

DURABLE SOLUTIONS FOR BALCONIES & DECKS



MAY 2023



Acknowledgements

This project was funded through a cooperative research agreement (19-JV-11111135-046) between Home Innovation Research Labs and the USDA Forest Service Forest Products Laboratory.

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This research was supported with Railing Product provided by AGS Stainless, Inc.

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Citation: Home Innovation Research Labs. 2023. Durable solutions for balconies & decks. Upper Marlboro, Maryland: Home Innovation Research Labs. 59 p.

The publisher has provided a Spanish translation of this publication:

https://www.homeinnovation.com/trends_and_reports/featured_reports/soluciones-duraderas-para-balcones-y-terrazas

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1. INTRODUCTION

Durable Solutions for Balconies and Decks is an illustrated guide that identifies design principles and construction practices to improve the moisture performance of wood-framed balconies and decks in low- and mid-rise multifamily buildings.

Wood-framed construction is common for low- and mid-rise multifamily and mixed-use buildings containing apartments or condominiums, as well as commercial or retail spaces. It is also typical for these buildings to have balconies and decks in all or most dwelling units, for both their functional and architectural qualities.

In terms of durability, balconies and decks represent one of the most vulnerable construction elements in the building. Several high-profile balcony and deck failures, such as the June 16, 2015, Berkeley Balcony Collapse [1], which killed 6 people; the June 29, 2003, Chicago Balcony Collapse [2], which killed 13 people; and many less publicized balcony and deck collapses, call into question whether design and construction practices have adequately addressed moisture infiltration and the potential for structural failures. In many cases, forensic investigations have discovered construction defects and major deviations from the design as primary causes of structural failure.

After the 2015 Berkeley Balcony Collapse, California's Contractors State Licensing Board (CSLB) published technical findings, leading to changes in the California Building Code that were later adopted into the 2018 International Building Code (IBC) [3].

Section 2 of this Guide highlights the IBC code provisions and identifies three key design principles to minimize moisture-related structural failure: (1) sloping of the walking surface; (2) flashing and drainage of the construction assembly; and (3) ventilation and drying of the substructure. Please note that many state and local jurisdictions may not have adopted the most recent IBC [4].

Section 3 illustrates the design approach for cantilever balconies and decks, and explains how the key design principles should be applied to alternative balcony and deck designs.

Section 4 covers material selection, compatibility, and durability. Since some building materials may chemically react with each other, the design professional must review information provided by the manufacturer to ensure that components of complex assemblies will work together.

Section 5 discusses how project management impacts the change order process when considering field modifications, which happens often during construction and can be the source of unexpected problems.

Section 6 illustrates the use of a design mock-up to bridge the gap between what is specified within the construction documents and what is built by the contractor.

Finally, Section 7 discusses the importance of inspection and continual maintenance and provides a basic checklist that can be used by maintenance staff to ensure balconies and decks remain in good condition during occupancy of the building.

2. BUILDING CODES & DESIGN PRINCIPLES

Design professionals have a wide range of choices to select from when considering balcony designs. This Guide focuses on cantilevered balcony designs, which have historically sustained most of the catastrophic structural failures.

The critical area for any cantilevered design is the interface between the cantilevered member and the wall. In addition to sloping of the walking surface and waterproofing membrane, the flashing details must keep water out of the building envelope and promote drying of any components that get wet.



Figure 1. Wood Cantilever Balcony Design

2.1 CODE OVERVIEW

2021 INTERNATIONAL BUILDING CODE (IBC) REQUIREMENTS

The 2021 IBC [4] requires the following design features to improve moisture performance and durability in balconies and decks:

- The construction documents must include details of all elements of the impervious moisture barrier system and the **manufacturer's installation instructions**.
- **Drainage features** must be confirmed during inspection. The impervious moisture barrier system shall not be concealed until inspected and approved.
- **Ventilation is necessary** for any enclosed structural framing. The ventilated area on the underside of the balcony or deck must be equal to at least 1/ 150 of the total area beneath the balcony or deck.

Other relevant balcony and deck construction requirements from the 2021 IBC include:

Live Loads: A minimum uniformly distributed live load is needed for balconies and decks equal to at least 1.5 times the live load for the area served and up to a maximum of 100 lbs/ sf (IBC) [4].

Lumber Decking: When using lumber decking, patterns designed and installed in accordance with the general provision of IBC lumber decking requirements are sufficient to demonstrate code compliance. All other designs must be verified through engineering analysis.

Thresholds: Doorway thresholds must not exceed 3/4 in. (19.1 mm) in height above the finished floor or landing for sliding doors serving dwelling units or 1/2 in. (12.7 mm) above the finished floor or landing for other doors. Raised thresholds and floor level changes greater than 1/4 in. (6.4 mm) at doorways shall be beveled with a slope not greater than one unit vertical in two units horizontal (50% slope). Other exceptions may exist depending upon the building type. The design professional must consult with the 2021 IBC and the local building code.

Guards: The guards (or railing) must be located along open-sided walking surfaces, including balconies and decks that are located more than 30 in. (762 mm) measured vertically to the floor or grade below at any point within 36 in. (914 mm) horizontally to the edge of the open side. The guards must be designed in accordance with load requirements of the applicable building code.

If glass is used to provide a guard or as a portion of the guard system, the guard must meet the requirements in Section 2407 of the 2021 IBC for glass in handrails and guards.

Exterior Walls/ Projections: Exterior balconies and similar projections extending beyond the exterior wall must meet the requirements of fire and smoke protection of the 2021 IBC (section 705.2) and exterior wall construction of the 2021 IBC (section 1405). Additional requirements must be met if the balcony is part of the path of egress and when considering fire separation distance requirements and material type. Generally, three options for fire protection are recognized within the building code: (1) fire-retardant-treated wood; (2) heavy timber members; and (3) sprinklers.

2021 INTERNATIONAL WILDLAND-URBAN INTERFACE CODE (IWUIC) REQUIREMENTS

If the building is in the wildland-urban interface zone, unenclosed accessory structures attached to buildings, such as balconies and decks, may be required to meet specific IWUIC requirements [5]. This can be achieved through a combination of material selection and specified design details. The design professional will need to adapt design principles in this guide to meet special fire zone requirements of local communities.

