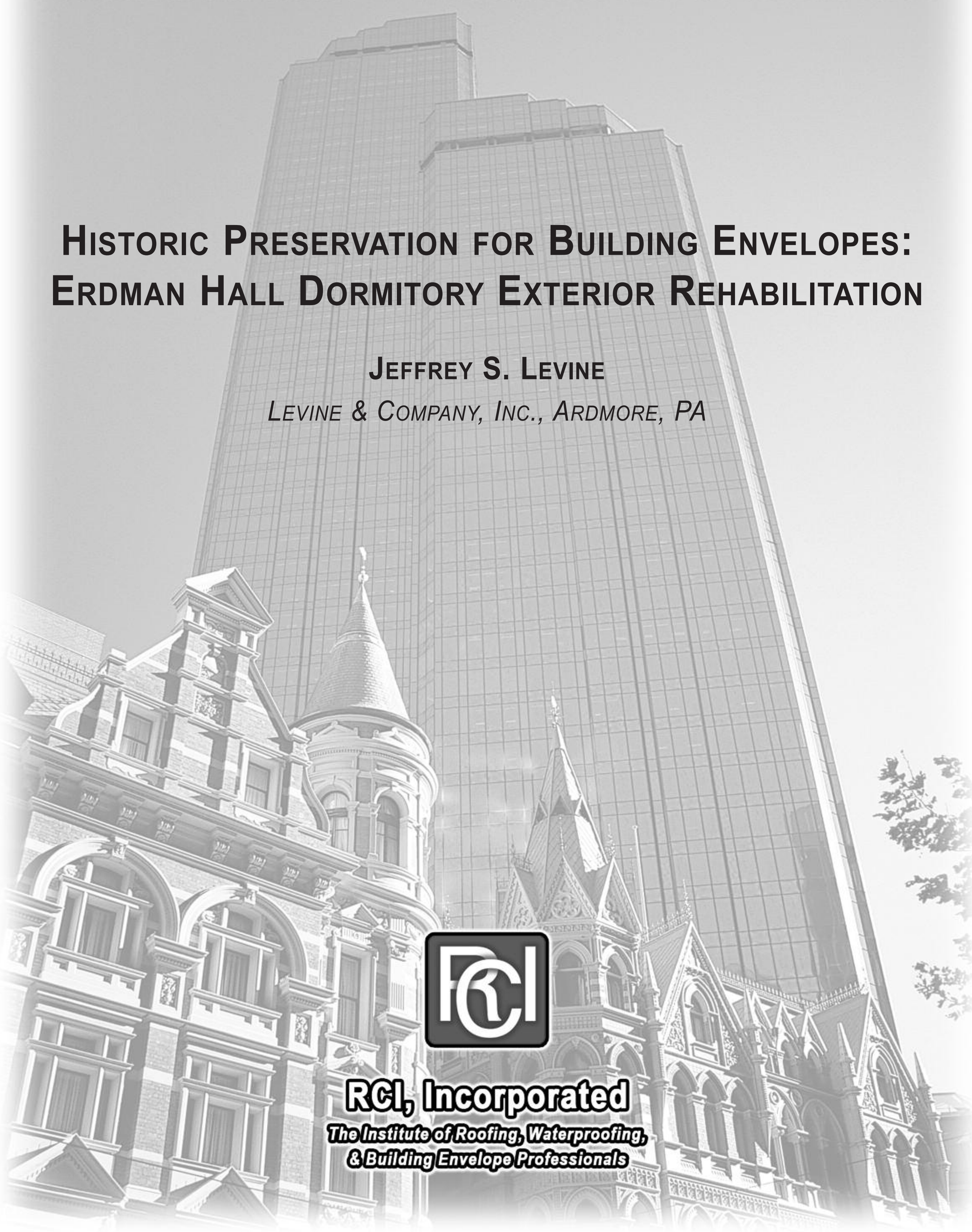


HISTORIC PRESERVATION FOR BUILDING ENVELOPES: ERDMAN HALL DORMITORY EXTERIOR REHABILITATION

JEFFREY S. LEVINE

LEVINE & COMPANY, INC., ARDMORE, PA

RCI, Incorporated

The Institute of Roofing, Waterproofing, & Building Envelope Professionals

ABSTRACT

One of the most notable buildings on the Bryn Mawr college campus in Bryn Mawr, Pennsylvania, is Erdman Hall, a dormitory designed by celebrated architect Louis Kahn. Kahn's crenellated parapets and unusual roof form had challenged many an architect and contractor, resulting in three roof replacements in less than 40 years. In addition, structural deficiencies in the anchors securing over 2,200 of the building's slate wall panels posed unexpected rehabilitation challenges. Rigorous feasibility studies explored rehabilitation options for the roof and wall panels. The options which best preserved the historic integrity of the building were ultimately selected by the college.

SPEAKER

Jeffrey S. Levine – Levine & Company, Inc – Ardmore, PA

Jeffrey Levine is president of Levine & Company, Roof Consulting and Architectural Conservation. Mr. Levine's expertise in the field of slate roofing is nationally recognized. He has served as project manager for over 200 restoration and rehabilitation projects, preservation plans, and maintenance programs for a large variety of building types, including academic, commercial, and ecclesiastical buildings; house museums; and residences. Mr. Levine has an M.S. in historic preservation planning from Cornell University, has written numerous articles on slate roofing (including Preservation Brief No. 29, published by the National Park Service), and is a founding director of the National Slate Association

Historic Preservation for Building Envelopes: Erdman Hall Dormitory Exterior Rehabilitation

INTRODUCTION

One of the most notable buildings on the Bryn Mawr College Campus is Erdman Hall, a dormitory designed by celebrated Philadelphia architect Louis I. Kahn between 1960-64. Kahn's crenellated parapets and unusual roof form had challenged many an architect and contractor, resulting in three roof replacements in less than 40 years. Color changes to the original envelope sealants, which were a key design element as expressed in the miles of exposed panel joints, further obscured the modernist intent of the structure. Past, unnecessary attempts to waterproof the slate wall panels left the panels with a streaky appearance that could not be removed. These factors, in combination with deficiencies in the slate panel anchors, posed unexpected building rehabilitation challenges and raised serious questions about the long-term protection of this historic resource.

