Balcony View

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Abstract

Many wood-framed buildings include exterior balconies in their designs. At these balconies, structural framing is often located in an interstitial space below the walking surface of the balcony, which typically places the wood framing in a poorly protected exterior portion of the building. This configuration requires that particular attention should be paid to the management of runoff from rain and incidental moisture at these structures. To be effective, the water resistive plane of the building envelope must be extended out to encompass this interstitial space and must be continuous around all elements that require protection.

This paper will review case studies of buildings that have experienced water intrusion at these interstitial spaces and water intrusion's impact on the wood structure that supports the balcony. It will also discuss the composition of the balcony assembly and the path water can take to cause damage to the structure below. The case studies will illustrate the hazards of improper design and installation of the building envelope, highlight the importance of directing water toward the exterior of the building, and discuss proper structural member selection. Current design practices will be considered and attention will be drawn to the damaging effects of improper waterproofing design and poor structural member selection/detailing.

Introduction

Water damage to balcony structural systems is a recurring failure often seen in residential construction. Balconies experiencing this distress are typically covered with a continuous walking surface and wrapped with exterior finishes along the edge and soffit. With this configuration, water can migrate inside these balcony assemblies and become trapped against wood framing members, which are sensitive to long-term moisture exposure. This moisture exposure causes unprotected wood materials to deteriorate and eventually leads to a loss of strength that can lead to structural failure. To better comprehend this problem, it is important to understand the nature and mechanics of building envelopes.

Case studies provided in this paper illustrate both the impact of the failure at the weather resistive barrier and the damage water intrusion from this failure can cause to the structural system.

Building Envelopes

To better understand damage at balconies, one needs to start with a discussion of what should be done to initially to protect the structural components of the building. The assembly of materials that separates the exterior environment from the interior of a structure is called the building envelope. This envelope serves as the outer shell or "skin" that protects the building from the elements while also facilitating climate control within. Typical components of a building envelope include the exterior walls, roof, doors, windows, balcony decks, etc. These components shed water away from the building and form a barrier to prevent the migration of water inside. One of the key concepts in developing a system to prevent water intrusion is to lap upper components over lower components in what is termed a "shingle lap" manner. Intersecting components must also be constructed of materials that are compatible and connected in a manner that diverts water away from the interior of the structure. An improperly designed or installed building envelope allows water to migrate to moisture-sensitive materials and can have a significant impact of not only the aesthetics of the building but also the integrity of its structural system.

Flashing, sealant, and/or trim should be installed at these building components to prevent water from entering the building. Provisions should also be made to collect water that might pass beyond the flashing, sealant, and/or trim and divert it back to the exterior of the building. If entrapped water is not allowed to migrate to the exterior and is confined within the building's interior cavities for long periods of time then serious life-safety damage can occur in the wood structure.

Balconies

Similar to the roof of a building, the top horizontal surface of a balcony deck should be protected by a waterproofing membrane system which is sloped toward the building edge at a minimum 1/4 inch per foot. This membrane should be specifically manufactured for this type of installation and attached to the building's vertical walls and columns with flashing, sealant, and trim to create a fully integrated, continuous building envelope protecting the interstitial space enclosing the balcony structure below. The exposed traffic bearing surface (tile, topping slab, etc.) applied over this waterproofing membrane should utilize a drainage underlayment system designed to allow any water that might become entrapped between the tile and the waterproofing membrane to weep to the front exterior face of the balcony. If solid veneers like stucco are applied to the face of the balcony, a weeping system should also be incorporated into the underside of the interstitial space (soffit) to allow water to escape from the balcony assembly. When water breaches the interior of the balcony assembly and is not allowed to escape, deterioration of moisture-sensitive materials, such as the wood framing, will occur.

Case Studies

Field observations indicate that, in many cases, the design and installation of balcony waterproofing was not developed sufficiently by the building designer to protect the structural system that supports the balcony. The following four case studies illustrate the impact of not providing a proper weather protection system during the installation and/or design of balcony assemblies.

Case Study #1: A single-family residential structure in a North Carolinian coastal city experienced damage to aesthetic features along the perimeter of the balcony. A tiled walking surface, a synthetic stucco cornice and veneer and a gypsum soffit enclosed the structural system of the balcony. Destructive testing exposed discolored and deteriorated wood framing (**Figure 1**).

Figure 1: Exposed balcony assembly

Architectural and structural details for the balcony were included within the construction drawings for the building. The structural plans indicated beam and joist locations with beams consisting of sawn lumber and laminated veneer lumber (LVL). The general notes prepared by the structural engineer specified all LVL beams to be wrapped "*so as to prevent exposure to weather*" (emphasis added). The notes did not indicate the material with which the LVL lumber was to be wrapped. The architectural drawings included a balcony plan and elevation with profile sections that illustrated the cornice along the perimeter of the balcony. No details or notes on the architectural plans provided direction for weatherproofing of the balcony.

