Remediation of Balcony Waterproofing and Structural Framing

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Abstract

The speaker will present two case studies of the investigation and remediation of water leakage and construction defect issues related to waterproofing of the balconies on two different assisted living facilities. Due to many design errors and construction issues, the balconies at both of these projects leaked water over time, which resulted in significant structural damage and water intrusion. These balconies were designed with wood framing, wood joists, engineered wood products, and common waterproofing membranes. Renovation included redesign, modification, and replacement of several portions of the original structural framing, associated parapet walls constructed of Portland cement plaster, and brick and stone veneer cladding assemblies. Additional drainage and slope considerations were also engineered for these facilities.

Speaker

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A TALE OF TWO CITIES

This paper will present two case studies of the investigation and remediation of water leakage and construction defect issues related to waterproofing of the balconies on two assisted living facilities located in different Texas cities. The projects were linked by the fact that they are owned by the same developer and had been constructed by the same general contractor. However, they had different overall designs created by different architects, used different waterproofing materials, and had different subcontractors who installed the waterproofing. Due to the number of design errors, lack of detailing, and construction defects, the balconies at both of these projects exhibited significant water leakage over time, which resulted in widespread and prevalent structural damage and water intrusion.

These balconies were designed with wood framing, dimension lumber wood joists, and engineered wood products, using common waterproofing membranes. For both projects, the waterproofing membranes were designed with “wearing surfaces” comprised of cast-in-place concrete. For the Houston project, the perimeter utilized an aluminum T-bar assembly that provides some drainage via integral weep holes, but did not incorporate a drainage composite to facilitate water runoff. For the Austin project, the waterproofing system did incorporate a drainage composite, but clear paths of water removal and discharge were not consistently constructed.

Our firm “inherited” both of these projects after other consultants had performed initial investigations and found some of the aforementioned problems. For various reasons, those consultants either did not want to continue with the projects or were unable to complete the services required for the remediation. In each case, additional investigations and analyses were required before developing the renovation schemes eventually implemented. Ultimate renovation included redesign, modification, and replacement of several portions of the original structural framing, associated perimeter flashing systems, parapet walls of Portland cement plaster, as well as brick and stone veneer cladding assemblies. Additional drainage and slope considerations were also engineered for these facilities. This paper will include a review of some of the challenges involved in planning and coordinating reconstruction of the balconies while allowing these facilities to remain open for business and fully occupied.

General Theories of Analysis and Design

Our philosophy of balcony waterproofing design has been developed over a 44-year career that has involved both investigating failed projects and designing new and remedial projects for our clients. Although a number of resources have been utilized over the years, including manufacturers’ specifications and details, standard texts (such as Architectural Graphic Standards by Ramsey and Sleeper and the NRCA Roofing and Waterproofing Manual), we have also found that several ASTM standards, practices, and guides have provided beneficial information and assistance. These ASTM guides included the following, among others: ASTM C981, Standard Guide for Design of Built-Up Bituminous Membrane Waterproofing Systems for Building Decks; ASTM C989, Standard Guide for Use of High Solids Content, Cold-Liquid-Applied Elastomeric Waterproofing Membrane with Separate Wearing Course; and ASTM D5898, Standard Guide for Standard Details for Adhered Sheet Waterproofing.

General Principles

Probably the most important principle of waterproofing design to which we always try to adhere is to provide (or create) slope within the deck, as well as drainage of water at the membrane level of the waterproofing assembly. If the existing structural system does not provide adequate slope, achieving that goal with overlays or fillers can be challenging. However, in the case of both of these projects, achieving slope within the wood framing was relatively easy. Another important principle is to provide direct paths for water collection and discharge of water from the assembly. Usually, this will take the form of drainage composites, fixed drains, perimeter scuppers, etc. This aspect of the drainage capability can almost always be achieved—whether you are dealing with new construction or a remediation project. If fixed drains are used, make certain they are dual-level: capable of accepting water runoff at the top of the wearing surface, as well as at the membrane level. Take proactive steps to avoid clogging of the drains, particularly if fixed drains are used. This may require enlarging existing holes in the drain body, creating additional holes within the drain body, or providing geotextile filter fabrics around the drains as a permanent barrier.