FAIR HOUSING ACT REQUIREMENTS

The U.S. Department of Housing and Urban Development (HUD) publishes the *Fair Housing Act Design Manual* [6], which provides design guidance about accessibility requirements that must be incorporated into multifamily buildings.

The Design Manual is divided into seven chapters, reflecting the seven basic accessibility requirements defined in the Fair Housing Act's implementing regulations:

1. Accessible Building Entrance on an Accessible Route
2. Accessible and Usable Public and Common Use Areas
3. Usable Doors
4. Accessible Route into and Through the Covered Unit
5. Light Switches, Electrical Outlets, Thermostats, and Other Environmental Controls in Accessible Locations
6. Reinforced Walls for Grab Bars
7. Usable Kitchens and Bathrooms

This Guide focuses on Requirement #3, Usable Doors, because the balcony or deck door thresholds in multifamily buildings require a low- or no-threshold entryway for wheelchairs to meet requirements of the Fair Housing Act.

Publicly funded housing requires a percentage of apartment units to be accessible, which are designed in accordance with requirements found in the 2010 *Americans with Disabilities Act Standards for Accessible Design* [7].

Compliant door thresholds must not exceed 3/4 in. in height for exterior sliding doors and other types of doors. For interior doors, the threshold must not exceed 1/2 in. in height.

Any change in height between 1/4 in. and 1/2 in. must have a beveled slope equaling 1:2.

For any change in height greater than 1/2 in., the threshold will need a sloped transition (1:12 or more).

The floor or ground surface within the maneuvering clearances at the doorway must not have a slope steeper than 1:48.

2.2 THREE KEY DESIGN PRINCIPLES

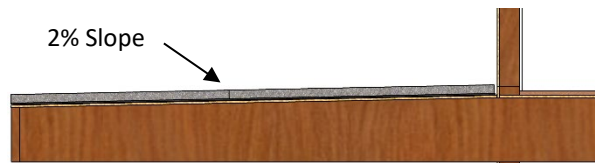


Figure 2. Principle One: Sloping Surface

PRINCIPLE ONE

Sloping the Walking Surface & Waterproofing Membrane

Balconies and decks must have a positive slope to drain. We recommend a minimum 2% slope (1/4 in. per ft.) away from the building envelope to

ensure proper drainage of bulk water (Figure 2). Note: the Fair Housing Act (FHA) accessibility guidelines and the Americans with Disabilities Act (ADA) mandate a maximum 2% cross-slope in certain cases. The design professional should be aware of this and adjust the drainage slope to ensure a required 2% cross-slope is not exceeded. Good drainage prevents water from ponding on the deck surface or pooling at the intersection between the building envelope and the balcony or deck substructure. If water drains towards the building envelope this can lead to the degradation of the surface materials and premature rot of the structure and connections. Proprietary deck and balcony surface systems may require sloping that is different than 2%. In these cases, the design professional must ensure that the proprietary system meets the local building code and FHA accessibility guideline requirements and should follow those instructions. If installing wood or synthetic boards on balconies or decks, no slope is recommended as per ASTM-E2266 (Standard Guide for Design and Construction of Low-Rise Frame Building Wall Systems to Resist Water Intrusion).

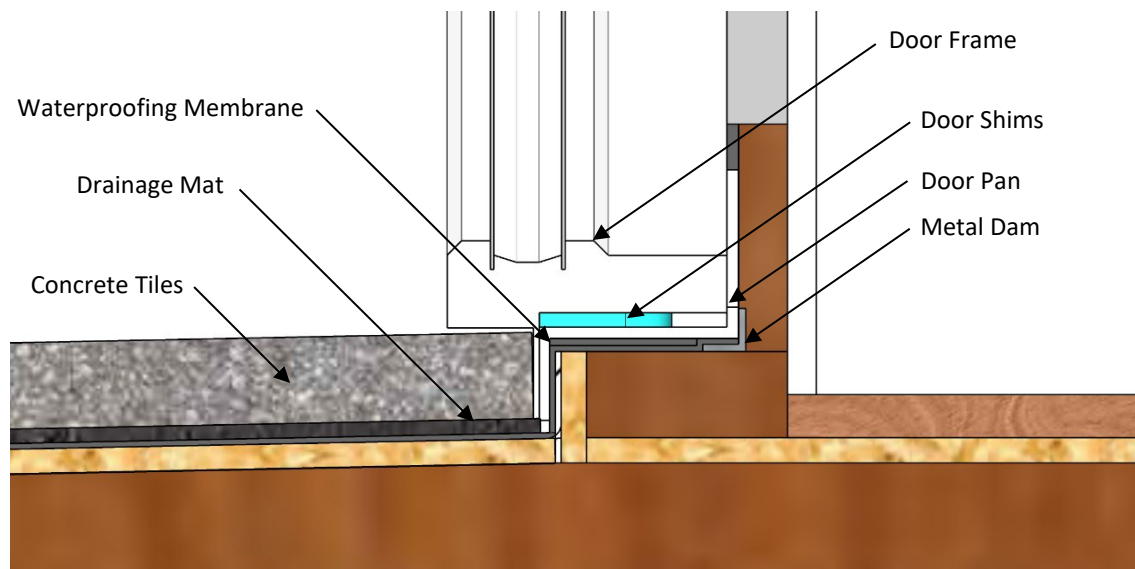


Figure 3. Principle Two: Flashing & Drainage

PRINCIPLE TWO

Flashing & Drainage

The intersection between the building envelope and the balcony/ deck substructure is an area vulnerable to rot that must be protected from water infiltration. Typically, an impervious moisture barrier system is installed that includes multiple layers of flashing and drainage features – designed to keep water away from the interface area. Close inspection of Figure 3 illustrates the flashing at the door threshold. In the Appendix, we have included conceptual sketches to illustrate the drainage principle.

PRINCIPLE THREE

Ventilation & Drying

The objective of the first two principles is to keep water away from vulnerable areas of the building envelope and substructure of the balconies and decks. The third principle promotes air circulation that will allow materials in the balcony or deck assembly to dry out if they ever get wet. Figure 4 illustrates the underside of the deck with a ventilated enclosure. If a typical vented soffit is not allowed, then fire rated vents, sprinklers, or other products will be needed (consult with your local building code official). If there is ongoing leakage caused by poor flashing or drainage, the wood substructure may never fully dry out, even with cross ventilation.

