connections on galvanized AHU frames is discouraged for this reason. Corrosion is now evident to varying degrees in the welds and in the steel components in the vicinity of the welds.

At this time, the corrosion is still superficial and the structural capacity of the frame has not been adversely affected. FBRA recommends hand tool cleaning of the connections and the beam extension plate, followed by field painting of the affected areas with a primer and finish coat compatible with galvanized steel finishes. If cosmetic improvement is a concern, then the existing connection welds should be ground smooth prior to painting.

See additional comments below regarding welding of AHU supports to the steel frames.

The AEC Audit comments related to the bolted fan and motor damping connections (page 34) are a mechanical equipment concern that was not reviewed by FBRA.

5. AEC Audit, page 34, second paragraph: "*Considering the identified issues and consistently reduced level of workmanship and quality, a structural systems evaluation by a NH licensed Professional Structural Engineer is recommended*". On the basis of this assessment, FBRA believes this is an overstatement. FBRA concurs that the vertical masonry wall cracks and AHU-4 support frame issues referred to on pages 33 and 34 of the AEC Audit are genuine concerns where monitoring, repair or remedial action are recommended. However our review of the entire school and the 2005 era work specifically does not support the contention that there is a "consistently reduced level of workmanship and quality in the building structure". FBRA did observe other issues and concerns in the course of our review, several of which relate to the installation or support of mechanical systems. Those additional concerns are enumerated below. However, with the exceptions of the defects noted above and our additional comments below, the condition of the building structure was observed to be generally good and construction was per the contract drawings. The defects noted in this report appear to be isolated concerns that are not reflective of the general structural conditions.

#### **Additional Observations**

The following are additional issues identified by FBRA in the course of this assessment.

1. Interior masonry wall step cracks, south wall of gymnasium, over central entry portal: Viewing this entry portal from the gymnasium, there is a step crack emanating from the upper left corner of the portal opening, extending upward and to the right. In addition, there is one block over the right jamb where the face shell apparently was removed (or displaced) out of the wall and the unit has been reinstalled in the wall.

The step crack is evidently due to temperature and shrinkage stresses in this wall. This wall has vertical control joints located at the  $\frac{1}{4}$  and  $\frac{3}{4}$  points along its length, but there is no vertical control joint at the  $\frac{1}{2}$  point (near this portal). Note that the north wall of the gym has three equally spaced control joints, including a joint at the  $\frac{1}{2}$  point. In the absence of a control joint, the step crack occurred at the minimum wall section (the portal) to relieve shrinkage stresses. This crack is most likely static and accordingly we expect that it can be re-pointed with a low likelihood that it will reoccur.

The reason for the displaced/repared face shell over the right jamb could not be ascertained during this assessment.

2. Floor slab crack between NE gym lobby and main corridor: This crack is expressed in the VCT floor finish. The crack occurs across the minimum slab section. Because of the floor finish, we were not able to determine if a control joint was provided along this line, or if the crack simply appeared across this minimum section. In either case, the relative movement across this line was not anticipated in the floor finish installation. (Note that the intended control joint pattern is not illustrated on the structural contract drawings).

FBRA recommends consultation with the architect about the possibility of adding a joint cover at this location.

3. Area C laboratory classrooms – lateral bracing configuration anomalies: The science labs along the east exterior wall on both the first and second floor levels in Area C occur in pairs. Each pair of labs has a prep room between the two labs. The two labs and the prep room are linked by an alcove. The alcoves are along the exterior wall of the building, at the rear of each lab. The alcoves have double doors to provide for separation of the two labs.

According to the original structural drawings, column lines CG and CX in this area contain structural steel bracing bays. If the structural drawings were correct, the bracing diagonals would cut across the alcove entry and be visible (obstructions) in the finish work. No such bracing is in evidence in the finished building.

**Update:** Construction documentation on file at the SAU office includes sketch SKS-22; part of a change directive issued by the original Structural Engineer of Record. This sketch depicts the reconfiguration of these bracing bays to avoid the alcove openings. This issue is resolved.