Rehabilitation options for the roof and wall panels were explored via two separate feasibility studies. The options which best preserved the historic integrity of the building were ultimately selected by the college. These included a new coal tar pitch built-up roof and the removal, salvage, and reinstallation of over 2,200 slate wall panels.

After some background information, this case study will examine the three major phases of the Erdman Hall Exterior Rehabilitation Project – condition assessment, construction documents, and construction. Along the way, some of the project's preservation challenges will be explored. In many instances, Kahn's original detailing was respected, but improved upon to help enhance the building envelope's weathertightness. It should also become obvious that it is not building materials that make this a Landmark structure, but rather the building's plan.

BACKGROUND

Erdman Hall (*Figure 1*) is a dormitory located on the southern edge of the Bryn Mawr College campus in Bryn Mawr, Pennsylvania. It was designed between 1960 and 1964 by Architect Louis Kahn, and constructed between 1964 and 1965. Kahn (1901-1974) is considered one of the foremost architects of the twentieth century. His design's simple forms, rooted in the International Style, earned him the AIA Gold Medal in 1971. Kahn's other commissions include the Kimbell Museum, Fort Worth Texas (1967-1972); Richards Medical Center, University of Pennsylvania, Philadelphia, Pennsylvania (1957-1961); and the Salk Institute, La Jolla, California (1959-1966). The exterior rehabilitation of Erdman Hall commenced in late 1999 and was completed in 2003.

Much has been written about Erdman Hall's plan (*Figure 2*) – three diamonds, each with a footprint of 10,000 square feet, touching at their corners and with common spaces at the center of each – a dining hall, an entrance hall, and a gathering space or

Figure 1 – Erdman Hall c. 1980.

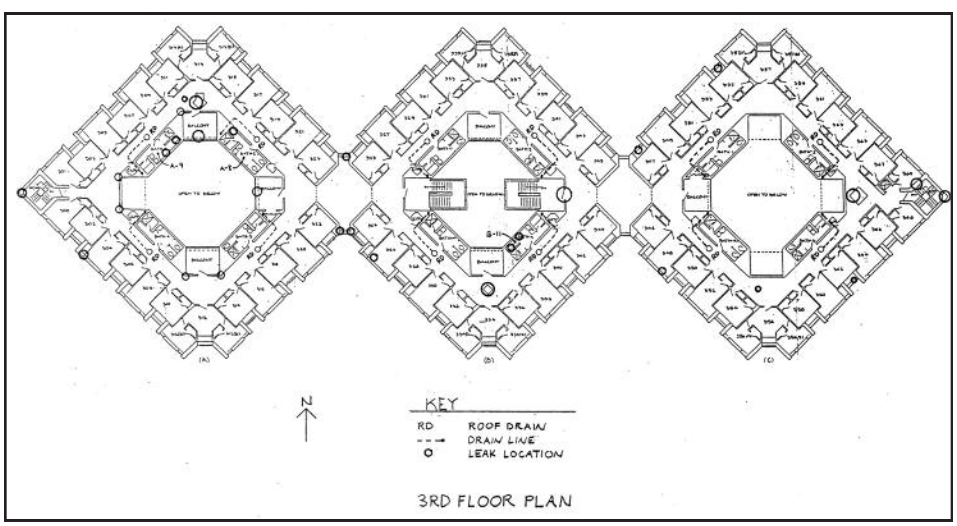


Figure 2 – Erdman Hall, 3rd floor plan showing active leak locations in 1999.

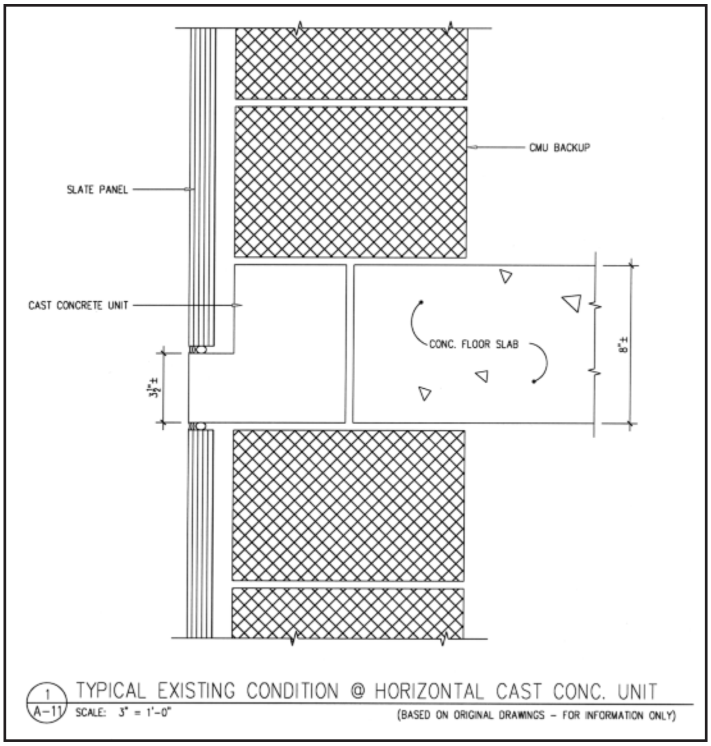


Figure 3 – Typical wall section.

great room. Student rooms ring the perimeter of each diamond. Bathrooms are towards the center of each wing. Light flows in from all directions, including the structure's large clerestory windows.