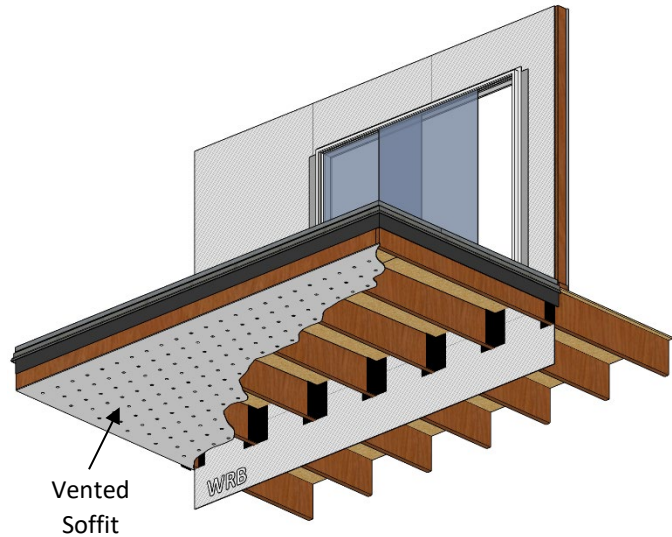


Figure 2. Principle Three: Ventilation & Drying

3. DESIGN GUIDANCE

The guidance within this document, and this section in particular, is provided to illustrate the key design principles that can improve the durability of balconies and decks. The design guidance presented is **not** a substitute for a project-specific design from a licensed architect or engineer. It is recommended that you hire the necessary design professional to ensure compliance with your local building code and moisture-management system requirements.

3.1 CANTILEVERED DESIGNS

A cantilevered balcony is structurally supported by continuous structural members extending from the interior floor through the building envelope to support the walking surface of the deck. Figure 5 illustrates typical structural framing for a cantilevered balcony or deck.

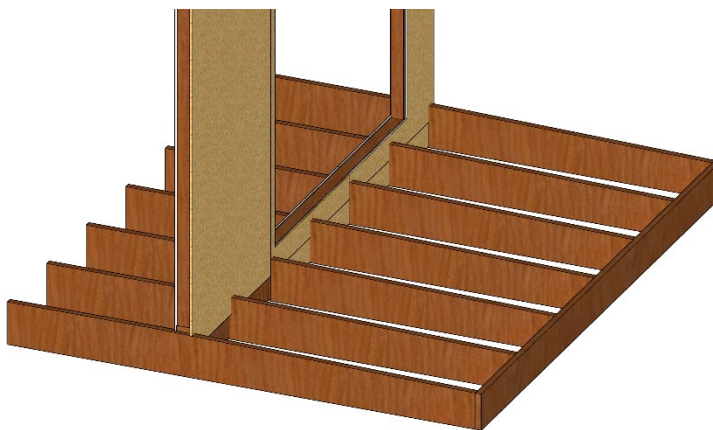


Figure 3. Typical Cantilevered Structure

The top of the cantilevered structural members must be tapered to create a 2% (1/4 in. per ft.) slope or the waterproofing membrane and walking surface must have a 2% slope (Figure 6). This means that bulk water (i.e., rainwater) will be directed away from the building envelope.

Note 1: Exception – Sloping is not necessary for deck boards with spacing between them for drainage.

Note 2: The building code does not allow dimensional lumber to be ripped to create the slope.

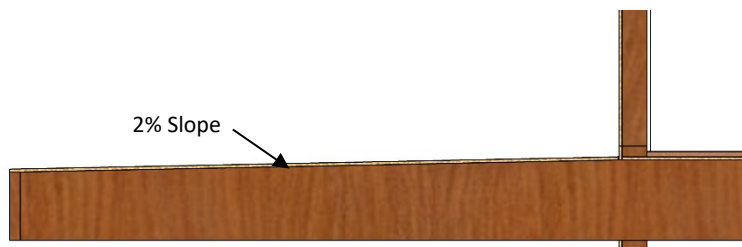


Figure 4. 2% (1/4 in. per ft.) Sloped Substructure

PRINCIPLE ONE

Sloping the Walking Surface & Waterproofing Membrane

Critical Area to Protect from Moisture Damage

Intersection of exterior wall and cantilevered structure.

PRINCIPLE ONE

Sloping the Walking Surface & Waterproofing Membrane

Critical Design Feature

2% (1/4 in. per ft.) slope away from the exterior wall. Except: Standard Lumber Members with Deck Boards.

3.1.1 MASONRY SURFACE & METAL RAILING

The masonry surface is illustrated in the following figures. Figures 7 through 16 show the flashing steps [8] for the critical intersection with the doorway threshold. The cross-sectional details are intended to illustrate the key principles and should **not** be a substitute for guidance or drawings provided by a licensed design professional.

WALL INTERSECTION: Sealing & Back Dam Flashing

PRINCIPLE TWO Flashing & Drainage

Caulk the areas where the edges meet at the critical intersection.

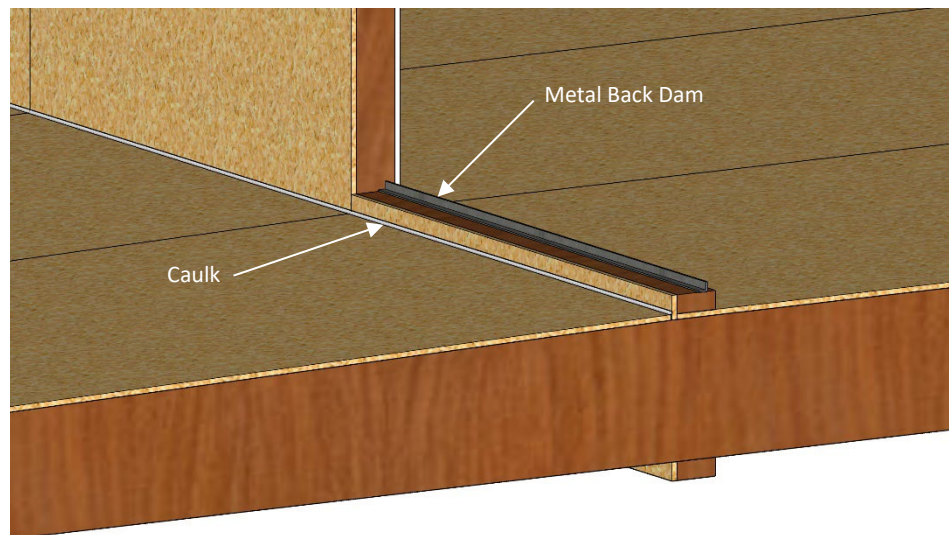


Figure 5. Caulk Intersection and Install Back Dam

PRINCIPLE TWO Flashing & Drainage

Install waterproofing membrane. The waterproofing membrane protects the wood substructure, intersection area, and the doorway threshold.