A review of the exposed wood framing indicated that the LVL beams were not wrapped with a water-resistive barrier. Further examination indicated that the waterproofing membrane between the tile floor finishes and the balcony floor sheathing terminated inside the finishes at the perimeter of the balcony and did not overlap any other weather-resisting component. When constructed, this configuration directed water inside the finishes, which was trapped against the LVL beams and caused them to deteriorate behind the finishes. A sketch of the balcony assembly is provided in **Figure 2** below. The waterproofing members are indicated in red, and the path of moisture is indicated in blue.

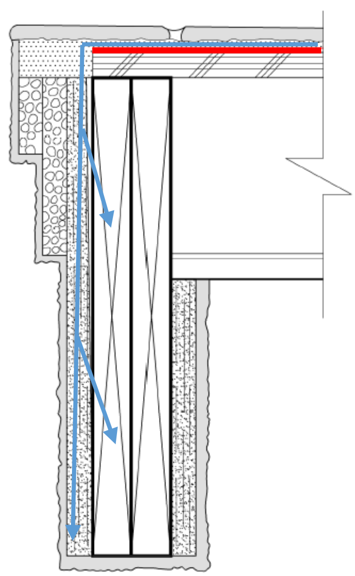

Figure 2: As-built balcony detail

In this assembly, there were no weather-resisting components that directed the water to the exterior of the veneer. In addition, there were no features that allowed entrapped water to escape the assembly.

Case Study #2: The balcony of a single-family residential structure experienced excessive deflections and fractures in the stucco veneer. Partial removal of the stucco veneer revealed a beam assembly supporting the balcony that included approximately 1/2" thick exterior oriented strand board (OSB) sheathing attached to both sides of a composite beam. The composite beam contained two (2) 2x12 beams sandwiching a 3/4" thick OSB plate. A vapor barrier was wrapped down the exterior face of the beam and returned approximately 3/4" along the beam soffit. The exterior stucco veneer was continuous down the front side of the beam and wrapped around the base of the beam to the top of its interior side. A granule-coated, bituminous membrane was applied over the wood floor sheathing, and metal drip edge flashing was provided at the top of the stucco veneer along the exterior edge of the balcony (**Figure 3**).

Figure 3: Removed stucco veneer

The beam was deteriorated to the extent that the stucco veneer at the opposite side of the beam was visible through the missing sections of the beam (**Figure 4**).

Figure 4: Deteriorated beam with exposed interior face of veneer

The design and construction of this structure allowed water to migrate inside the balcony assembly and access the beam. Even though the installation of a vapor barrier mitigated water intrusion from the exterior face of the beam, the beam was still not protected from entrapped water as the vapor barrier was not provided along its interior face. In addition, there was no mechanism to allow water to drain from the assembly.

Case Study #3: A single-family residential structure in the Tampa Bay area exhibited vertical fractures around beam and column interfaces at the second and third story balconies. These veneer fractures were indicative of a possible compromise in the balcony's structural system (**Figure 5**).

Figure 5: Stucco veneer distress at balcony beam and column interface

Destructive testing exposing the wood framing revealed the balcony to be constructed with wood I-joist engineered lumber, LVL beams, and concrete masonry unit (CMU) columns. A stucco veneer was applied to the exterior of the beams and columns, and a single layer of felt paper was installed between the stucco veneer and the wood framing. The building paper terminated at the base of the beams with no provision incorporated into the veneer below the beams to allow water to weep from the balcony assembly. The exposed framing exhibited extensive deterioration along the full depth of the LVL members, which were easily disturbed with pressure applied by hand (**Figure 6**).