As with all waterproofing projects, care should be taken to provide proper flashing heights and terminations for the waterproofing membrane at all perimeters, terminations, and penetrations. Where appropriate and required, provide counterflashing of the waterproofing membranes at transitions, particularly where exposed to ultraviolet light or possible maintenance activity. Where possible, minimize the amount of water exposure experienced by the system. While this goal cannot always be achieved, and the ASTM definition for “waterproofing” includes resistance to water under hydrostatic pressure, it is best to limit the exposure to water. Reroute discharge from the roof into collector systems, and limit the amount of direct water collection and runoff, if possible.

One of the most important principles we use in our practice is to avoid the use of “separate wearing surfaces” that are difficult to remove and that restrict access to the membrane and flashings for normal inspection and maintenance. Implementation of this principle means that we try by any means to not specify or use concrete topping slabs, or even tiles and pavers installed in mortar-setting beds. Eventually, a leak will occur, and such wearing surfaces will either 1) delay required actions, 2) incur significant labor costs to remove the overburden, or 3) complicate the remediation due to noise, inconvenience, and damage to...
Based on our experience, we have found that where the actual design and/or original construction of “failed” waterproofing installations deviate from those general principles outlined above is where we typically discover the “cause” of the waterproofing failure or lack of performance. For new construction projects, we attempt to steer our clients away from making mistakes in violating these principles. For our remediation projects, we are obligated to evaluate the effectiveness of the existing design to adhere to these principles and make modifications necessary to correct certain issues, where possible.

**HOUSTON PROJECT**

**Basic Construction**

Basic construction of the project in Houston consisted of a four-story assisted living facility with multiple connected, building “wings” in various Y-shaped configurations coming off a central core. These connected building wings consisted of multifamily-style construction with 144 private balconies, arranged in “stacks” corresponding to the various interior space layouts (see *Figure 1*). Both corner-type and projecting configurations were provided, with tubular steel columns occurring at the corners of each level to support the framing above. Wood framing consisting of a combination of dimension lumber, engineered wood products (beams), and prefabricated wood trusses was utilized. The fortunate thing about this configuration was that the balconies did not extend into or over an occupied space; they were all “outside” of the building exterior walls. However, there was still significant deterioration of the OSB decking and wood framing that made the balconies unsafe for occupancy and use (see *Figures 2 and 3*).

One unfortunate aspect of the construction was that oriented strand board (OSB) panels had been utilized for the balcony decking and served as the substrate for the weatherproofing applications. Despite the Engineered Wood Association (APA) assertions to the contrary, it is our opinion that OSB panels, while exhibiting adequate structural strength and properties when they are in pristine condition, do not provide the same stability and longevity as standard plywood panels for waterproofing applications. Our experience is that the OSB panels are more sensitive to moisture absorption and ambient moisture variations, as well as the underlying waterproofing. Our experience is that it will be all three!

![Figure 1 – Houston typical elevation.](image1)

![Figure 2 – Wood damage at balconies.](image2)

![Figure 3 – Deteriorated decking and framing.](image3)
as more susceptible to moisture deterioration.\textsuperscript{1,2,3} On these projects, the OSB decking was used in conjunction with self-adhering bituminous membrane waterproofing, 1½- to 2½-in.-thick concrete topping slab, and aluminum T-bar perimeter metal with integral weep holes and drip flashing.

The original design documents prescribed, and selective demolition confirmed, that the basic structural framing and decking did not provide slope, with the idea that the top surface of the concrete topping slab would be sloped to the perimeters. Accordingly, there was minimal to no slope at the membrane level, and the waterproofing had not been provided with a drainage composite. Each balcony also had a number of penetrations, including structural columns and the base plates and fasteners for numerous decorative handrail posts. Our investigation also found that the perimeter flashings had been improperly integrated with the surrounding walls, which consisted of both masonry brick veneer and ¾-in. Portland cement plaster (stucco). The final aspect of this construction related to the balconies was the use of gypsum board ceilings on resilient furring channels that provided an Underwriters Laboratories (UL)-rated assembly.

About seven or eight years after completion, a number of the balconies at this project began to exhibit signs of distress, which included cracking of the concrete topping slab, what appeared to be “settlement” of the decking, distortion of the soffits, displacement of the sheet metal flashings, and water stains on the ceilings of balconies below. The building owner’s maintenance personnel began to observe a gradual worsening of these conditions, which led to an investigation that uncovered the underlying causes. Ultimately, the owner authorized the development of drawings and specifications to implement the required structural repairs and waterproofing remediation work (see Figures 4 through 7).

