

# THE ROOF REPLACEMENT OF THE JAMES C. COLGATE STUDENT UNION AT COLGATE UNIVERSITY — A Case Study

By Douglas Arena, AIA

Figure 1 – James C. Colgate Student Union in the 1940s (Colgate University archives).

## INTRODUCTION

In 2014, Colgate University undertook a roof investigation to study persistent leaks around the dormers on the James C. Colgate Student Union Building and identify a repair scope of work. Designed by the noted New York City architect Walter Chambers and constructed in 1937, the original slate roof had endured 78 harsh central New York winters. The university had finally decided that the frequent repairs, water damage, and overall disruption to the spaces were intolerable. A study of the condition of the building and the technical issues identified the need for a more comprehensive roof replacement and restoration project than was originally conceived.

This case study illustrates the beneficial outcomes of studying the issues of a roof restoration and replacement project in the early stages of the project. It also illustrates the challenges unique to undertaking a restoration project and the careful attention paid to evaluating materials that are consistent with the campus architectural vocabulary



Figure 3 – Architectural renderings from the 1930s (Colgate University archives).



Figure 2 – Photo from the 1940s (Colgate University archives).

and that ensure durability and predictable performance for the next 75-100 years.

## HISTORY

Unlike many of the early 19th-century buildings on campus, the Student Union Building was initially funded by student organizations, alumni, and small donors. It was the last of four high-profile university buildings conceived by Colgate University President George Cutten and designed by architect Walter Chambers (*Figures 1-3*).<sup>1</sup> Under Cutten's leadership, Chambers' buildings solidified and homogenized the signature campus style that would influence the development of the campus. The distinctive architectural characteristics of the campus include the use of random ashlar stone façades (originally quarried from the hills adjacent to the campus); simple ornamental limestone detailing; and copper, lead-coated copper, and slate roofing. The campus buildings are heavy masonry structures—solidly built and representative of an institution of higher learning.

The three-story student union building was originally intended to serve the student body and student-related activities and clubs. It was equipped with game rooms, lounges, a college post office, a large dining hall and kitchen, and offices for student organizations. Informational pamphlets produced by the campus in the late 1930s labeled the student union as “a social center of realizing the informal values of a liberal education.”<sup>2</sup> Although the building use has been modified and adapted to the changing needs of the campus and the building codes, it still generally serves the student and faculty population. Dedicated on October 23, 1937, the student union cost the handsome amount of \$300,000 to construct. Adjusted for inflation, it would cost almost \$30 million in 2016 dollars.

## ROOF STUDY

The initial 2014 project was conceived of as repairs to localized areas of the roof dormers (*Figure 4*). For many years, the university had been chasing leaks around the dormers, slates, flashings, and the original wood windows. The windows and their original wood frames and sashes were in terrible condition—both leaky and drafty. The interior plaster was severely damaged by the roof leaks and in need of replacement. The university requested recommendations from the architect on a repair scope of work that would address the source of the roof



*Figure 4 – Prior to 2014 roof replacement project.*

leaks in anticipation of a future third-floor renovation. The university and the architect quickly realized that if the dormer roof repairs were to be done correctly, it would involve disturbing all the roof and cladding materials on the dormers and between the dormers, leaving only a portion of the original slate undisturbed. So the question was redefined: What would be involved in a more comprehensive roof replacement, given that much of the slate was in poor condition or beyond repair?

The building also had a history of systemic icing and ice damming problems. The prominently featured dormers on the front and back of the building are a unique architectural component and provide light and air to the attic spaces. They are also problematic because they obstruct snow and ice in places that are difficult to flash properly, are difficult to repair, and have a tendency to leak. In one particular area, a corbelled corner dormer created a very awkward roof drainage condition (*Figure 4* – inside corner on the left side).