One of the unusual things about working on modern historic structures is that the original drawings are more likely to exist and be available for study. For Erdman, a full set of architectural, structural, mechanical, electrical, and plumbing drawings was available. Interestingly, the architectural set for the entire building consisted of only about 16 sheets, several of which dealt with interior finishes! Everything Kahn wanted to convey fit on 16 sheets. By comparison, the exterior rehabilitation set of drawings consisted of 24 sheets.

In fact, one of the reasons Kahn only needed 16 sheets is that the building is put together in a relatively simple manner: a reinforced concrete frame and floor slabs with CMU infill and slate wall cladding (*Figure 3*). The slate wall panels were quarried in the soft-vein district of Pennsylvania, in Northampton County, and they are known as Pennsylvania Black. Interior walls in the common areas are poured-in-place concrete. In the student rooms, the walls are furred out, sheet rocked, and painted. Interior doors are wood. Windows are galvanized steel (not original). Basically, though, the building is constructed of just three materials: concrete, CMU, and slate.

Another unusual thing about working on modern historic buildings is that at least some of the original designers tend to still be alive. So, if you have a question, you can pick up the phone and call. You cannot do that for a building designed by Mellor and Meigs, or Addison Hutton, or Cope & Stewardson, late 19th- and early 20th-century architectural firms, all of whom are represented on the Bryn Mawr campus. This fact came in handy when some holes had to be cored through the roof deck to accommodate overflow drains. The school said "you can't do that, it's a post-tensioned deck." A quick check of the original drawings indicated no such thing. The school retorted that it was a change made during construction. What to do? A brief discussion with Kahn's lead structural engineer, who is still quite active with the same consulting firm that assisted Kahn in 1964, settled the matter. There are no post-tensioned roof decks in the structure.

CONDITION ASSESSMENT

When the project began in 1999, Erdman Hall was not looking too good (*Figure 4*). Panels were stained. Bronze-colored silicone sealant altered the appearance of the walls, giving them a more monolithic appearance. Some of the sealant had failed. Moisture was observed below the roof mem-

Figure 4 – North elevation, fall 1999.

Figure 5 – View of roof prior to rehabilitation.

Figure 6 – Test opening in existing IRMA roof system.

brane in several test locations. And, there were some 30 ongoing roof leaks (*Figure 2*).

The project started off simply as a roofing project. All the penetrations and complicated wall geometry had challenged many an architect and contractor, resulting in three roofs in a period of about 35 years (*Figure 5*). The leaks also really challenged the college's ability to preserve Kahn's legacy. It is very difficult to run a dormitory that is plagued by leaks and for which a reliable roof system cannot seem to be had.

The project began with a feasibility study of the roof. The history of past roof leaks, active roof leaks, past repairs, and past roof replacement programs was examined. The advantages and disadvantages of various re-roofing options were also studied. The first three roof systems installed on the building were an asphalt-based, built-up roof covered with slag; followed by a spray polyurethane foam roof by Dow Corning (a spray-applied foam insulation and spray-applied, weather-resistant, elastomeric coatings); followed by a torch-down modified membrane installed in an inverted roof membrane assembly, or IRMA system (also called an insulated roof membrane assembly, *Figure 6*). These systems lasted about 20 years, five years, and ten years respectively.

Based on repair records, the IRMA roof seems to have leaked from day one. Puddling, due to inadequate roof slope and sagging of the concrete roof deck, was causing large areas of the insulation to float, including areas in front of the stair tower doors. This made it difficult to open the doors after a rain. For the new roof system, the college was very interested in one that would hold up well under water, as it was assumed that the puddling problem could likely be mitigated, but probably not completely eliminated. A five-ply, coal-tar pitch, built-up roof with a 25-year manufacturer's warranty and an expected service life of 50 years (based on past experience) was recommended, and ultimately selected by the college (*Figure 7*). Designing the new roof system would be the next logical step in the process.

Developing a set of construction documents is somewhat akin to playing chess in that one must think about what is likely to happen several moves out and anticipate what the contractor will want to know when he shows up on site. With that in mind, test openings were undertaken. It is at this point that the nature of the project changed dramatically.

Figure 8 – Test opening at stair tower wall.

Figure 7 – Installation of new roofing system.

Figure 9 – Outer portion of steel clip engaging stainless steel pin is completely corroded away.