Figure 6. Install Waterproofing Membrane

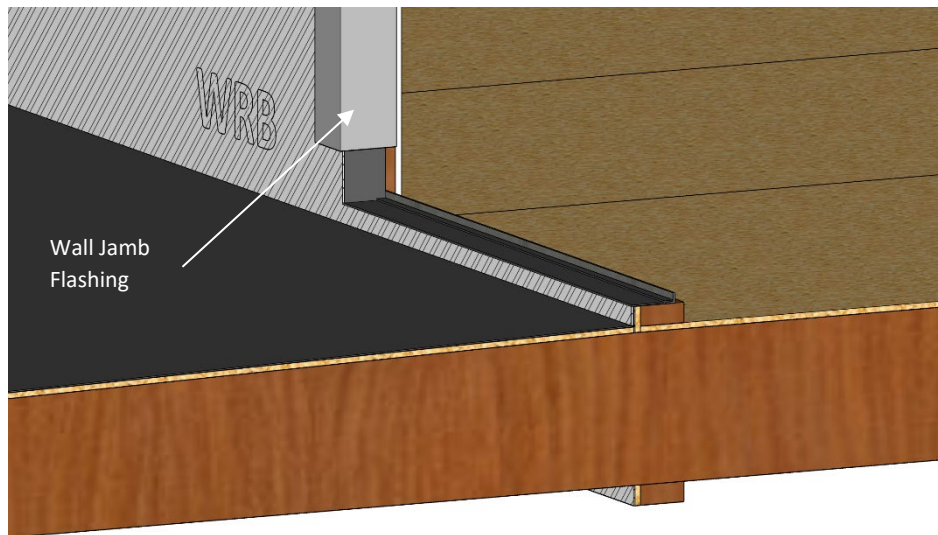
WALL INTERSECTION: Flashing & Water-Resistive Barrier



PRINCIPLE TWO Flashing & Drainage

Install the water-resistive barrier (WRB) on the exterior wall.

Figure 7. Install Water-Resistive Barrier (WRB)



PRINCIPLE TWO Flashing & Drainage

The flashing protects the wood structure.

Figure 8. Install Wall Jamb Flashing

WALL INTERSECTION: Pan Flashing & Door Installation

PRINCIPLE TWO Flashing & Drainage

Pan flashing and shims protect the door threshold and allow water to be directed away from the building interior.

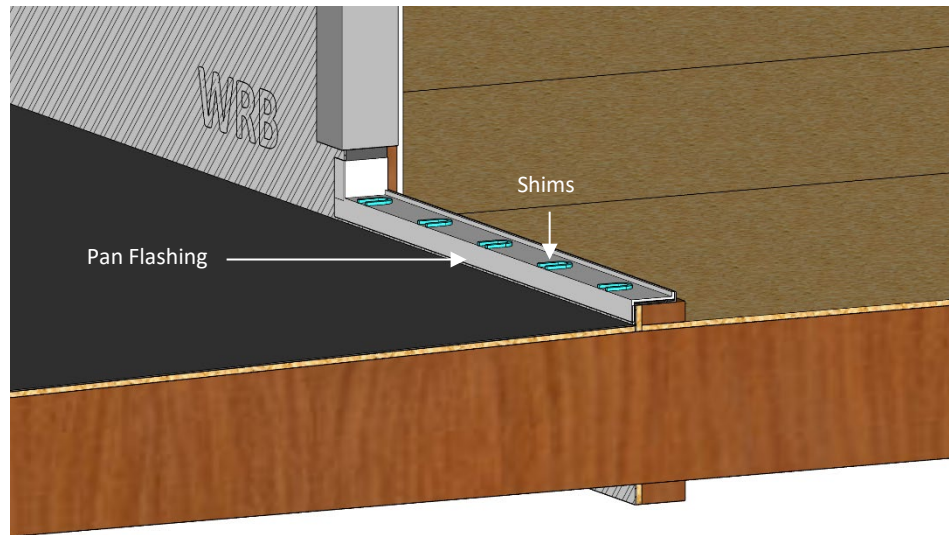


Figure 9. Install Pan Flashing at Door Threshold

PRINCIPLE TWO Flashing & Drainage

The door frame should be installed with the walking surface height in mind to determine if a transition will be necessary.