Roof cuts, masonry investigations, an infrared study, pull tests, and hazardous materials testing were undertaken early in the roof study. The original asphaltic felt underlayments were brittle and ineffective to resist water infiltration from ice damming. In the days prior to the development of rubber and bitumen polymers, layers of built-up felts and asphalt mastics (which often contained asbestos) were used to cre-

ate ice and snow underlayments to combat ice damming. Although these improvised barriers were initially effective, the felts eventually failed well before the slate materials. Suspected hazardous material samples confirmed that asbestos was present throughout the eaves, valleys, and rake edges.

The architect organized observations, findings, and recommendations into a report that concluded that the student union had systemic icing and ice damming due in part to the geometry and configuration of the roof dormers, but predominately because the attic was effectively uninsulated. Uninsulated mechanical air handlers and ducts in the attic spaces were contributing to the roof heat losses. In the end, the most cost-effective repair, given the number of dormers and the extent of asbestos, was to consider options for a full roof replacement of the slates, flat-seam copper, and modified-bitumen roof areas. Controlling the roof drainage was also important, given that some of the roof areas converged into valleys and corners over doors and sidewalks.

## WHITE STUFF

On average, Hamilton, New York, receives over 100 inches (254 cm) of snow per season, and the average heating dry-bulb temperature is 3.6°F (-16°C).<sup>3</sup> Said another way, it is snowy, and the winters are long and cold. But for the most part, New Yorkers are accustomed to the weather here and have



Figure 5 – Typical 1940s winter in Hamilton, New York (Colgate University archives).

adapted the built environment accordingly. Photos from the 1930s and '40s depict a bucolic winter wonderland (Figure 5).

In 1936, when the student union was built, it was unlikely there was much, if any, insulation in the open wood-framed attic spaces. Over the main dining hall, called the Hall of Presidents, the vaulted scissor truss ceilings originally would have offered very little insulation value. A close look at early photos shows the roof of the student union generally clear of snow, presumably having either melted away or slid off. There is no evidence that a snow retention system (e.g., snow pads or rails) was ever installed. For the most part, the building envelope appears to have functioned reasonably well, because the snow melted away before causing problems. At some point, however, the attic spaces were outfitted with forced-air mechanical heating and cooling systems and loose-laid fiberglass batt insulation, which created problems. It was clear that the roof was suffering from inadequate thermal insulation, air losses, and damaging accumulations of snow and ice (Figure 6).

The New York State-required snow loads for Hamilton, NY, were reviewed, including the uniform loads, unbalanced loads, and drift loads. It was important for the architect to review the historic and the current snow load requirements early, given that the project was considering improvements to the thermal performance of the roof

assemblies and the introduction of snow retention systems, both of which were potential increases to the calculated snow loads from the original designs. It was found that in certain areas, simply applying an additional layer of plywood could increase the section modulus of the roof framing enough to compensate for the current code-required snow loads, based on stress-skin principles. These

options, along with the necessary plywood fastening details, would be further developed later in the construction documents.

#### SLATE

The original slate specification for the student union building was written long before the development of ASTM standards and test methods for slate.<sup>4</sup> In 1936, the

architect called for a high-quality, ¼-in.-thick Vermont-quarried unfading green and mottled purple slate. Because slate is a natural material quarried from the earth, variability in its appearance and durability is expected. But a grade S1 slate has sufficient hardness and low-water absorption to provide an excellent roof covering for a service life of at least 50-75 years, if not more. The demand for slate roofing has tapered significantly since the late 18th and early 19th centuries in North America, but it is still recognized and specified as a durable material and a good roofing investment for many homeowners and institutional buildings. Given that slate matches the aesthetic of the campus very well, there are few other roof options that would be appropriate for Colgate University. The author would be remiss not to state that while slate is still readily available, qualified and experienced slate roofing contractors and sheet metal mechanics are difficult to find.