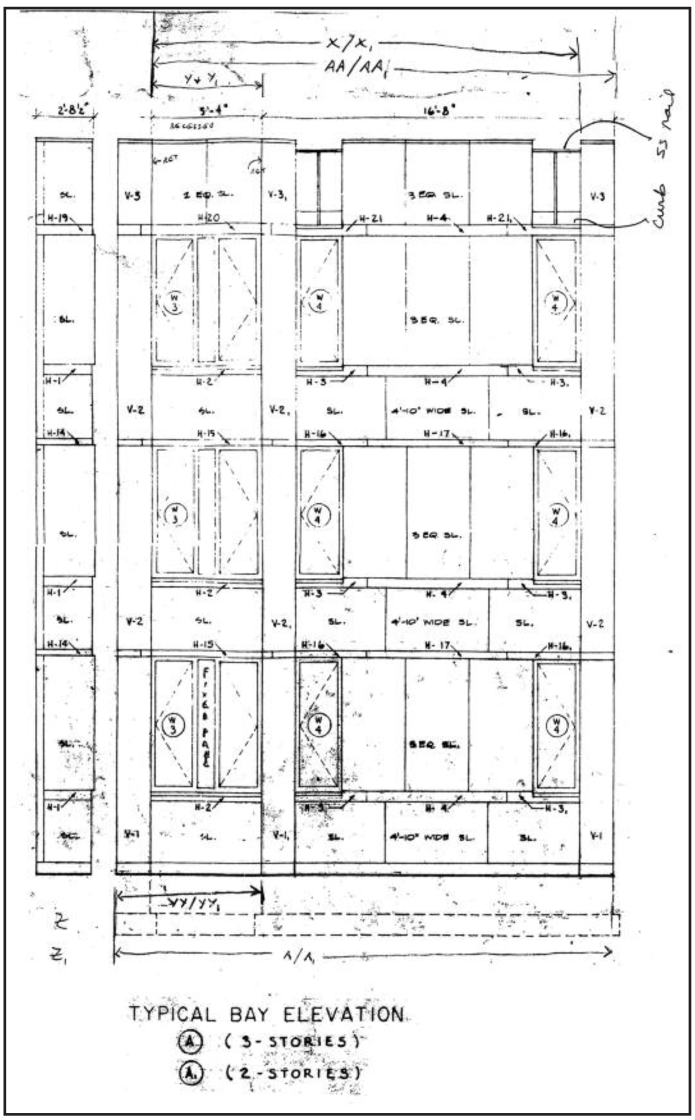


Figure 10 – Kahn's typical bay elevation.

One of the test openings was at a stair tower wall where a change in the roof membrane's base flashing height from 0 inches to 8 inches was anticipated (*Figure 8*). When one of the slate panels was removed, it was found that the clips securing the panel to the backup CMU wall were completely corroded (*Figure 9*). The College then reported that it had found the same thing when it had made a new door opening at grade to create more secure access to the dining area. Further test openings on the main exterior walls revealed that there was no apparent pattern to the corrosion. It was not as if the clips on the north elevation were all corroded and those on the south were fine.

The original clip used to secure the slate panels consisted of an L-shaped, light-gauge, galvanized steel strap held in place with two hardened steel masonry nails. A pin that passed through a hole in the strap and engaged a hole in the edge of two adjacent panels was made of stainless steel.

What to do? This was not something the college could just walk away from and pretend they knew nothing about. The panels weigh several hundred pounds each. They wanted options. Those explored included the following:

- Face-anchoring the panels with countersunk expansion anchors;
- Face-anchoring the panels with surface mounted expansion anchors;
- Face-anchoring the panels with countersunk Helifix restoration anchors;
- Removing the slate panels and installing pigmented stucco in their place;

All of the above options are irreversible and would have severely detracted from the historic appearance of the building. We also explored the option the college eventually chose – removal, salvage, and reinstallation of the slate panels using a stainless steel anchor assembly. This was clearly the best option. It would allow the contractor to know exactly what he was setting anchors into because the backup masonry would be exposed. It permitted better sealant preparation because all edges of the panels would be exposed. It is also the option that best preserved the historic integrity of the building. It was, of course, also the most expensive option.

CONSTRUCTION DOCUMENTS

The project became a two-phase one, with masonry restoration taking place in Phase 1 and roof replacement in Phase 2.

One of the most difficult things about preparing the construction documents was creating elevation drawings. Most buildings have four elevations and each could be put on one sheet. Kahn's building has somewhere between 22 and 224 elevations, depending on how they were counted. What Kahn did is provide seven typical elevations (*Figure 10*) and a key plan (*Figure 11*) to let the user know where they occurred. This would have been too confusing for an exterior rehabilitation project. It was thought that the clearer and simpler the rehabilitation drawings, the lower the pricing would be. So, the elevations were put in their proper order (no small task) and the build-

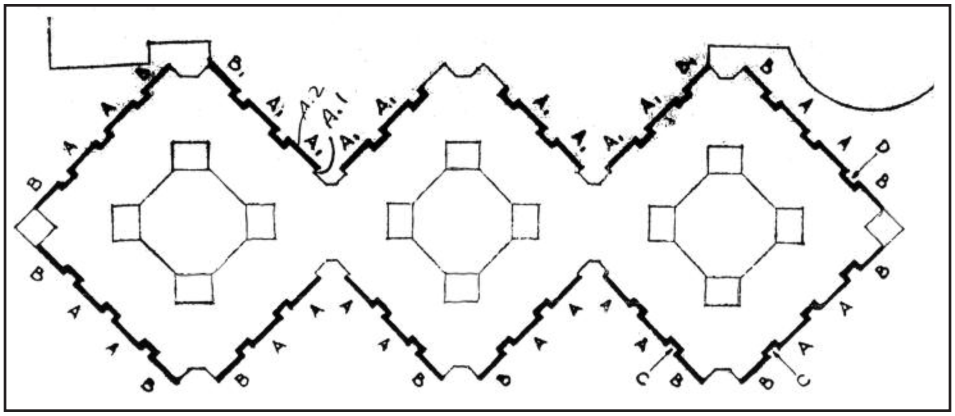


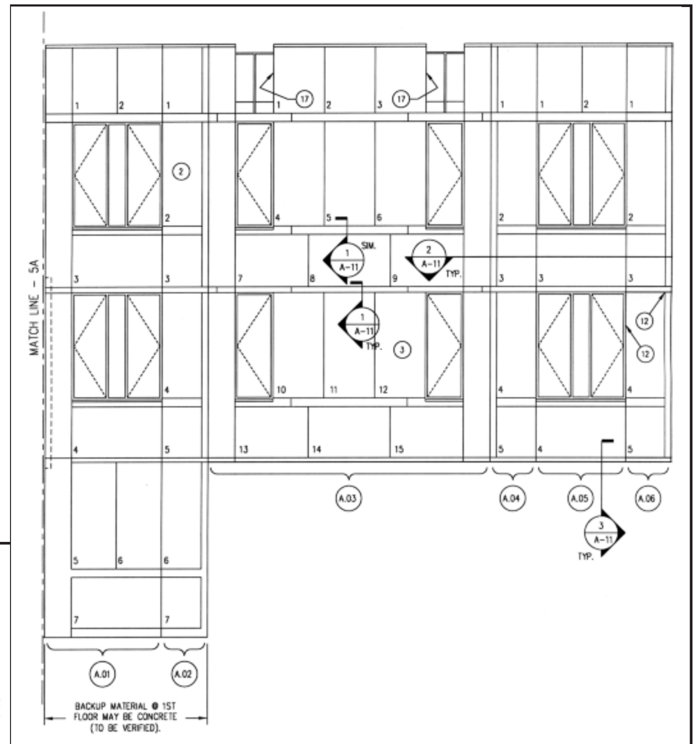
Figure 11 – Kahn's elevation key plan.