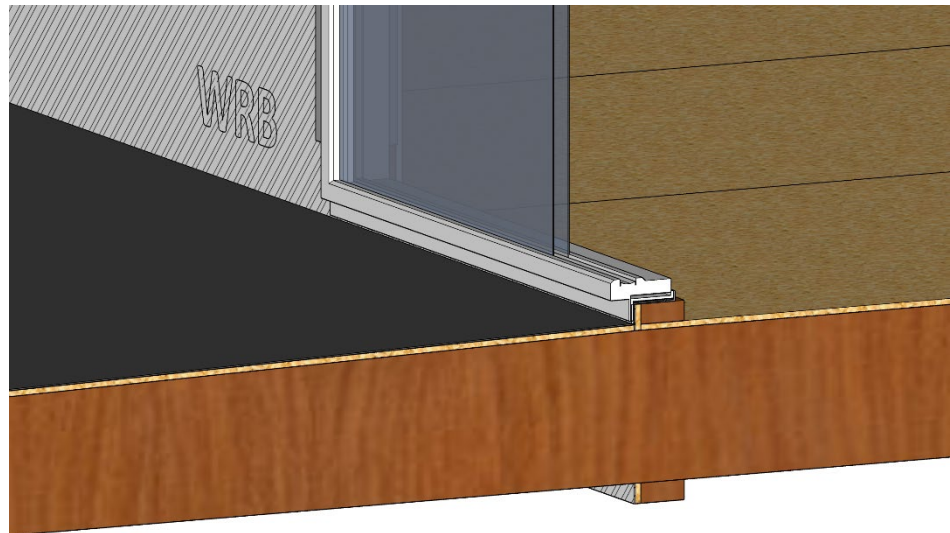
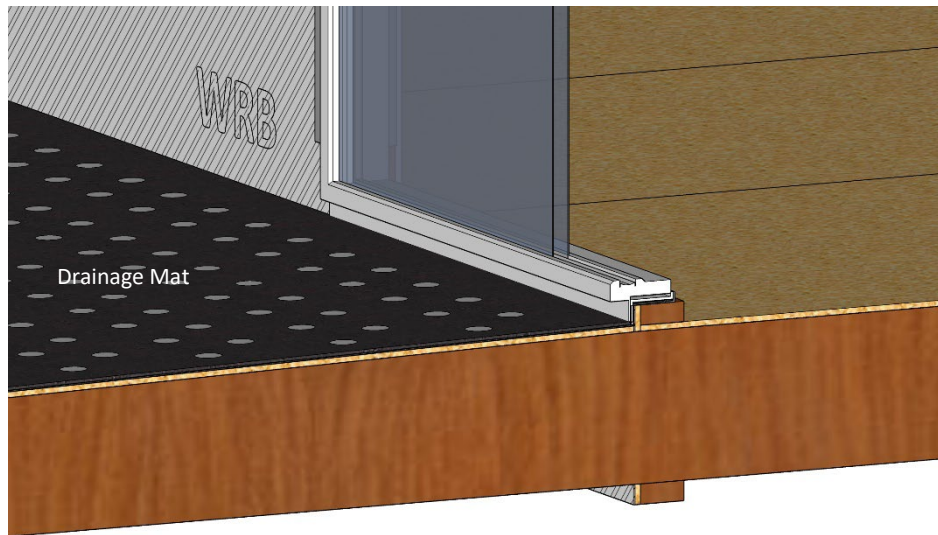


Figure 10. Install Door

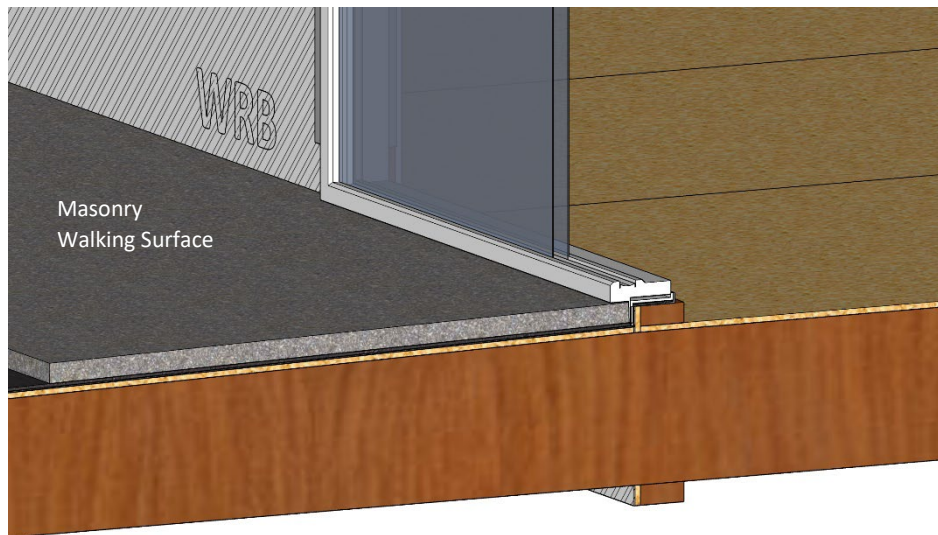
WALL INTERSECTION: Drainage



PRINCIPLE TWO Flashing & Drainage

The drainage mat is designed to direct water away from the walking surface and building envelope.

Figure 11. Install the Drainage Mat



PRINCIPLE TWO Flashing & Drainage

The walking surface will allow bulk water to drain away from the building envelope.

Figure 12. Install the Masonry Walking Surface

WALL INTERSECTION: Accessibility

Typical multifamily residential building projects must comply with the disabled access requirements of the Fair Housing Act (FHA). These regulations allow a maximum threshold height of 3/4 in. Publicly-funded housing will require adaptable units complying with the FHA and accessible units complying with the Americans with Disabilities Act (ADA). These require a maximum of 1/2 in. high threshold. Both sets of regulations allow sloped transitions. The design professional must verify the applicable access provisions with the local Authorities Having Jurisdiction (AHJ).

In some cases, a door complying with ADA or FHA requirements may be the best solution to ensure a low threshold without the need for an entryway sloped transition. Depending on the height of the back dam and door pan, the design professional may need to specify a sloped transition on both sides of the balcony or deck door (see Figure 15).