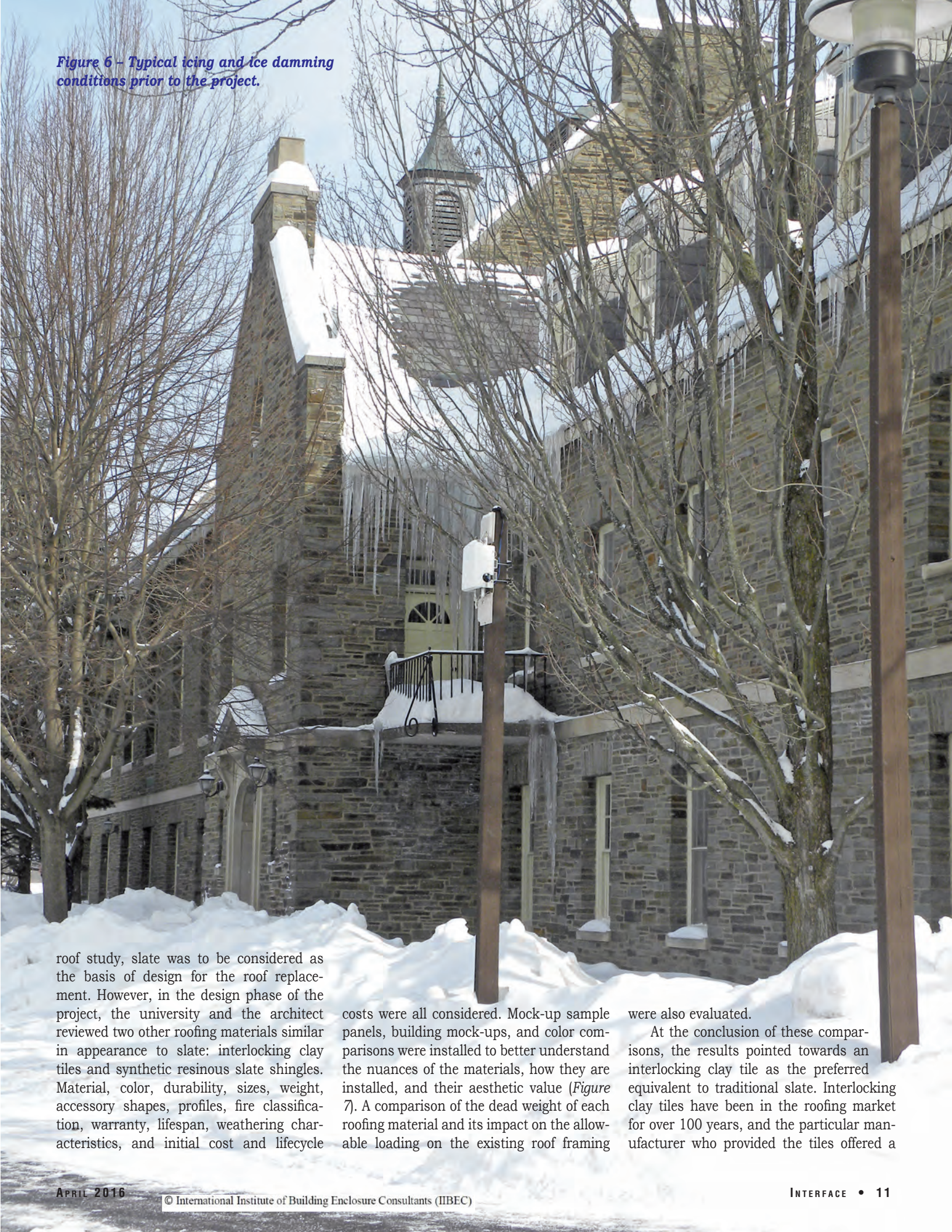
The cost of slate has also become prohibitive in many cases. For comparison, one square of standard-thickness, 800-lbs./square slate in 1920 cost approximately \$14 per square. In 2014, the material cost of a similar slate (Seagreen or Unfading green) would be in the \$400- to \$500-per-square range. The increase in the slate cost is more than double the rate of inflation over that period.