ing unfolded like an accordion. Each elevation was then numbered and keyed to a plan (*Figure 12*) and each slate panel given a number (*Figure 13*). One could then easily refer to, say, panel 15 on elevation A.03. There are 1,735 slate wall panels on the main elevations and 478 of the rooftop penthouses, for a total of 2,213 panels.

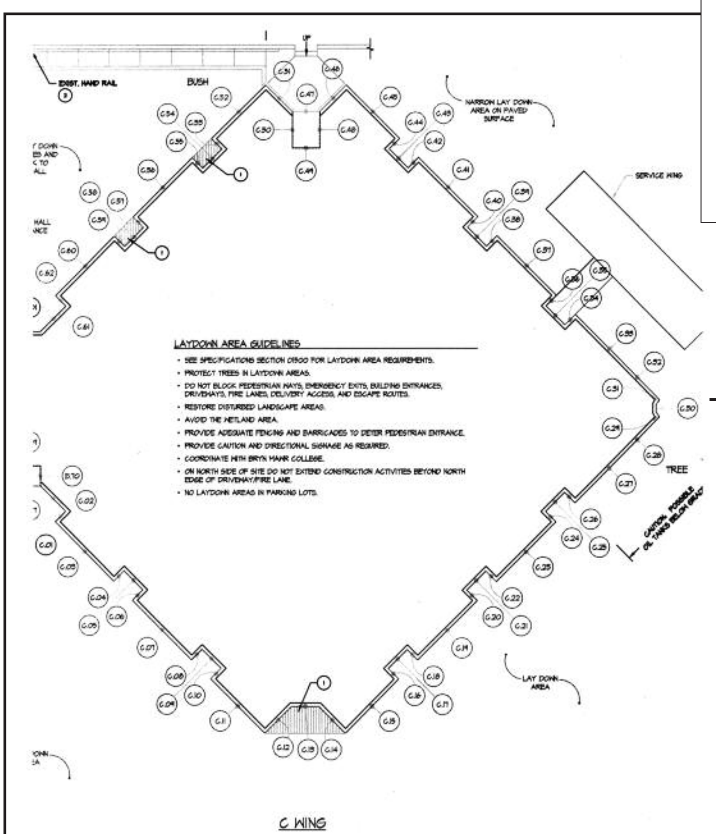
The anchor assembly chosen for re-securing the slate panels to the CMU and concrete backup was similar to the original, but consisted of a heavy-gauge, stainless-steel tie and two stainless-steel expansion anchors (*Figure 14*). Pull-out values obtained on the anchors exceeded a safety factor of four for rotational and wind loads. Weep holes were provided along the bottom edges of the panels to allow any moisture penetrating the wall cladding to drain.

Several subtle but important changes to the building were incorporated into the rehabilitation design for three basic reasons: to improve performance, to obtain a roof warranty, and to satisfy the plumbing code. In keeping with preservation design principles, the enhancements were made without altering Kahn's original design intent. The enhancements were as follows:

- The clerestory and stair tower roofs were changed from a membrane system to flat seam copper. Gutters and downspouts were added to better



Above: Figure 13 – Rehabilitation elevations A.01 through A.06.



Above: Figure 12 – Elevation key plan for rehabilitation project.

Below: Figure 14 – New anchor assembly for slate wall panels.

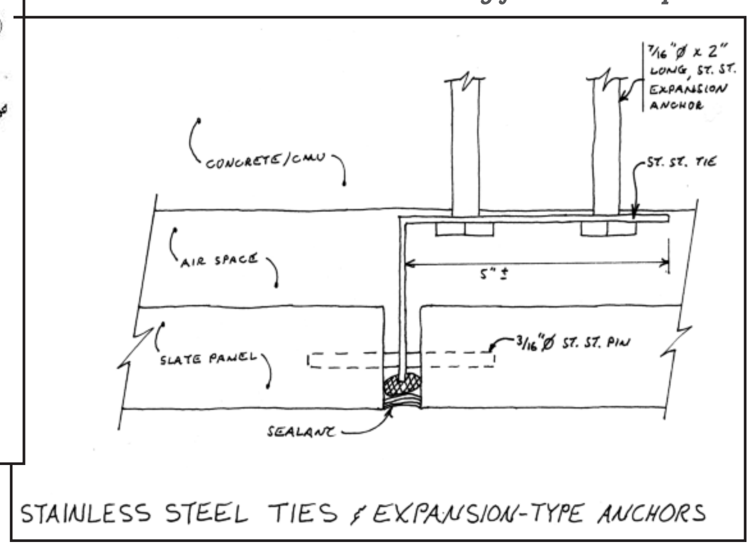
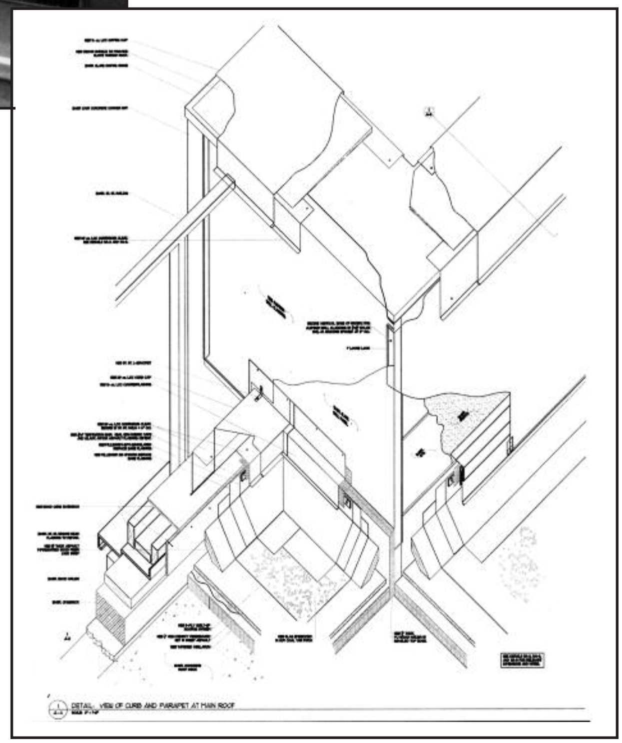