4. Library, SW corner, bent bracing rod at turnbuckle: The 2005 renovations included the addition of bracing rods to the glued laminated timber frames on the north and south sides of the pre-existing library. These rods are installed approximately 7 feet above the library floor. The rods are equipped with turnbuckles for adjustment purposes. One rod, located in the SW bay of the library, has a significant kink, occurring at the turnbuckle. This condition can and should be straightened, both as a structural and a cosmetic issue.
5. Typical rooftop Air Conditioning Condenser (ACC) unit supports. These units are installed on 4x4 pressure treated wood sleepers. The sleepers are approximately 8 feet long and the ends of the sleepers are bolted to a steel W6x25 sections that bear on rubber pads on the roofing membrane.

FBRA noted several instances where the 4x4 sleepers are split or sagging badly, and in one instance shims had been placed under the ACC unit because the 4x4 has essentially failed.

The entire assembly is not positively secured to the building roof and may therefore be vulnerable to wind storm damage. FBRA recommends that this support detail be reviewed by the original mechanical engineer to determine positive attachment to the roof is necessary. The support details for these units should be redesigned and modified to provide adequate support for the units.

6. Typical rooftop Laboratory Exhaust Fan (LEF) supports. These fans are also supported on short lengths of 4x4 sleepers. The entire assembly can be lifted off the roof or laterally displaced by a single person.

These units should be positively attached to the roof. The spring isolators that support these fan units are also irregularly installed.

7. AHU-1 steel rooftop support frame screen. AHU-1 has a red metal panel screen on the east side of the unit. This is intended as a visual screen to conceal the unit. The unit sits on a structural steel support frame, and the screen cantilevers off of the support frame.

There are angle braces that extend from the bottom edge of the screen up to the east side of the AHU frame. The southerlymost angle brace is absent entirely, although the connection tabs for

this brace exist at either end. Additionally, the horizontal cantilevered beams that support the screen are moment-connected (i.e., flanges are welded together) to the longitudinal beam that supports the east side of the AHU, but there are no similar moment connections attaching the backup beams to that longitudinal beam. As a result, the weight of the screen is carried by the longitudinal beam in torsion. It is doubtful that this was the designer's intent. The backup beams should also be moment-connected to the longitudinal beam.

8. Rooftop AHU-to-frame welding for all units supported on steel support frame systems or curbs: Typically, the AHUs are welded to the supporting steel (or to curbs) with field welds spaced approximately 2 feet on centers. These welds should be treated with a zinc rich paint to protect them from corrosion.
9. South exterior wall of auditorium stage, SE corner, viewed from adjacent low roof: This wall has a 4" concrete masonry block exterior veneer. The lower courses in the vicinity of this corner and just above the low roof level have been re-pointed at least twice previously. This is probably due to a concealed issue within this wall involving the flashing or the drainage of the wall cavity. FBRA recommends consultation with a building envelope consultant on this issue.

### **Construction Documentation Review**

The original construction drawings package was reviewed for this report. FBRA spot inspected the actual building to check for general conformance with the original contract drawings. The only significant anomaly noted was the C wing bracing at the science laboratory alcoves. A review of testing reports and construction correspondence records at the SAU office satisfactorily resolved the issue of the missing bracing at the science laboratory alcoves (item 3 above).

Those construction records also include shop drawings for the rooftop frame supporting AHU-4. Those shop drawings specify a 10'-0" spacing between the longitudinal beams that support the AHU. As installed, those beams are spaced at 10'-3", and as built the beams are correctly aligned beneath the long sides of the unit. It appears that the frame dimensions were not coordinated with the final rooftop unit dimensions. This discrepancy (3") is responsible for the field modification and welding of eight framing connections in the steel frame. Two additional connections also required welded modification due to the west end beam (beam 157C) having been fabricated 3" too short.

A review of the concrete testing reports indicates that generally the concrete delivered to the project met or exceeded the specified 3000 psi at 28 days design strength. In many instances, the test cylinders attained the specified strength in only 7 days.