Based on the recommendations in the



Figure 7 – Clay tile mock-up.

*Figure 6 – Typical icing and ice damming conditions prior to the project.*



roof study, slate was to be considered as the basis of design for the roof replacement. However, in the design phase of the project, the university and the architect reviewed two other roofing materials similar in appearance to slate: interlocking clay tiles and synthetic resinous slate shingles. Material, color, durability, sizes, weight, accessory shapes, profiles, fire classification, warranty, lifespan, weathering characteristics, and initial cost and lifecycle

costs were all considered. Mock-up sample panels, building mock-ups, and color comparisons were installed to better understand the nuances of the materials, how they are installed, and their aesthetic value (*Figure 7*). A comparison of the dead weight of each roofing material and its impact on the allowable loading on the existing roof framing

were also evaluated.

At the conclusion of these comparisons, the results pointed towards an interlocking clay tile as the preferred equivalent to traditional slate. Interlocking clay tiles have been in the roofing market for over 100 years, and the particular manufacturer who provided the tiles offered a



Figure 8 – The rake-end condition of the interlocking clay tile assembly, prior to completion.

material warranty of 75 years. It was clear that the synthetic shingle products had demonstrated a successful introduction into the roofing market, but it was not widely understood how snow would stick or slide on the surface. Because slate and clay tiles have some absorptive characteristics, they have a nominal increase in surface friction.

Interlocking clay tiles were the clear winner in the lifecycle cost analysis. Not all aspects of the interlocking tiles were favored over slate and synthetic tiles, however. They

have a fixed exposure (the face of the tile exposed to view) of about 11 in. (28 cm), which is approximately 3 in. (7.6 cm) larger than the existing slate exposure. And similar to synthetic shingles, interlocking clay tiles are molded products with stiffening ribs on their undersides. Once the tiles are cut, the ribs can become visible in an undesirable way when they are placed around penetrations or along valleys (Figure 8).

The fire classifications in the current New York State Building Code are modeled after the 2006 International Building Code (IBC) and generally require either a Class A or a Class B roof covering. For this project, a Class A-rated roof covering system was specified over the existing combustible wood deck. All the roof coverings considered either had test data to support their compliance with the fire classification requirements

or, in the case of slate and interlocking tile, were generally exempt from the testing requirement. Had this project been designed according to the 2012 or 2015 editions of the IBC codes, slate and interlocking clay tile would not automatically have met the fire classification tests on combustible wood decks without supporting test data.

#### THERMAL IMPROVEMENTS

One of the recommendations in the roof study report addressed thermal improvements to the roof assembly, primarily to reduce the amount of melting snow, ice buildup, and energy losses. Applying fiberglass batt insulation to the underside of the roof joists was an option that was explored, but it was realized that it would only be possible to access about 50% of the roof surfaces. The remaining roof rafters were either finished ceilings, such as in the Hall of Presidents, or were not accessible without removing the interior finishes. The prospect of partially insulating the roof was undesirable and could make conditions worse, considering that thermal “shorts” could actually aggravate the icing and ice damming issues.

The preferred method of insulating the roof was continuous insulation on top of the existing wood deck. The roof report outlined an option to apply a layer of modified asphalt vapor/air barrier and two layers of continuous insulation and a plywood nail-board over the existing tongue-and-groove deck, achieving an R-value of 20. This option also required that the framing cavities at the roofing sill plate were air-sealed and insulated, and all the wall flashings, step flashings, and through-wall flashings were raised to accommodate the additional roof thickness. The thickness also



Figures 9A (above) and 9B (right) – Architectural renderings of the existing and proposed dormer reconfiguration.



James C Colgate Student Union Building Rendering – East Elevation

affected the windowsills, as described later in this article. This option was appealing in part because it provided a continuous plane of insulation over the entire roof assembly, but also because it did not disrupt the interior operations of the student union. The option was quickly endorsed.