Figure 15 – New clerestory roofing.

Figure 16: – Detail view of new flashings at embrasures.



direct the flow of rainwater away from the masonry walls (*Figure 15*). The gutters and downspouts are not noticeable from grade.

- Curbs at the openings (embrasures) in the parapet were raised approximately 4 inches to obtain an 8-inch base flashing height (*Figure 16*). This change, although visible from grade, is not recognizable as such because there is no reference point for comparison. That is, there is no "before" view and the 4-inch difference in height is not enough to capture the eye (*Figures 17* and *18*).
- We continued the use of lead-coated, copper, coping caps, improving on the design by sloping them toward the roof. This prevented run-off from staining the slate panels and giving them a whitish haze. Kahn's 1-1/4-inch thick slate caps had no through-wall flashing below them and no overhang. Here, a through-wall flashing could have been designed that would have been less visible, but it would have been difficult to keep the lightweight coping stones in place.
- The backs of the parapets were clad with heavy-gauge, black aluminum because the stucco on CMU was simply not watertight enough to prevent water from getting below the new membrane. This

Figure 17 – Embrasures before rehabilitation.

Figure 18 – Embrasures after rehabilitation.

Figure 19 – Parapet flashing before rehabilitation.

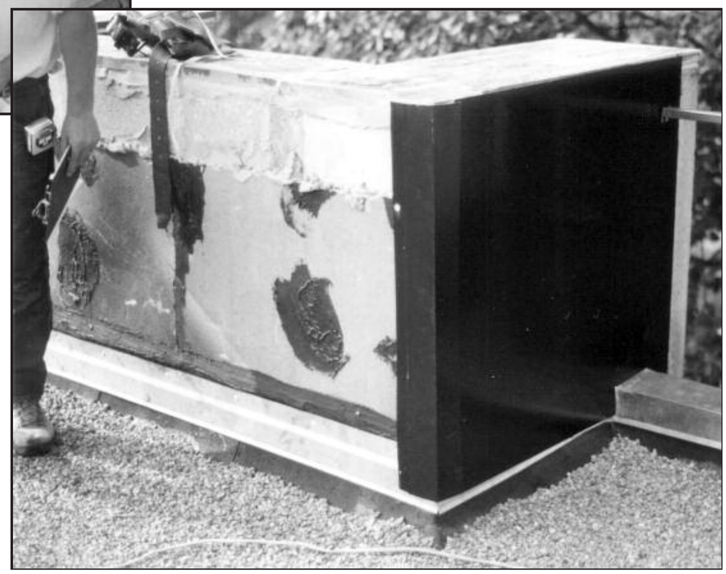


Figure 20 – Parapet flashing during construction.

had been done before, probably in the 1980s (*Figure 19*). To help mitigate the chance of leaks at the window heads below, the aluminum cladding was carried around to cover the slate panels on the parapet end walls as part of the rehabilitation (*Figure 20*). Again, this change is visible from grade, but the color and gloss match to the slate is so good that it is not noticeable (see *Figure 18*).

- Two non-functional light bollards and some rooftop equipment were removed to eliminate as many roof penetrations as possible (*Figure 21*).
- Twelve overflow roof drains were installed, four per wing. As a result, short lengths of insulated pipe are now visible in the hallways on the top floor of each wing.
- At the stair tower roofs, 6-inch high curbs were installed at their outside corners to prevent rainwater from draining down the side of the building, as it had done for 35 years.
- Lastly, a clear coating was applied to the slate panels. As indicated earlier, the existing slate panels had a streaky appearance, both from the lead-coated copper coping caps, which lent a whitish haze, and from some other source that created dark streaks. Cleaning the slate was originally planned, but test panels carried out early in the construction phase yielded poor results, turning the panels a light gray color and having no effect on the dark streaks. The source of the dark streaks remained a mystery until the contractor figured it out. In a desperate attempt to limit moisture infiltration through the parapet, probably around the same time the aluminum cladding was added to the backside of the parapet, a contractor applied a sealer to the slate panels at the parapet level – and dripped