### Framing Challenges

The structural repairs at this project were complicated by the fact that the structural drawings were not explicitly followed during the original construction. This information was gathered by limited selective demolition within the ceilings of several units at various locations in order to discern the extent and severity of the framing deterioration. Observations quickly revealed that the main framing (usually prefabricated, plate-connected wood trusses) sometimes occurred longitudinally, but almost as often occurred laterally to the long direction of the balcony. The main framing members were supplemented by glued-laminated beams (glulams), as well as dimension lumber, typically consisting of short-span beams composed of three 2 x 12s nailed together. However, the consistency of the framing for even similarly sized and configured balconies was nonexistent. Information became available suggesting the original construction was accomplished using three or four different framing crews, each of which apparently brought its own level of skill (of lack thereof) to the task at hand without much regard for the structural and architectural drawings. In addition, structural connections were not consistently implemented, resulting in omission of connection hardware and utilization of nails in bending rather than in simple shear.

### Remediation Design

Our plan was to implement the complete balcony renovation of the second, third, and fourth levels of all balcony “stacks” for all 144 balconies, while allowing the residents to remain in occupancy and without totally evacuating portions of the building. This plan avoided the cost and disturbance of displacing the residents while completing the work. It required extensive and early communication between the contractor and the owner in order to coordinate and provide notice to the residents as each phase of the construction was scheduled and implemented. It also required quite a bit of forbearance and patience on the part of the residents, due to the noise and restricted use of the balconies. The restricted use of the balconies was not entirely due to the construction, since, as the engineer-of-record responsible for the “health, safety, and welfare of the public,” we had previously written a letter recommending that the balconies not be used until the remedial work was completed.

The renovation documents required demolition of the concrete topping slab, waterproofing, and OSB decking down to the framing. All damaged and deteriorated wood members were removed and replaced, or else necessary repairs were implemented as appropriate (see Figure 4). Connections of all wood framing were inspected and confirmed as adequate, or else revised and repaired. Slope of ¼ in. per foot was achieved within the framing by adding “sistered” framing members or shims on top of the existing members; however, there were limitations that were imposed by the existing height of the thresholds for the doors accessing the balconies from within the units.

New 23/32-in.-thick exterior-grade plywood was installed over the reconfigured
framing, while the steel framing was shored up and supported. All work was implemented at the fourth level first, working down to the lower levels in succession. Waterproofing membranes were installed to the primed decks and properly integrated with the surrounding wall systems, requiring new combination through-wall flashings and receivers at both the brick veneer and the plaster walls (see Figure 5). Minimum flashing heights were obtained by either installing plywood vertically at the wall framing, or else by using the original brick veneer as a substrate. Water intrusion within the brick veneer and plaster cladding systems were collected and weeped from the wall at these through-wall flashings. The membrane flashings were counterflashed using prefinished sheet metal inserted into the receivers and fastened. Special details for the penetrations were developed, including for the steel tubular columns and posts for the decorative wrought iron handrails.

For the wearing surface, we specified and detailed the use of individual pavers on a proprietary pedestal system, which abutted the counterflashing and walls on one side for the projecting balconies and on two sides for the corner balconies (see Figure 6). In order to “replace” the aluminum T-bar perimeter metal, we designed a perimeter system composed of prefinished 0.060-in. aluminum retainer metal, which was shimmed away from the membrane perimeter discharge at the perimeter (see Figure 7). The retainer metal served both as aesthetic closure for the paver perimeters, as well as a restraint against both wind uplift and lateral sliding. After all balcony waterproofing renovation work was complete, appurtenances, such as decorative fiberglass columns and the decorative wrought iron handrails, were reinstalled. The residents were allowed to move furniture and plants onto the balconies after successful completion of the punch list for each phase of the work.