These nailboard insulation products consist of foam plastic isocyanurate boards factory-laminated to 3/4-in. (19-mm) plywood. A base layer of flat stock iso board is laid down first, with joints staggered, and the nailboard is mechanically attached with 6-in. (15-cm) structural insulated panel (SIPS)-type screws. Fastener pullout and pull-over tests were conducted to verify the appropriate number of fasteners needed to resist the thrust and wind uplift pressures.

Similar nailboard insulation products were applied to the sidewalls of the dormers. In effect, all surfaces above the roof plane were wrapped in a continuous vapor-impermeable air barrier and 4 in. (10 cm) of insulation. The amount of insulation exceeded the New York State Energy Code requirements for Hamilton, NY (Climate Zone 6A) at the time the roof report was written. However, by the time bidding documents were prepared, the state of New York had announced adoption of portions of the 2012 International Energy Conservation Code for commercial buildings and ASHRAE 90.1-2010. These changes increased the minimum continuous requirement to R-30 and would become effective shortly after the bidding period but before construction. Aside from the fact that the bidding documents were nearly completed and fully detailed, the increase in insulation thickness posed a serious flashing height issue for the already low parapet through-wall flashings. Instead of conceding to the requirements, the university took the unusual step of filing for the building permit before the effective date of the code change to preserve the parapet's historical integrity.

## DORMERS

Historical photos of the student union show that there were 20 shed or hipped dormers on the third floor of the student union (Figure 1). The dormers are clearly a unique architectural feature of the building. In the 1980s, an existing fire escape ladder at one of the dormers on the backside of the building was replaced with a fire egress stair addition to meet fire code requirements. In general, the dormers and windows had remained relatively unaltered since the orig-

inal construction.

Given that the university had been struggling with persistent roof leaks for so many years, there was interest in options that could simplify the number of flashing details around the dormers. From a maintenance and repair point of view, fewer inside/outside and transition corners would be simpler to construct, less expensive to build, and easier to service in the future. The architect developed options to consolidate the dormers into monolithic shed dor-

mers (Figures 9A and 9B). The final designs balanced the need to preserve the historical appearance of the student union with the maintenance and costs by consolidating almost all the dormers on the back side of the building into one dormer but leaving the dormers on the front of the building unchanged.

Initially it was envisioned that the dormer consolidation could carve out additional usable space inside the building on the third floor, but the project could not absorb



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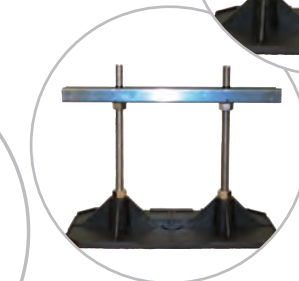
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Figures 10A and 10B – Typical dormer before (left) and after (below) the project.



the structural costs or the disruptions to the users. In the end, it was decided that the dormer consolidation would be an over-build connecting the existing dormers. In the future, the university could capture that space, should they choose to do so.

Due to the small size of the dormers, the architect proposed cladding them in an interlocking copper-siding panel instead of slates. The slates had proven to be difficult to maintain and were easily damaged by sliding snow. The size and scale of the copper-siding panels mimics the coursing of the slate, and the weathering of the copper was consistent with the materials used elsewhere on the building and the campus (Figures 10A and 10B).

#### WINDOWS AND INTERIOR

It was impossible to ignore the poor condition of the original double-hung single-pane wood frame and sash windows in the dormers. Many of the sills and window sashes were rotted away, sashes were inoperable, and others had been replaced with vinyl replacement units. The interior plaster finishes were water-damaged, unsightly, and in some cases made the rooms unusable. In general, it was not effective to repair the

windows, and it was decided early on that the windows would need to be replaced as part of this project.

The replacement windows specified were high-performance aluminum-clad wood window units with insulated glass and simulated divided lites. As described earlier in the article, insulation was incorporated on top of the existing wood deck, which affected the flashings at the windowsills. The existing windowsills were too low and needed to be raised. In order to keep the windows from appearing too squat, the height-to-width proportions of the windows were modified to keep them as similar to the existing proportions as possible.

