Case Study - Insulation

Lyman House Weatherization Project: Insulation

A Component of Energy Retrofit project supported by Massachusetts Department of Energy Resources

Work completed April 2012

Pre-Work

Statement of Condition

There was no insulation of any kind in the Lyman House. The installation of insulation was considered an important component of the retrofit project in order to achieve a 50% reduction in energy use. Due to the nature of infringement on building fabric as a part of any insulation project the use of insulation for the house was limited to the attic spaces.

Treatment Plan (scope of work)

The simple plan was to remove the floor boards of the third floor and blow in dense pack cellulose insulation in the joist bays. The complexities of that plan are detailed under the **Work** section below.

Dense pack cellulose was chosen over batt insulation due to both the general accessibility of the space and the varied sizes of the spaces. To properly install batt insulation would require the removal of all the flooring on the third floor. Blown in cellulose would require the removal of select floor boards. Additionally, joist spacing was known to be varied and thus would require extensive cutting and piecing together of the batt insulation. This high labor component would negatively impact the budget and the invasion on historic fabric would be high. As a bonus to the decision, dense pack cellulose provides additional air sealing capabilities in its ability to closely pack around any openings in the ceiling spaces.

Philosophical Approach

As the building has a center core of three stories plus attic and two wings of two stories plus attic, the general idea of ñinsulating the atticò is challenging as thermal breaks between the core and the wings would have to be established since the insulation would be effectively at two different levels.

While the third floor space is large and broken up into functional rooms, egress from the space is limited. To legitimately use the third floor space for offices would require the implementation of a second means of egress. The window openings on the third floor are too small to accommodate a temporary rope type ladder for egress, the provision of a second means of egress would be significantly impactful on the building architecturally and aesthetically. Thus, the third floor was determined to be unconditioned space, suitable for storage only.

Setting the third floor as unconditioned space allowed for the insulation plane to be over the second floor of the wings and center core. A thermal break was still required in the ballroom area as the ballroom space is two levels, exposing approximately 3ô of conditioned office space to unconditioned space over the ballroom.

Work

Work Performed

Large voids (>1ò) between the second and third floor caused by electrical, plumbing, and data runs were reversibly ñsealedò with the use of Roxul insulation. Roxul is a rock-based mineral fiber insulation comprised of basalt rock and recycled slag. It has advantages over fiberglass with its ability to be moisture resistant and vapor permeable. As such, if it does become wet, once dry it will regain its original performance characteristics whereas fiberglass will not.

The use of a highly compressed porous foam (CC Expanding Sealer) was used to seal accessible gaps that were less than 1ò in diameter. This foam has a light adhesive backing to hold in position over the 1-3 hour expansion time. The foam slowly expands to mold into the opening space, conforming to the irregularities of the opening.

The voids adjacent to the chimney in the ballroom attic space were covered with foil backed foam board.

CC Expanding Sealer expands into opening created for plumbing and data cables

Roxul insulation fit into joist bay openings above the ballroom

Roxul insulation fit into opening created by previous plumbing pipes

2" foam board cut to fit around opening adjacent to chimney above the ballroom

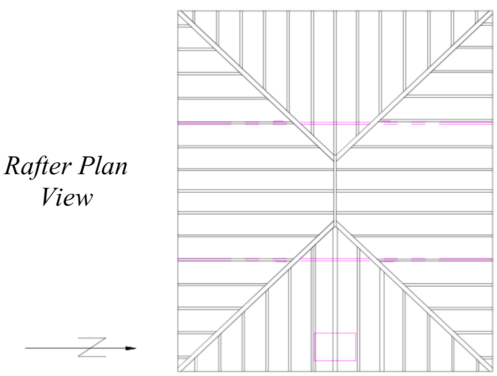
Typically, such penetrations are sealed with a polyurethane-based expanding foam. This type of product is messy in application and leaves a residue on whatever it touches. Its long term reversibility and performance were unknown and it was a product excluded from consideration in this project.

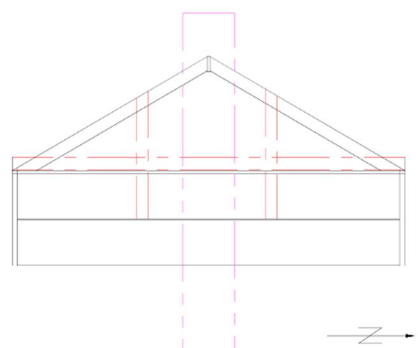
The blown in cellulose insulation was installed using two different methods.

<u>Ballroom Area</u>
The ballroom is approximately 1-1/2 stories with a coved plaster ceiling over the main part of the ballroom. The transition between the hallway and the ballroom is a single story with a chamber above. This layout provides a two level attic space above the two rooms.