PRINCIPLE TWO Flashing & Drainage

Critical Design Feature Accessibility and Drainage

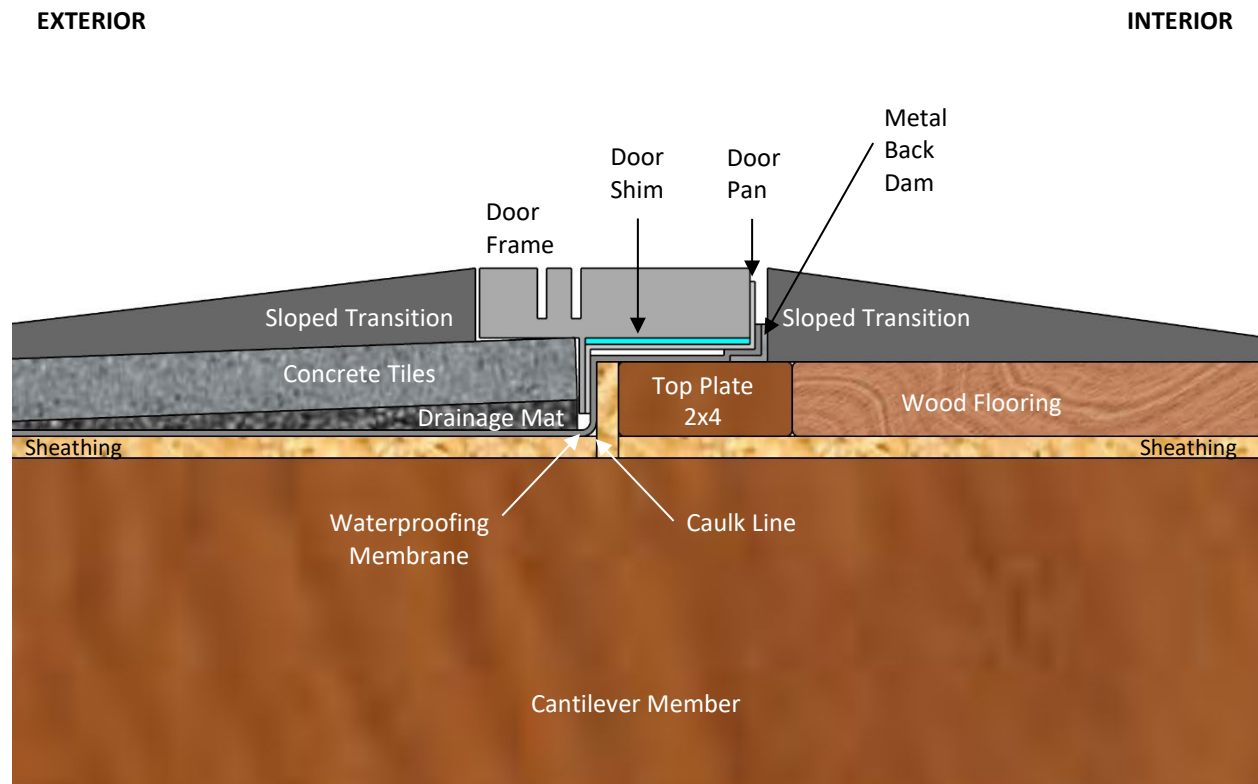
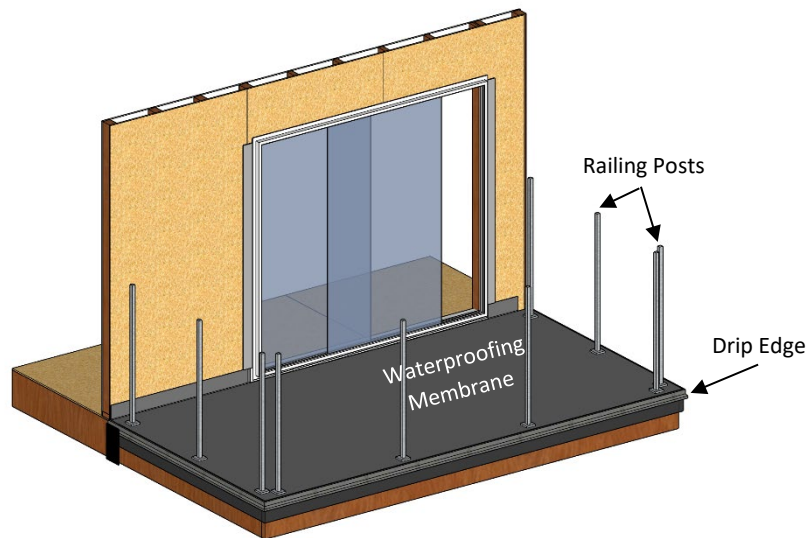


Figure 13. Sloped Transition for Accessibility

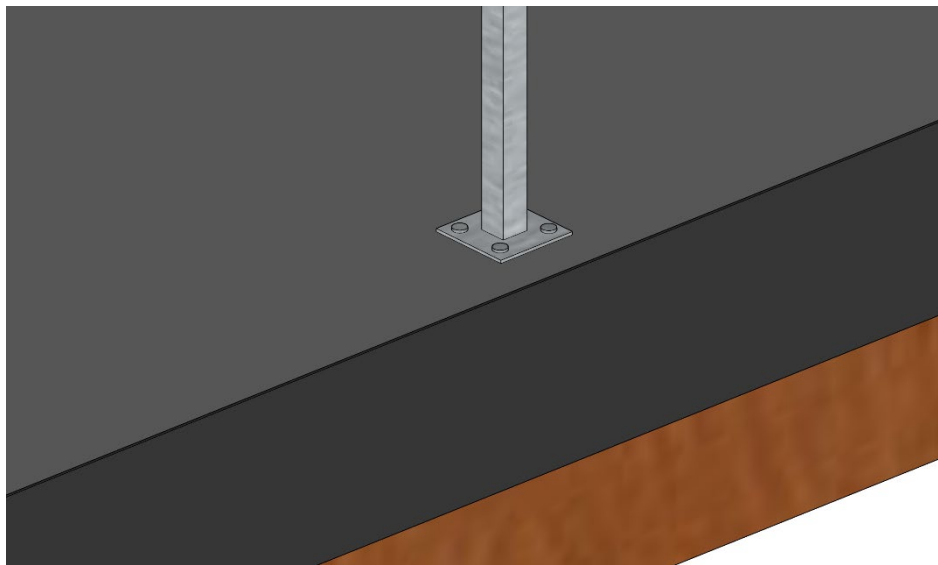
TOP SURFACE MOUNTED METAL RAILING: Flashing

Railing posts can be installed through the top walking surface into the wood substructure below. Figures 16 through 23 illustrate one method of sealing fastener penetrations through the waterproofing membrane, which is a critical design feature – if the waterproofing membrane is compromised, water can find a path to the wood substructure. The railing product and design must meet or exceed the local building code requirements. The rail design in this Guide is provided to illustrate the principle and should not be a substitute for design and drawings provided by a licensed design professional.



PRINCIPLE TWO Flashing & Drainage

Figure 14. Install Metal Posts through Top Surface



PRINCIPLE TWO Flashing & Drainage

Anchor through waterproofing membrane into framing designed to withstand the design load.