A building code analysis uncovered a fire code requirement for two of the windows adjacent to the existing egress stair tower that had been overlooked in the earlier building modifications. In accordance with the NYS Building Code, any opening (whether a window, door, or louver) within 10 ft. of a fire-protected and enclosed exit stair must be protected to prevent the spread of

fire to the stair. The existing glazing units in the egress stair were not believed to be fire-rated, and the two window units in the dormers adjacent to the fire stair were within 10 ft. (3 m). The proposed aluminum-clad wood window units could not offer the one-hour fire protection rating required, so a fixed steel-framed window unit with one-hour insulated laminated fire glass was specified. The unit itself had similar sight-lines to the new window units with a surface-applied divided lite grill. They proved to be an adequate, but not an exact, match in appearance, and met the building code requirements.

#### CONSTRUCTION ISSUES

After the interlocking clay tiles were selected as the roof covering, the process to approve samples, mock-ups, and submittals began. A blend of purple, green, and gray tile colors by Ludowici Roof Tiles were

initially selected and approved. The project also called for accessory tile shapes to supplement the field tile, matching one-piece ridge tiles, starter tiles, and rake-edge tiles. Some of the benefits of the interlocking clay tile system were revealed early in the project, but as with all materials, every product has some limitations. When it came time to incorporate snow rails into the interlocking tiles, the manufacturer of the snow rail brackets needed to custom-fabricate and mill down brass base plates of the same size and interlocking profiles of the field tiles (Figure 11). This had no impact on the interlocking clay tiles or their performance, but it added an unanticipated cost to the project.

Because of the interlocking tabs on the clay tile shingles, they must be installed starting from the left to the right. In large, open, and relatively unobstructed roof areas, the layout is simple, straightforward, and fast. In cases where dormers break up both the running bond patterns and the coursing of the tiles, it becomes significantly more tedious and time consuming to lay out. This was discovered early in the construction.