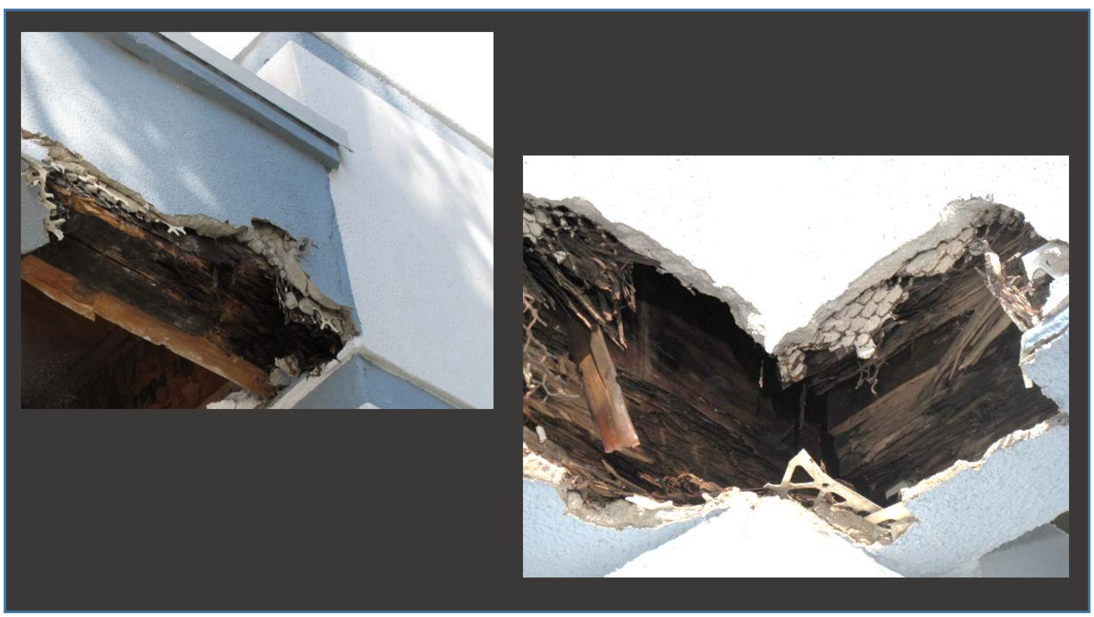

Figure 6: Deterioration of LVL beams

A fiberglass lining extending a few inches up each of the adjoining walls and columns was installed over the floor sheathing of the balcony. Metal drip edge flashing was installed along the edge of the balconies and was terminated inside the field of the stucco. In addition, no control joints were provided in the stucco at flashing terminations, which allowed veneer fractures to develop above the flashing terminations letting water migrate inside the beam assembly. Water that entered the beam assembly became trapped against the LVL beams causing them to deteriorate to the point of imminent collapse.

Case Study #4:

Multiple buildings in a complex of multi-family structures exhibited water damage at the soffit of the balconies. The buildings were configured to project the balcony floor beyond the roof line above. Guttering was not installed along the eave of the roof, which directed roof runoff directly toward the edge of the balcony floor.

An asphalt-based roofing membrane was installed between the tile and floor sheathing toward the interior of the balcony and a vinyl waterproofing membrane was installed along its exterior edge. The vinyl membrane was lapped over the asphalt-based membrane, which created a reverse lap in the membranes (a condition where the lower component is incorrectly lapped over the upper component). This improper lapping of the membranes directed water into the lap, below the vinyl membrane, and into the balcony assembly causing severe deterioration to the structure below (**Figure 7**).

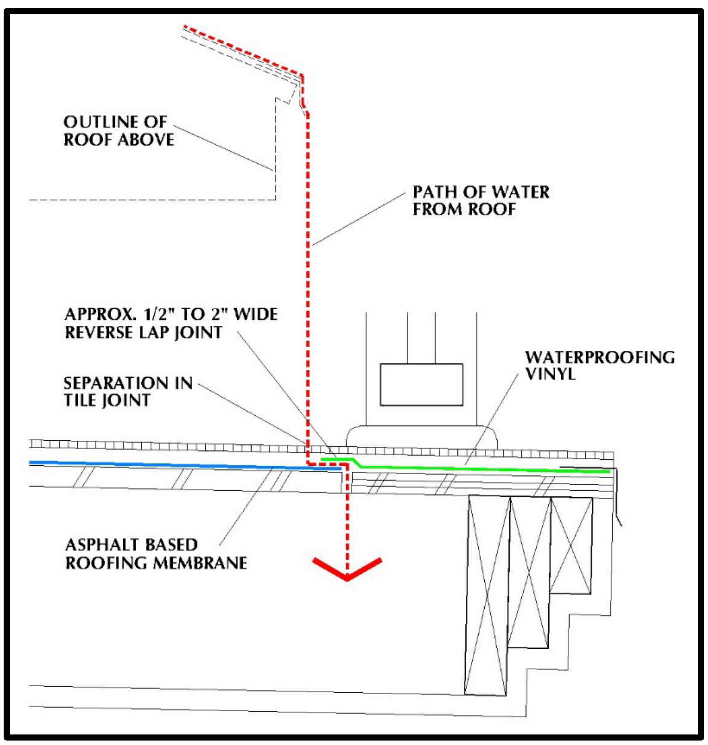

Figure 7: Balcony configuration

Water Management

To effectively divert water away from the interstitial space of a balcony assembly, the waterproofing membrane on top of its deck must be continuous and/or properly lapped and all of its water shedding components must direct water to the exterior of the veneer at the edge of the balcony. Water damage at balconies should also be further mitigated by installing elements that weep water away from the interior of the assembly. ASTM Standard C1063 requires that stucco, as a solid veneer, have weep provisions along the base of all framed walls. In this standard, section 7.11.5 requires a weep screed with a non-perforated vertical flange is required at the base of the framed walls (ASTM 2012). Section A2.2.3 of ASTM Standard C926 also requires a drip edge configuration at the intersection of horizontal and vertical faces in stucco veneers (ASTM 2012). This is the type of intersection that occurs at the base of balcony beam assemblies. Drip edge and weep screed accessories are manufactured for stucco veneers to permit the migration of water to the exterior of balcony assemblies.