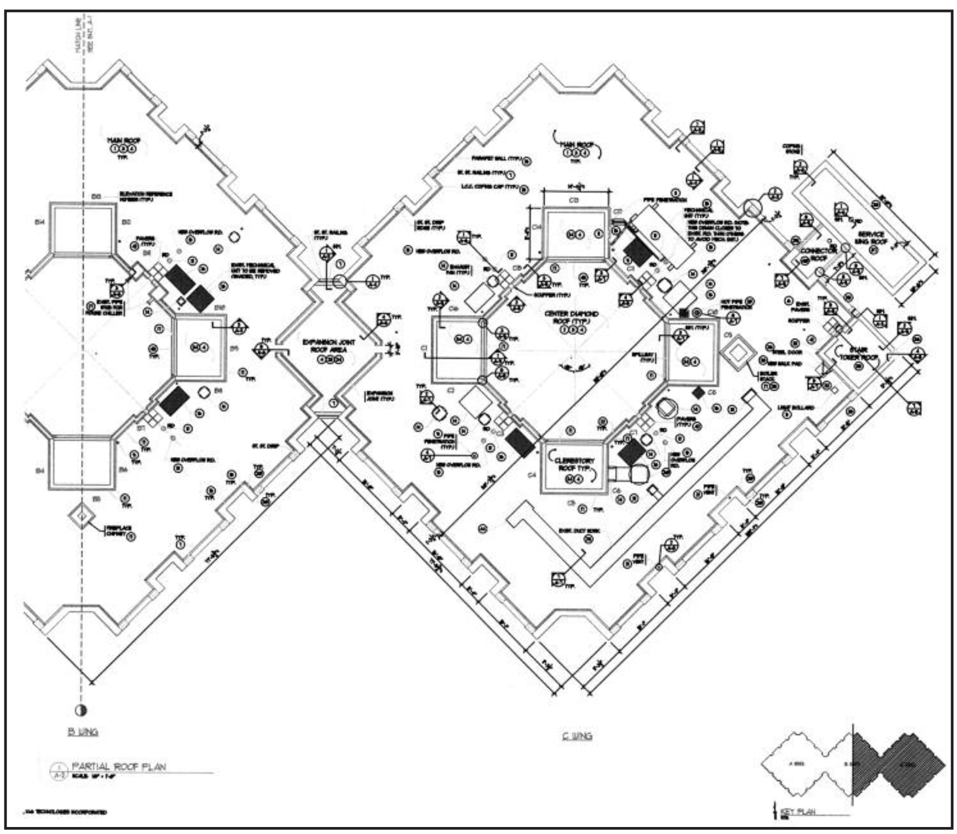


Figure 21 – Partial roof plan. Objects shown in black were to be removed.

Figure 22 – Vacuum removal of ballast in progress.

sealer the whole rest of the way down the façade. There was no choice but to seal the panels – not for waterproofing, but for aesthetic reasons. An acrylic, anti-graffiti coating by Chemprobe Coating Systems was selected based on test panels. Although it was a very small part of the work, sealing the slate panels had the greatest restorative impact, unifying the panels' appearance, and making the building look like new (see *Figure 28*).

CONSTRUCTION

During construction, there were hundreds of challenges, ranging from the 36-hour window to shut down the dining hall's air conditioning system so that we could roof below its chiller, to dealing with the un-reinforced parapets. The three biggest challenges were puddles, getting the slate anchors just right, and prepping the slate panels to receive new sealant.

In the spring of 2001, the ballast and insulation were removed from the roof (*Figure 22*) and the roof basically became a small lake after each rain, due to deck deflection (*Figure 23*). The contractor could do nothing but sweep and pump each day prior to starting work.

Tapered insulation secured with adhesives was chosen for re-sloping the concrete roof deck after some test panels and much debate about using mechanical fasteners. Lightweight concrete was also considered, but, in the end, it was felt that there was insufficient time available to wait for the concrete to cure fully. After several go-rounds, the final tapered insulation layout plan developed for re-sloping the 10,000 square feet of roof deck in each wing vastly improved each roof's drainage (*Figure 24*). In the end, however, ponding could not be completely eliminated, due primarily to restrictions imposed by curb heights at the embrasures in the parapet. The slight bit of ponding that remained will have no deleterious effect on the roof, due to coal tar's low solubility in water, and may even help prolong the life of the roof by keeping the pitch cooler and limiting its flow.

Getting the new anchors for the slate wall panels just right proved to be a little trickier and more time consuming for the

Figure 23 – Puddling on roof during construction.

contractor than expected (*Figure 25*). It all looked nice and clean on the drawings: just drill two or three holes and start installing the assembly. Several things made this a challenging exercise: The 1-1/4-in thickness of the slate panels left no room for play; the anchor pretty much had to be dead center. But, the panels are not all exactly 1-1/4-in thick; they varied between 1-1/8-in and 1-1/2-inch in thickness, and for the finished wall to look good, any variances had to be taken up on the backside. Complicating this even further was the fact that some of the panels were a little warped. Then consider that the panels weigh several hundred pounds each, that their overall lengths and widths varied, and that the joints between panels had to be 1/4-in plus or minus a 1/16-in, and it is not hard to imagine that trying to get three or four 3/16-in diameter pins into 5/16-in diameter holes aligned precisely across from each other in two panels got a little tricky.

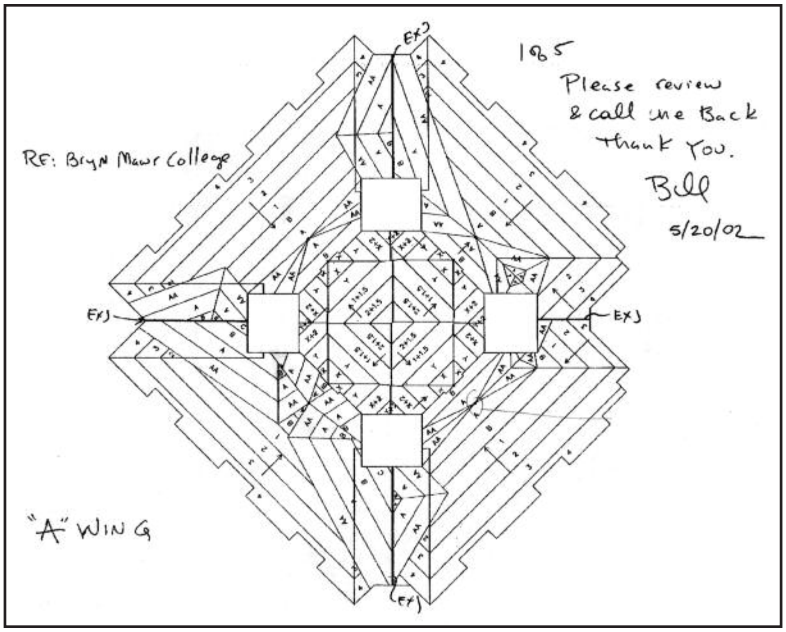


Figure 24 – Tapered insulation plan.