Waste from cutting tiles also needs to be

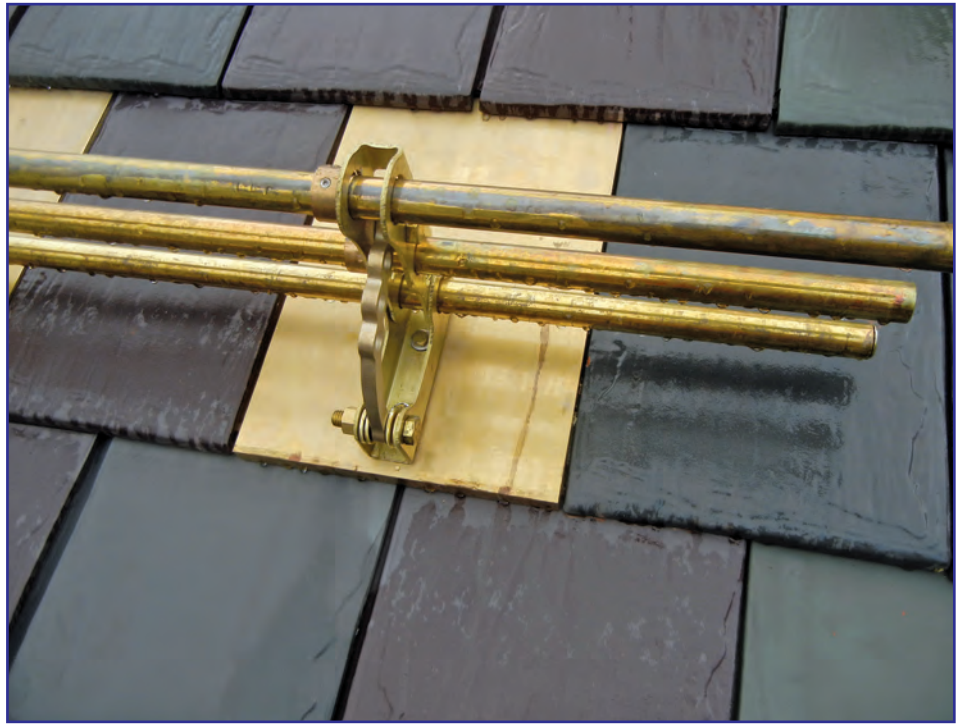
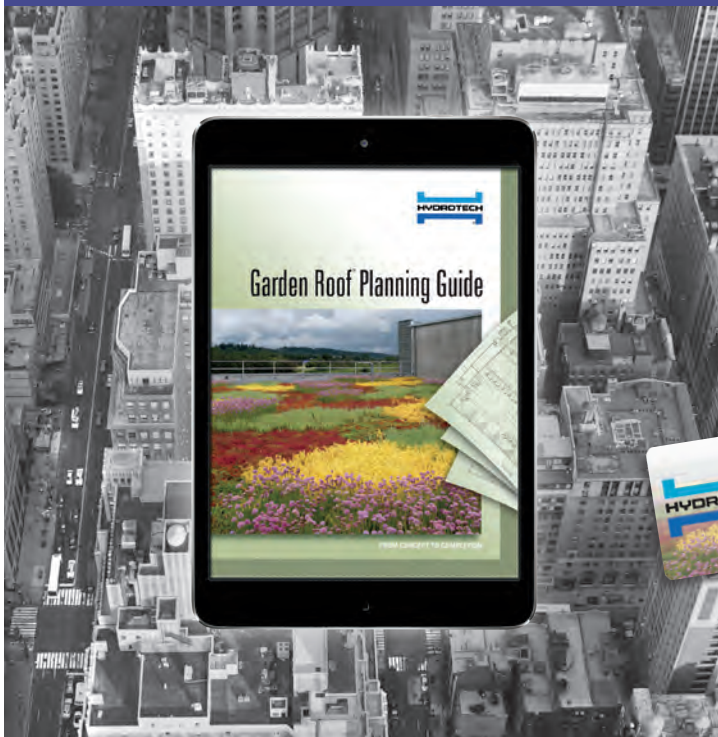


Figure 11 – Typical snow rail and bracket incorporated into the interlocking clay tile system.

factored early in take offs, and preplanning the layout of the tiles around rake walls, eaves, and valleys should be discussed

early. Depending on where the tiles are field cut, the finished edges have the potential to expose the stiffening ribs and/or the red-

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Figure 12 – Tile accessory shapes under consideration for an eave condition.

dish color of the fired clay tile itself. There were locations where this could be visible and therefore undesirable. For this project, it was neither practical nor could the schedule accommodate the time for custom pieces to be fabricated. In hindsight, it may have been desirable to have standard solid tiles made with homogenous color for locations where the tiles needed to be cut. But through some creative Tetris-type arrangements, the contractor was able to take a combination of cut tiles, eave tiles, rake tiles, and copper flashings and lay out a pattern to resolve these problem areas (Figure 12).

Another challenging aspect of the project was the flashings, flat-seam copper panels, and standing seam panels fabricated of copper-clad stainless-steel sheets. Such composite sheet metal products are fused under high pressure, similarly to how a penny is made. They are marketed as copper equivalents (measured in thousands of an inch but advertised in ounces) but with reduced thickness and the yield strengths of grade 400 stainless steel. The qualification and experience articles in the specifications

called for each sheet metal mechanic to demonstrate his or her ability to fabricate, tin, and fully sweat a flat-seam copper panel satisfactory to the architect and owner. Despite the presence of qualified mechanics on the project, it was found that the copper-clad stainless-steel, 16-oz. (0.18-in.) and 20-oz. (0.21-in.) sheets were very temperamental to form and break, with less ductility than traditional copper, due to the inherent memory in the stainless steel and copper composite. Soldering also presented challenges due in part to the lower conductance of the stainless steel base metal. Lower soldering iron temperatures were needed so that the solder would flow and sweat the joints without running. After some trial, error, and corrections, these issues were



Figure 13 – Drainage basin around the corbelled dormer prior to the project.