Figure 15. Anchor through Top Surface

TOP SURFACE MOUNTED METAL RAILING: Drainage

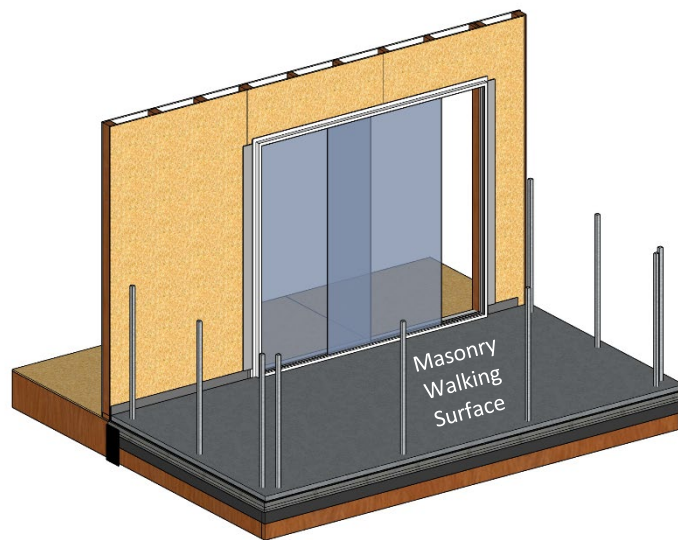


Figure 18. Install Drainage Mat, Drip Edge, and Walking Surface

PRINCIPLE TWO Flashing & Drainage

The drainage and top surface must be installed around the post.

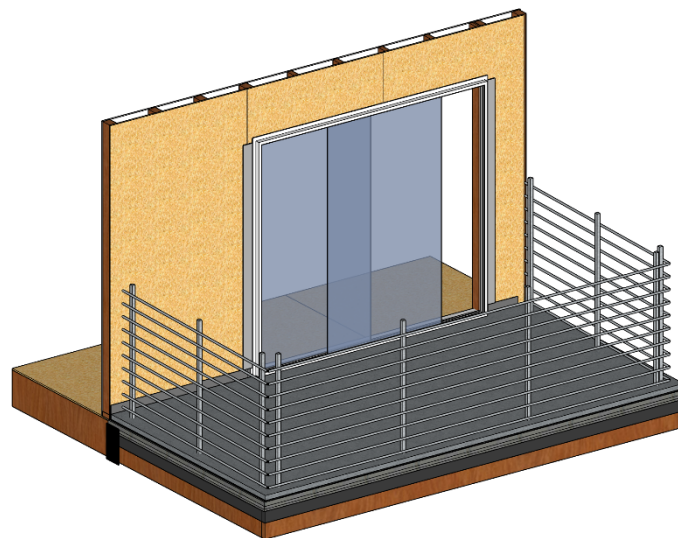


Figure 19. Complete Metal Rail Installation

PRINCIPLE TWO Flashing & Drainage

The horizontal railing system is then installed.

VENTILATION & DRYING

PRINCIPLE THREE

Ventilation & Drying

Option 1:

Keep the substructure open to allow for ventilation and drying.

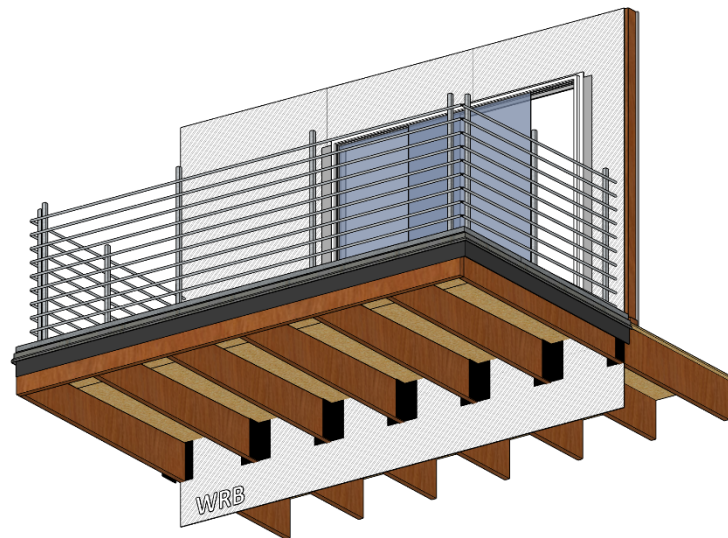


Figure 20. Open Substructure

PRINCIPLE THREE

Ventilation & Drying

Option 2:

Enclose the substructure with a vented soffit to enhance the aesthetic appearance.

Vented soffits must have adequate openings for drainage and be maintained.

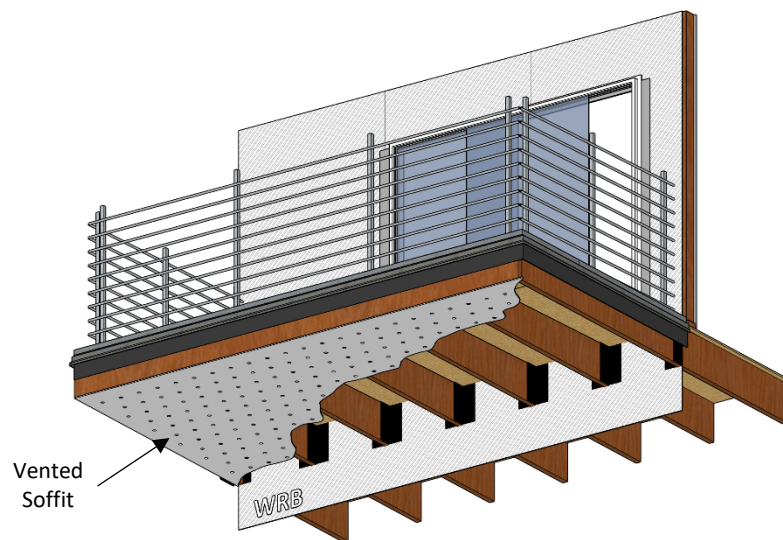


Figure 21. Enclosed Substructure

3.1.2 WOOD OR COMPOSITE SURFACE

A wood or composite walking surface is illustrated (exception: sloping of the substructure is not needed because of spacing between the wood or composite deck boards for drainage). Figures 24 through 30 show the flashing steps [8] for the critical intersection with the doorway threshold. Again, the cross-sectional details are intended to illustrate the key principles but are **not** a substitute for design or drawings provided by a licensed design professional.