**AUSTIN PROJECT**

**Basic Construction**

Basic construction of the project in Austin consisted of an assisted living facility that ranged in height from three to six stories as the facility accommodated a change in natural terrain. Again, there were multiple, connected building “wings” coming off a central core. These connected building wings consisted of multifamily-style construction, with a total of 126 balconies, some of which were fully or partially covered, while there were 38 private balconies that were fully exposed to the weather, randomly arranged throughout this facility with no particular pattern (see Figure 8). The balcony configurations included corner-type, projecting, and “double” or tandem styles. Most of the “exposed” balconies terminated with wood-framed parapet walls that were clad with plaster on the interior surfaces, and with either stone or plaster on the exterior surfaces. The cast-in-place concrete topping slabs sloped away from the building space to through-wall scupper sleeves that discharged to the exterior. Occasionally, balconies were provided with lanais composed of tubular steel columns and cedar beams, in which the steel columns penetrated the topping slabs and waterproofing membranes. The wood framing consisted solely of dimension lumber in combination with typical platform-style framing at the parapets and surrounding exterior walls. At certain limited locations, the balconies extended into or over occupied spaces, which tended to complicate the overall remediation work.

As with the other project, the Austin project also utilized OSB panels for the balcony decking, and due to the relatively small
Figure 8 – Austin typical elevation.

sizes of the balconies, the support framing was typically comprised of 2 x 8 wood joists installed with no slope. The waterproofing system used at this project was a cold, liquid-applied, modified-bituminous membrane, with flashings that extended up onto the fiberglass-faced gypsum sheathing on all sides. As previously stated, the waterproofing system was provided with a drainage composite board; however, investigations revealed that the drainage composite had been improperly placed onto the waterproofing membrane prior to it being allowed to cure. Accordingly, the waterproofing was “deformed” into dimples formed by the plastic “waffle” board of the drainage composite, causing inadequately thin membrane thicknesses, as well as cutting and displacing the membrane at certain locations. In addition, the scupper openings were often partially blocked, and water runoff was restricted by the drainage composite being installed with a turned-up edge.

Although the waterproofing turned up the walls an adequate amount, these flashing membranes were only “counterflashed” using a spun-bonded polyolefin nonwoven weather barrier, as well as the metal lath and plaster of the surrounding walls. Also, the plaster of the exterior walls and parapet walls extended down into the topping slabs, with the topping slabs having been placed after the plaster was installed. Although this juncture had been provided with a sealant joint, the bottom of the plaster was always subjected to water runoff at the topping slab surface, as well as absorbed moisture from the drainage plane below. Finally, although the concrete topping slabs were specified to be 2.5 in. thick, selective demolition found them to have been actually installed 5 to 6 in. thick.

One of the original aspects of this construction that hindered the initial investigations and complicated the remediation work was that the ceilings of these balconies were comprised of full-thickness plaster on metal lath attached to the bottoms of the wood joists. Where the steel columns from the lanais penetrated the membrane, the flashings were not constructed well and caused significant leakage.

Again, about five or six years after completion, a number of the balconies at this project began to exhibit minor signs of distress, which primarily consisted of water stains on the ceilings of balconies below. Additionally, where the waterproofing had failed at the exterior walls, water intrusion had caused deterioration and organic growth within the occupied spaces at certain locations. The building owner’s maintenance personnel created selective demolition openings in the plaster ceilings in order to observe these conditions, which prompted a broader investigation to be commissioned (see Figures 9 and 10). Ultimately, the owner authorized the development of drawings and specifications to implement the required structural repairs and waterproofing remediation work.

Remediation Design

Our plan was to implement the complete balcony renovation of the exposed balconies, while making accommodation for any additional balconies that might exhibit problems during the renovation work. Once again, this work was accomplished while allowing the residents to remain in occupancy and without totally evacuating portions of the building. This plan avoided the cost and disturbance of displacing the residents while completing the work. Similar to the other project, this remediation scheme

Figure 9 – Deteriorated OSB and framing.

Figure 10 – Deteriorated OSB and framing.
required extensive and early communication between the contractor and the owner in order to coordinate and provide notice to the residents as each phase of the construction was scheduled and implemented. It also required quite a bit of forbearance and patience on the part of the residents, due to the noise and restricted use of the balconies during the remediation.

The renovation documents required demolition of the concrete topping slab, waterproofing, and OSB decking down to the framing. Due to the amount of known deteriorated wood members, all of the balcony joists were removed and replaced (see Figures 11 through 13). Slope of ¼ in. per foot was achieved within the framing during the replacement. New 23/32-in.-thick exterior-grade plywood was installed over the reconfigured framing (see Figure 14).