The documentation indicates that there were issues with the masonry construction. Initial mortar and grout strengths were lower than the specified values. The documentation indicates that the Architect and Structural Engineer were aware of these issues and issued appropriate directives, including instructions to discontinue the use of a packaged site-mixed grout mix in favor of a truck-delivered grout. Testing requirements were increased in response to these issues (and subsequently decreased once the issues were resolved). Additional core samples were taken from completed masonry construction and the results were reviewed by the structural engineer. The Engineer also issued directives modifying the high lift grouting procedures being used by the masons. The records regarding these masonry issues are not entirely complete, but it is clear from this documentation that the general contractor, the mason, the clerk of the works, the testing agency, the architect and the structural engineer were all aware of these issues and that remedial direction was provided to correct these conditions.

## **Roof Snow Loads**

In addition to our original scope of services, FBRA was asked to comment on the school's roof snow load capacity.

The general notes on the original contract drawings indicate the 2005 additions were designed to comply with the 1999 BOCA Code and (by reference) ASCE 7-95. Those were the applicable codes in 2003, when the building additions were designed. The drawing notes specify a ground snow load of 60 psf (psf = pounds per square foot) and a resulting flat roof minimum design snow load capacity of 42 psf. Those figures are correct for the locale and the details of the building, per 1999 BOCA.

Present day design snow loads applicable to new construction are predicated on the IBC 2009 Code, with reference to ASCE 7-05 and to "Ground Snow Loads for New Hampshire" (the latter publication has been adopted by NH as an amendment to the State building code.). The applicable ground snow load today would be 55 psf, with a resulting flat roof minimum design snow load capacity of 42 psf.

This is an unusual instance, in that the current design standard result in the same flat roof snow load design capacity (42 psf) used for the design of the 2005 additions, despite the significant changes in the building codes over the intervening years.

For this review, FBRA conducted spot reviews of typical open web roof joists used in the 2005 additions in Areas B (26K6 joists), C (8K3 joists) and D (22K4 joists). Typically, these joists would control the roof snow load capacity in those areas. In all three cases we found that these joists were capable of supporting the 42 psf minimum snow load.

FBRA also reviewed the load diagrams used for design of the long span joists in the auditorium roof. The design load used for those joists is again consistent with the 42 psf standard.

Since the density of snow varies, it is not possible to accurately equate the design roof snow load to the depth of the snow on the roof. A relatively high density for water saturated snow would be around 25 pounds per square foot. At that density, the 42 psf load capacity would equate to a snow depth of approximately 20 inches.

However lower snow densities in the range of 11 to 13 pounds per square foot are common and would equate to a depth of snow of 3 feet or more.

For a very heavy rain-on-snow event, the 20 inch limitation might be advisable for this roof. Under more typical snow densities, the 2005 building additions should be capable of supporting flat roof snow loads of 24 to 30 inches. These figures apply to flat roof areas that are not subjected to snow drift accumulations. Accumulations that exceed these snow depths should be monitored and cleared from the roof, if necessary.

Computation of drifted snow loads on low roofs that are adjacent to higher sections of the building is another concern. Design loads for snow drifts can be several times the minimum flat roof snow load used in no-drift areas. The computed drift load varies depending on the applicable building code and the geometry of the roof. Provisions for snow drift loads appeared in the building codes in the 1970s. Accordingly, the 2005 additions were designed with provisions for drifted snow included on those roofs. However the older 1964 areas of the building were most likely not designed for drift considerations.

This school has numerous roof levels, each of which represent a potential snow drift condition.

Our review indicates that the low roof areas of the 2005 additions adjacent to taller sections of the building do include provision for snow drift loads in the design. This applies, for example, to the low roof areas immediately adjacent to the gymnasium and the auditorium.

The areas that are potentially a concern are those low roof areas of the building constructed in 1964 that are immediately adjacent to taller portions of the school. Two such areas are particularly noteworthy. These are:

- The 1964 roof construction over Area C, over the school lockers area on the west side of the central corridor. This roof is now adjacent to the three-story, 2005 classroom addition. Note that the original 1964 Tectum roof deck was replaced with steel deck on this Area C roof, but the original 16" deep open web joists were not supplemented during the 2005 renovations.
- The 1964 roof construction over one-story Area A where it is adjacent to the taller 1964 roof construction of the two-story Area C and also to the (taller) library.