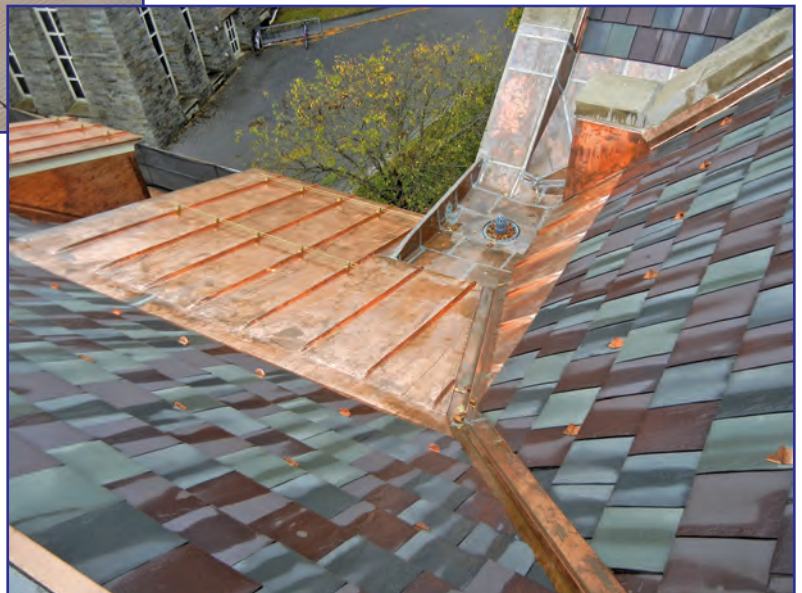


Figure 14 – Drainage basin after completion of the project.



Figure 16 – Snow on the roof after completion of the project.

Figure 15 – Snow on the roof after completion of the project.



satisfactorily overcome.

Many of the small details in the field were left to the skill and craftsmanship of the mechanics, such as the copper transition pieces at the ends of the dormer fascias and moldings and the soldered flat-seam copper drainage basin (Figures 13 and 14). Along the eave lines of the standing seam metal roof panels, the vertical double lock seams were specified to be cut at a 45-degree angle, hemmed, and crimped closed instead of leaving a squared, open-end cut. This detail was developed in part because it prevents sliding snow and ice from opening the end tabs, but also because it gave the seams a more refined appearance.

## CONCLUSIONS

The roof replacement project at the James C. Colgate Student Union began as localized roof repairs, developed into a roof study, and concluded with a comprehensive roof replacement project. By identifying the heat loss issues early, the project was able to incorporate insulation improvements that addressed the hazardous icing and ice damming issues, while incorporating snow retention systems with necessary structural upgrades into the overall roof project. The early study also enabled the architect and the university to develop a process




Figure 17 – The completed roof over the dining hall.



Figure 18 – The completed project in autumn.

to review alternate materials that would remain faithful to the architectural and material characteristics of the historical building. Successful collaboration among the owner, the architect, and the roofing contractor overcame many of the shortcomings and challenges presented by the existing building condition, the diversity of roofing materials, and their details. For these reasons, the project has been considered a success and met the desired outcomes conceived early in the project.

Many on campus have remarked that the restoration and overall visual improvements to the building have exceeded their expectations. In its first winter of service, it is clear that the roof design is behaving as predicted, thermal losses have been significantly reduced, and the snow retention systems are effectively holding snow in place

(Figures 15 and 16). The newly replaced copper and clay tile materials should last another 100 years or more, while the copper and brass materials slowly weather into the timeless finish that distinguish this and other similar buildings on campus (Figures 17 and 18). Most important, the student union building retains its architectural significance on campus. 

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