Structural Considerations

The damage to the structural systems illustrated in the case studies cautions the structural designer to consider the waterproofing system that protects the balcony structural system. Although structural designers are not typically responsible for the design of the balcony waterproofing, they should understand the intent of the waterproofing design in conjunction with their design of the structural members. Waterproofing details and specifications should indicate the type of deck membrane, the interaction between the components along the top edge of the balcony, and weep features in the veneer at the base of balcony beams. When these details are unclear, incomplete, or do not divert water to the exterior face of the balcony, structural designers should consider the structural members to be exposed to exterior conditions and should choose materials that are resistant to moisture exposure.

The case studies also illustrate that weatherproofing may be installed improperly or incompletely leaving the structural system unprotected. The structural damage observed at these sites not only reduces the lifespan of the structure but also presents a life-safety issue. These conditions underscore the importance of drainage features along the base of the balcony assemblies and proper weatherproofing design and installation.

Exacerbating the problem, balcony designers often capitalize on scenic views by maximizing the distance between columns. Often conventional sawn lumber does not provide stiffness required for the resulting long spans created between these columns. Proprietary wood products, such as LVL members, are made to provide more efficient structural performance for larger spans; however, these materials do not perform well under long-term moisture exposure. For this reason, manufacturers of LVL members often restrict the use of these products to areas that are not exposed to weather/moisture.

Technical literature prepared by one LVL manufacturer explains how restrictive the environment must be by indicating that these products "**are intended only for applications that assure *no* exposure to weather or the elements and an environment that is free from moisture from *any* source**" (BC 2013, emphasis added). Another manufacturer indicates that the LVL lumber is intended for "*dry-use*" conditions. This same manufacturer provides a treated parallel strand lumber (PSL) for exterior conditions (TJ 2014). However, technical information they provide for the PSL member indicates that it should not be encased in a solid veneer because the veneer cannot provide adequate ventilation or drainage. In lieu of a direct application of a solid veneer, the manufacture recommends the use of furring strips to offset the veneer from the face of the member and the provision of ventilation panels along the base of the beam, which is illustrated in **Figure 8** below (TJ 2015).

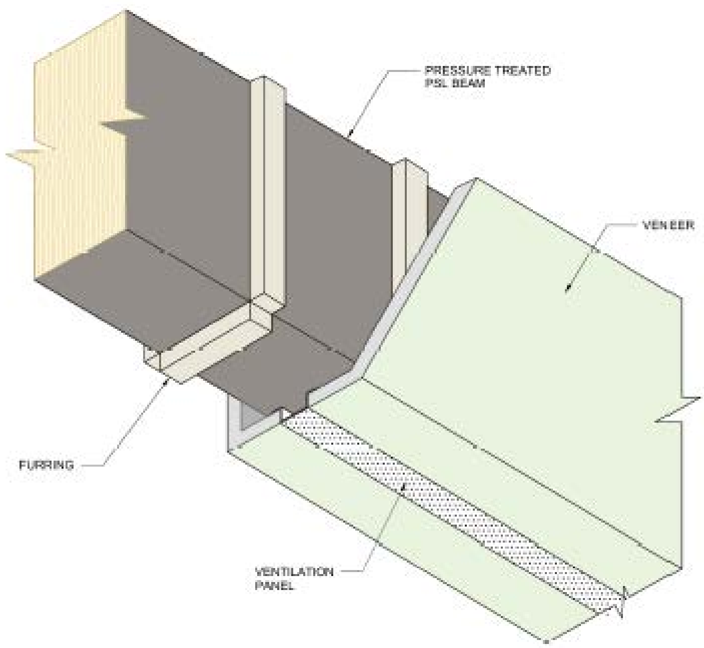

Figure 8: Recommended installation of veneer

The limitations provided by engineered lumber manufacturers indicate the importance of understanding water management at balconies and the impact that water intrusion can have on balcony assemblies and engineered lumber that supports those balconies. To provide a resilient structure, the structural designer must understand the environment in which the structural system will be placed and the limits of the material that will be used.

Conclusion

The case studies illustrate the importance of understanding the environment within which a structural system will be expected to perform. Environmental factors can compromise the integrity of a structural system and reduce the lifespan of a building. Deterioration at hidden balcony members can progress without notice until a life-safety hazard has developed. To design well-performing, sustainable balconies, structural designers should understand the environmental impact of the enclosed balcony space and the limitations of the material properties in the members that they are specifying.

References

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