Both of these areas should be further reviewed and the roof capacity should be quantified to determine their vulnerability to snow drift loads. Further evaluation is required to develop maximum drift height guidelines. Maintenance personnel should monitor snow drift accumulations along these particular high/low roof interfaces. Excessive drift accumulations in these areas should be removed.

## Conclusions

Some of the structural issues raised in the AEC Facility Audit are not of any concern. Of the remaining issues, the majority pertain to mechanical equipment installations on the roof.

The cracks in the masonry walls in the gymnasium and trainer's room should be monitored to determine if they are "active" (still moving ) or static conditions. This monitoring should be done by a testing agency, over a period of two years. If there is no further evidence of movement, these cracks can be re-pointed. These cracks appear to be the result of temperature and shrinkage stresses, combined with inadequate control joint spacing and detailing. We observed only three such cracks in the building.

The crack noted in the floor slab between the NE gymnasium entry lobby and the main corridor occurs at a predictable location. The construction drawings detail typical slab control joints, but no control joint layouts are illustrated. This problem is best addressed by replacing the flooring and providing a joint cover at this location.

The veneer issues at the SE corner of the auditorium should be reviewed by an architect or a building envelope consultant.

This report has raised additional concerns with regard to the installation of the ACC and LEF rooftop units. Those installations should be reviewed by the mechanical designer to insure that these units are adequately supported and secured.

**This review of the ORHS 2005 additions and renovations found only a limited number of structural issues, most of which were secondary in nature, or which related to architectural or mechanical concerns. Overall, we find the construction and level of workmanship and quality of the building structure is generally acceptable. FBRA recommends that the issues raised in this report be addressed or corrected, but we see no reason to be concerned regarding the integrity of the primary building structure.**

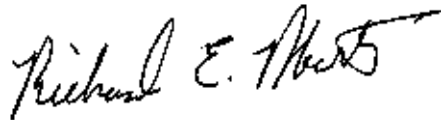


Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 9 of 18

We appreciate this opportunity to be of service to the Oyster River Cooperative School District.

Very truly yours,  
FOLEY BUHL ROBERTS & ASSOCIATES, INC.

A handwritten signature in black ink that reads "Richard E. Roberts". The signature is written in a cursive style with a long horizontal stroke at the end.

Richard E. Roberts, P.E.  
Vice President

Attached: Photos

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 10 of 18



Photo 1: Interior north wall of gymnasium at gym centerline: Step crack near fire beacon, above bleachers, does not follow the vertical control joint. (Control joint is visible at bottom right corner of this photo.)



Photo 2: Fabrication/MEP coordination error at AHU-4 RTU frame.



Photo 3: Step crack over central entry portal in S wall of gym.

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 12 of 18



Photo 4: CMU repair over entry portal, S wall of gym.



Photo 5: Science lab: Diagonal brace at alcove not per construction drawings (relocation of brace was approved by the SER during construction).

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 13 of 18



Photo 6: Kink in diagonal bracing rod at Library.