Each crew had a learning curve. The best crews were the ones headed by a very detail-oriented mechanic. Quality control was hard because, once installed, observations had to be made through the 1/4-in joint line. Is the pin there? Is it engaged? Was there blowout behind the pin?

Of the 2,213 panels, 95% or 96% of the original panels were salvaged and reinstalled in their original locations. What happened to the other 4 or 5% of the panels? Some broke during construction, some were cracked, but most were splitting apart along their cleavage planes. Replacement panels came from the original quarry in Pen Argyl, Pennsylvania.

At least two, and in some places, three sealants had been used in the joints between the panels over the years, including polysulphide and silicone sealants. The new sealant was to be a two-part polyurethane. None of these was compatible with another. So, it was very important that all of the existing sealants and any residues be removed right down to the bare slate. This was accomplished using a rigid protocol of scraping, buffing with a fabric wheel (*Figure 26*) and solvent wipes, followed by an equal-

Figure 26 – Removal of existing sealant from edge of slate panel prior to reinstallation.

Figure 25 – Reinstallation of slate wall panels.

Figure 27 – East elevation prior to rehabilitation.

ly rigid pull-testing program that ratcheted down as acceptable and consistent adhesion results were confirmed.

Historic photographs indicated that the original sealant color was white, not dark bronze as had been installed in later years. The engineer of record who worked with Kahn related how white was originally chosen: Kahn had just had cataract surgery and from 15 feet away, took about nine seconds to select white from a group of four or five different shades. Pre- and post-rehabilitation images of the building prove that sealant color has an unexpected, yet significant impact on the appearance of the building (*Figures 27* and *28*).

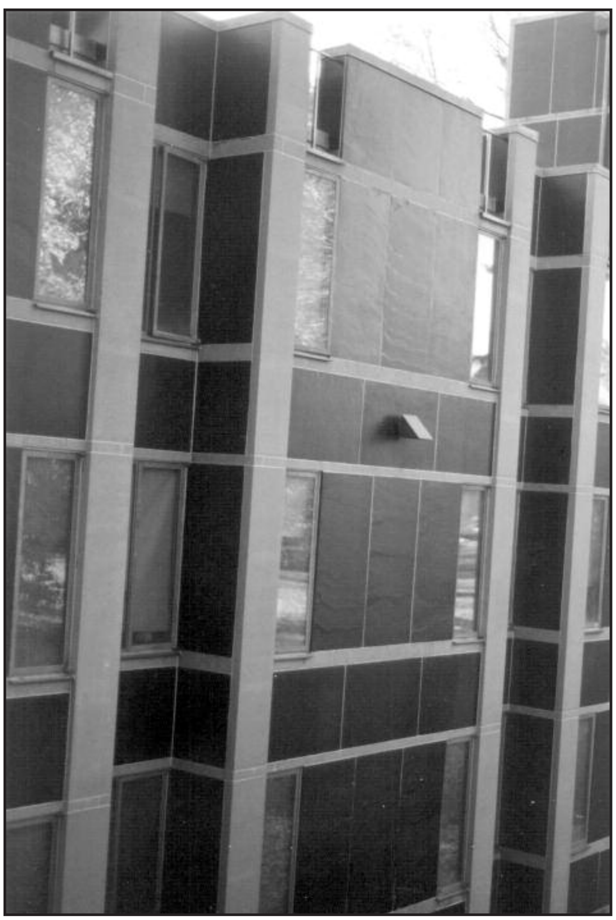


Figure 28 – West elevation after rehabilitation.

What was initially thought to be a big challenge – the fumes associated with installing a coal tar pitch roof – turned out to be no problem at all. The contractor was required to provide a new kettle and a fume recovery system. No complaints were had all summer. The only place fumes escaped into the atmosphere was at the lugger and mop head.

CONCLUSION

The successful exterior rehabilitation of Erdman Hall quite possibly saved this landmark structure from the wrecking ball. It took four tries, but the roof system installed as part of the current project is on its way to providing decades, not merely years, of leak-free service. Similarly, the new stainless-steel wall panel anchor assemblies are expected to remain serviceable for as long as the slate panels themselves – 100 years or more. Lessons learned from the project include the following:

- When addressing issues associated with the exterior envelopes of modern structures, take advantage of the ready availability of resources, such as original drawings and persons involved with the original construction.
- Take advantage of opportunities to enhance and improve upon existing detailing during rehabilitation and restoration projects, but do so in a manner that respects the historic integrity and appearance of the structure.
- Salvage and repair, rather than replace, important features of architecturally significant buildings.
- Select new roofing systems that best accommodate inherent vices, such as ponding, presented by existing structures.
- Providing rehabilitation options, along with an objective and detailed accounting of the advantages and disadvantages of each, permits owners to make rational and informed decisions concerning the preservation of their buildings.
- Test probes are a critical part of understanding existing conditions and determining new construction detailing. They can also serve to identify hidden conditions during the design phase of a project (i.e., before budgets are finalized and contractors with certain strengths are selected), rather than at the start of construction.