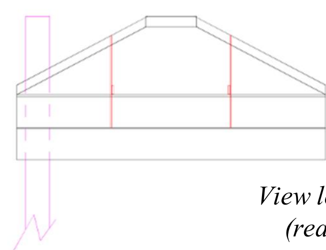
Directly above the ballroom ceiling is a space approximately 31-1/4ò high, capped by a floor. This then leaves a wide open space between the floor and roof of approximately 10ô in the middle, with diminishing heights commensurate with the hipped roof structure. As the 2^{nd} floor ballroom chamber abuts the ballroom attic, there is approximately 33-1/2ò of vertical exposure ï essentially a knee wall.

Rafter Plan View





View looking west



View looking south (rear to front)

There is a catwalk over the ballroom chamber with the ceiling joist bays exposed on both sides of the catwalk. As these bays were open, the bays were filled with cellulose insulation in a ñloose fillò manner. As such, the insulation was deeper in these cavities in order to provide for the desired R value. To contain the insulation, foam board walls were set along the sides of the catwalk to keep the insulation from covering the catwalk.

View over ballroom as seen from catwalk towards chimney at east end.

View over ballroom looking southeast

View of catwalk as seen from entry to ballroom attic space.

South wall of ballroom attic and knee wall at junction with ceiling over ballroom chamber

Over the ballroom space, it was decided to blanket the ballroom attic floor rather than attempt to fill the void between the ballroom ceiling and attic floor. Accessibility and risk of potential damage in this space was the primary decision driver. As the construction of the ballroom evolved over time with newer exterior walls, there was a series of joist bays along the perimeter. These bays were blocked at the level of the attic floor with the Roxul insulation batts stuffed into the opening. Similarly, the chases alongside of the chimney ran the full height of the building from the basement. These chases were capped off with foam board. Once the floor was sealed at the perimeter, approximately 2ôof loose fill cellulose insulation was blanketed on top of the floor. As this makes the ballroom attic floor inaccessible, a tower of foam board was set on top of a removable floor board section. If there is ever a need to access the space above the ballroom ceiling, this ñbeaconò provides identification of the access location and a path could be cleared to this opening.

Space between ballroom ceiling and attic floor

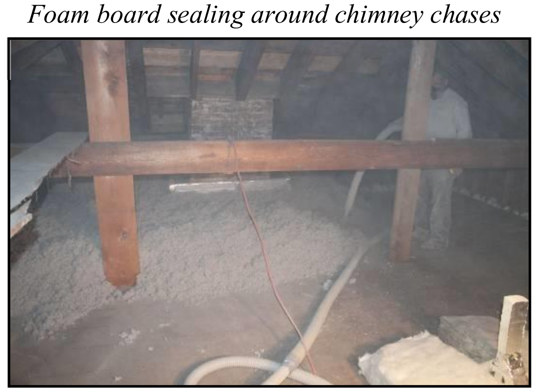
Catwalk space with open joist bays

Foam board "walls" in catwalk space to contain insulation

Insulation sealing the gaps in the wall pocket

Foam board sealing around chimney chases

Beacon to identify access hatch to ballroom ceiling



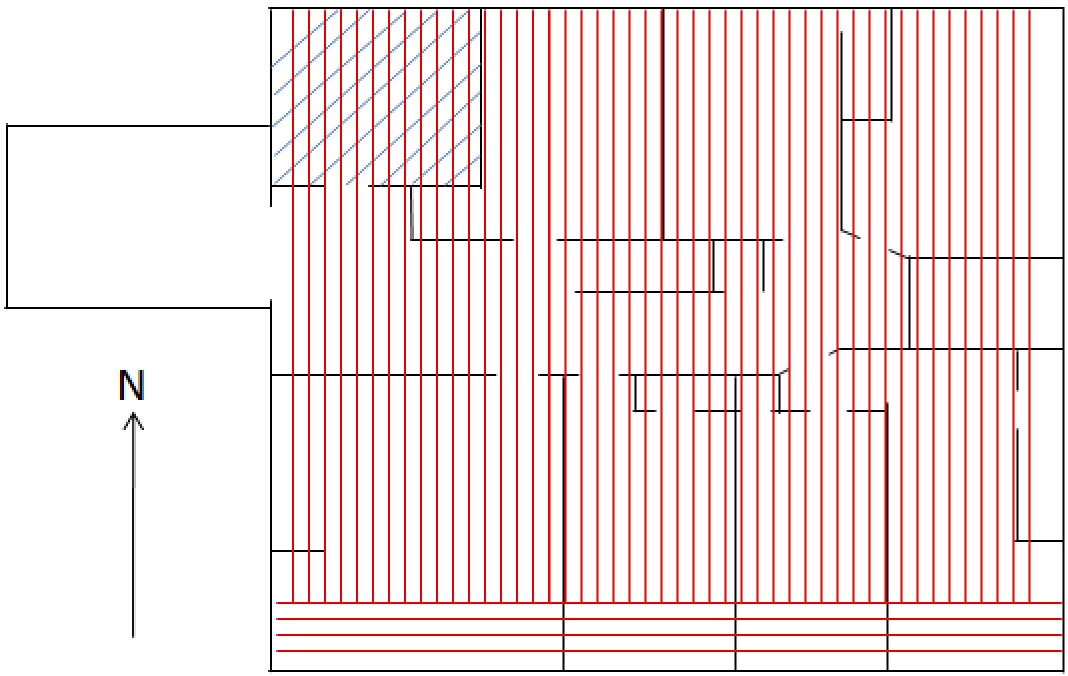
Filling the ballroom attic with insulation