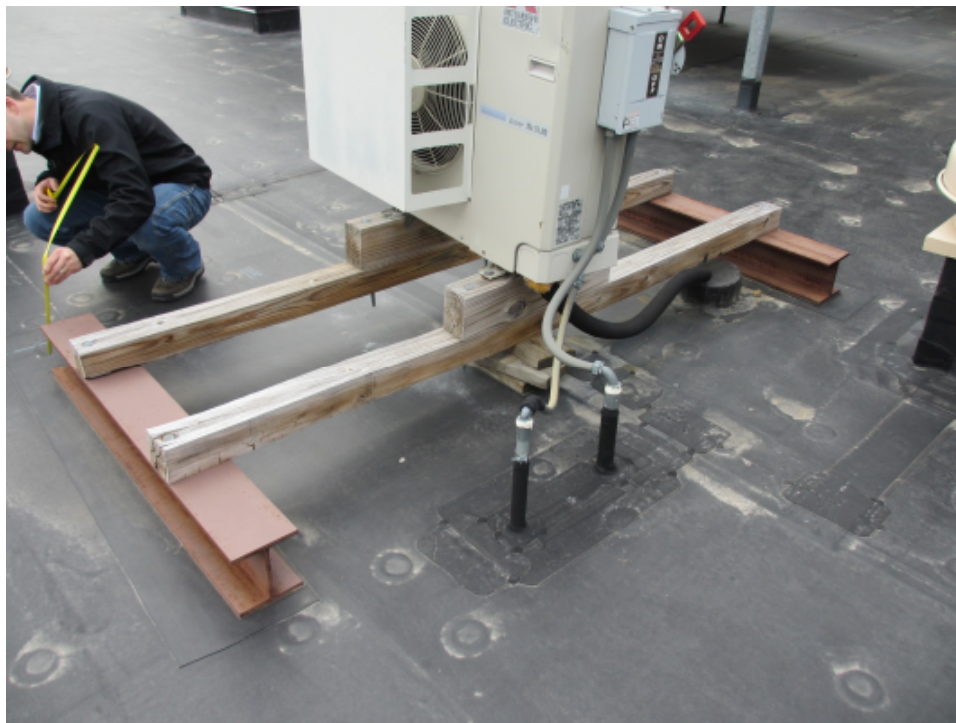


Photo 7: Typical rooftop ACC installation. Note shoring under wood sleeper. Installation has no positive attachment to the roof structure.

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 14 of 18



Photo 8: Typical rooftop LEF installations, unsecured, on wood sleepers.

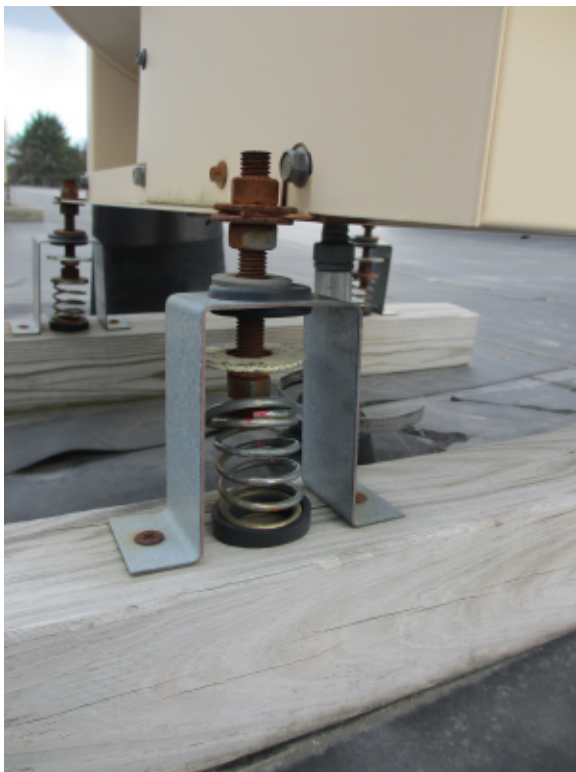


Photo 9: LEF spring isolator detail.



Photo 10: Dunnage frame at AHU-1, cantilevered screen is to the left. Note moment connection (welded top flange) is provided for the beam coming in from the left, but is not provided on the beam to the right.

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 16 of 18



Photo 11: AHU-1 rooftop frame – note bracing angle to bottom of screen.



Photo 12: AHU-1 rooftop frame – note missing bracing angle.



Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 17 of 18



Photo 13: Welds on AHU frames should be treated with zinc rich paint to retard corrosion.



Photo 14: Exterior wall at SE corner of auditorium: CMU veneer has been re-pointed at least twice. This is likely indicative of a wall cavity drainage issue at this corner.

Oyster River Cooperative School District  
**Oyster River High School**  
Structural review and assessment

April 22, 2012  
Page 18 of 18

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**End of Report Photos**