Waterproofing membranes were installed to the primed decks and properly integrated with the surrounding wall systems, requiring new combination through-wall flashings and receivers at the plaster walls. Minimum flashing heights were obtained by installing plywood vertically at the wall framing (see Figure 15). The membrane flashings were counterflashed using prefinished sheet metal inserted into the receivers and fastened, which will be easily removable for future maintenance and ultimate replacement (see Figure 16). Special details for the penetrations were developed, including for the steel tubular columns and posts for the decorative wrought iron handrails. In addition, for balconies that were not constructed with parapets and that had been constructed with just an ornamental railing, special details depicting a perimeter retainer metal were used to terminate the paver installation (see Figure 17).

For the wearing surface for this project, we specified and detailed the use of individual pavers on a proprietary pedestal system, which abutted the counter-flashing and walls at the exterior walls and parapets (see Figure 16). The original porous concrete coping stones were removed from the parapets. A stainless steel through-wall flashing was installed across the wall, and new castone coping stones were installed (see Figure 18). After all balcony waterproofing renovation work was complete, appurtenances, such as the lanais and the decorative wrought iron handrails, were reinstalled. The residents were allowed to move furniture and plants onto the balconies after successful completion of the punch list.
LESSONS LEARNED

Despite long-available information and guidance on how to design and construct balcony and plaza deck waterproofing assemblies, there appear to be a lot of design and construction professionals who are either unaware of this information and data, or else believe there is a better or cheaper way to do it that will perform just as well. If they are unaware of this information, which has been available for years, then omissions from these designs and improper details are a mistake and the product of ignorance. If these design professionals are simply seeking shortcuts, then these principles will inevitably teach the same lessons to these new “seekers” as those who helped to develop the guides and recognized industry literature in the first place. In our experience, taking shortcuts and not fully and faithfully implementing the basic principles outlined earlier in this paper will result in unsatisfactory waterproofing performance and problems that could likewise cause premature replacement of the affected systems and assemblies.

Particularly troublesome, in my view, is the use of concrete topping slabs as a separate wearing surface for waterproofing systems. Again, use of these materials hinders access for maintenance and investigation of the membrane, results in costly labor to ultimately remove, and causes significant disruption and noise when the need to remove the concrete topping slab inevitably occurs. For these reasons, the use of a concrete topping slab should not be selected as a design
choice except in the most extreme cases.

The other obvious design feature highlighted by these two case studies is the requirement for fully developed, functional, and efficient drainage for the plaza or balcony decks, which includes not only the surface collection and runoff, but, perhaps more importantly, adequate drainage at the membrane level. Accordingly, whether drainage is achieved by fixed drains, by scuppers, or by perimeter runoff, proper drainage should be fully detailed and achieved for each project, whatever the overall configuration of the construction may be. Professionals responsible for achieving compliance with these design principles should not be reluctant to innovate and develop whatever details are needed to accomplish those principles within the core systems to be designed.

In summary, the following key points have been made, although some are simply the opinion of this author.

- Provide proper substrates for the waterproofing systems, with stability and longevity in mind. Plywood decking may be a better choice for waterproofing applications over wood-framed structures.
- Select appropriate waterproofing materials and systems with a proven track record that are capable of accommodating the conditions anticipated for that particular project.
- Provide an appropriate protection course/drainage composite in order to promote the free flow of water at the membrane level. Be sure to explicitly detail or clearly specify the means by which the collected drainage will be discharged from the system, and provide quality assurance during construction to make sure it gets done.
- Provide for drainage at the waterproofing membrane level, as well as at the surface level in all cases. If fixed drains are used, make sure the pathway is free and clear at the membrane level.
- Select separate wearing surfaces that are not “permanent” (as is the case with cast-in-place concrete topping slabs and ceramic tiles installed in mortar setting beds), which make it more difficult to diagnose problems and ultimately repair the waterproofing deficiencies. Consider discreet concrete pavers on a proprietary pedestal system.
- Evaluate methods by which the amount of water runoff onto the balcony or plaza deck may be limited. Avoid discharge of downspouts or no-guttered roof systems onto such balconies or plaza decks, where possible.
- As much as possible, consider how and when future maintenance may need to be implemented, as well as how access to the membranes and flashings may be achieved. Consider materials and assemblies—including within the ceilings below the waterproofing deck—that are not permanent and that may be readily removed and replaced for inspections.

REFERENCES