<u>Servantôs Quarters and West Wing Attic</u>
The rest of the third floor space provided for a more traditional installation of dense pack cellulose. The floor system for the servantôs quarter is two layers. The subfloor layer is made of up 1ò thick rough sign pine of varying widths laid perpendicular to the floor joists and nailed with cut nails. The top floor is 1ò hemlock, painted grey. These boards are butt jointed rather than tongue and groove ï a detail that made careful removal possible. The floor joists are approximately 11-1/2ò wide. Below the joists there was diagonally laid strapping. The plaster lath strips were then secured to the diagonal strapping, but perpendicular to the floor joists. This extra strapping layer is not a common construction method, as typically the lath is secured directly to the joists. In this case, this detail provided additional rigidity to the ceiling structure below which lent more confidence to the plaster ceiling being able to withstand the new insulation load.

For the rooms that faced to the rear and for the hallway, the top floor and sub floor were laid parallel to each other. This allowed for the need to remove 2-3 top floor and 1-2 sub floor boards across the length of a room in order to expose the joist bays. Floor boards were carefully removed with pry bars. There was minimal damage to the top floor in this fashion as the cut nails were gradually coaxed free from the subfloor below. It was determined that the joist bays in these locations ran the full length of the room with no obstructions other than occasional diagonal bracing. This detail allowed for the easy insertion of the insulation delivery hose to the edge of the room and thus the gradual blowing in of the cellulose as the hose was pulled out. This is the ideal situation for dense pack blown in cellulose as the product can be installed in the compact area for the full length of the joist bay.

1 - Floorboard removal with the use of prybars and patience
2 - Hose delivery of cellulose insulation
3 - Removal of hose as joist pocket fills with insulation

In the front rooms, the front most 5ô-6ô of subfloor was perpendicular to the finish floor. This was due to the change in framing at this point as the subfloor must be perpendicular to the floor joists. The expansion of the front of the house for what is now the bay areas is the likely reason for a different framing pattern here. The finish floor in these locations was consistent with the rest of the room, a fact which changed removal processes in these front rooms.



Schematic representation of third floor framing. The red lines are the general framing of the floor/ceiling joists. The blue lines represent the diagonal layout of the subfloor in that room.

NOT TO SCALE

For the front rooms, the same process used for the rear rooms was used for the rear part of the room. Two to three top floorboards and one to two subfloor boards were removed to expose the underlying joist bay. However, this bay only extended for part of the room. In order to insulate the front part of the room, most (rather than two or three) of the top floor boards had to be removed as the joists ran parallel to the top floors. In order to access the joist bays, one 3ò hole was cut for each joist bay. The location of the joist bays could be easily determined by reading the nail pattern of the sub floor boards so that a minimum number of holes needed to be cut. In the smaller rooms, the floor boards ran the full width of the room and thus were fully removed. In the larger rooms, the floor boards were end joined so that the smaller board in each run could be removed to access the full length of the bay.

An alternative to the 3ò hole would have been to remove all the subfloor boards after they were exposed by the removal of the top floor boards. However, this application would then have resulted in a loose fill approach similar to that done in the ballroom attic spaces. In that application the depth of the insulation could be made greater in order to achieve the same R value as a more compact dense pack installation achieves. As the floor boards would be reinstalled in this case, there would have been a loss in R value of approximately 8-10%.

Upon reinstallation of the floor boards, each 3ò disc cutout was set back in its original location and covered with the top floor boards.

In the case of the room directly over the main stair, the subfloor was laid on a diagonal to the joists and the top floor. This area also had much smaller joists ï approximately 6-8ò resulting in a narrow cavity to fill and thus a lower R value. This construction is likely related to the coffered ceiling of the stairwell and the desire to keep the floor in the chamber above at the same plane as the other rooms.

In the attic space over the west wing, the removal of select floor boards for accessing the joist bays that ran the full width of the building (front to back) was easy. The space under the servantõs bathroom was also fully accessible from the adjacent attic areas so that none of the flooring in that bathroom was disturbed.

All floor boards were set back in place but not nailed back. This will allow for easier access for future documentation of framing or provision of new electrical runs if desired in the future.

Cost

Work Performed	Company	Amount
Insulation	Greenstamp	$ 15,861.00
		$ 15,861.00
	Total Insulation	**$31,722.00**