WALL INTERSECTION: Blocking & Flashing

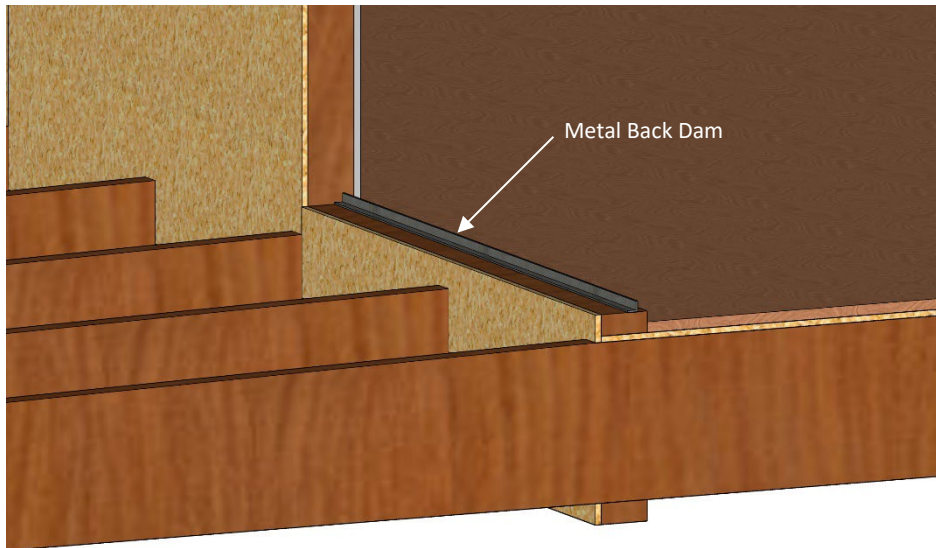


Figure 22. Caulk Intersections and Install Back Dam

PRINCIPLE TWO Flashing & Drainage

Caulk areas where the edges meet at the critical intersection and blocking.

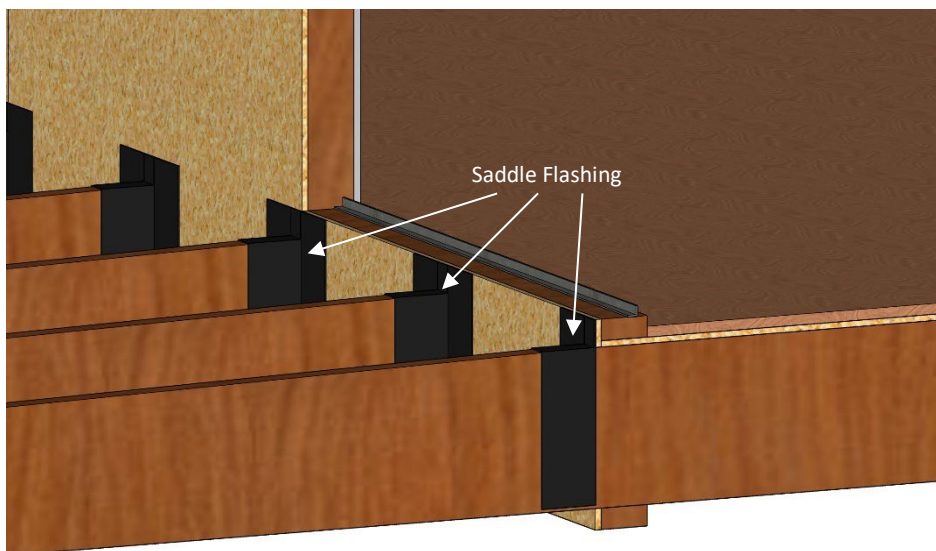


Figure 23. Install Saddle Flashing

PRINCIPLE TWO Flashing & Drainage

Saddle flashing must be installed at each structural member intersection with the exterior wall.

WALL INTERSECTION: Flashing & WRB

PRINCIPLE TWO

Flashing & Drainage

Critical Design Feature

Install waterproofing membrane for moisture management.

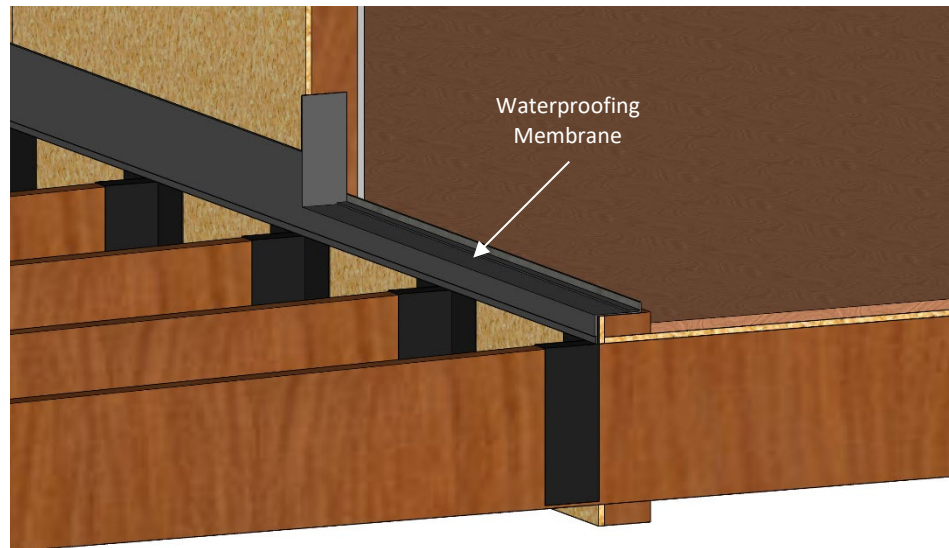


Figure 24. Install Waterproofing Membrane

PRINCIPLE TWO

Flashing & Drainage

Install the water-resistive barrier at the intersection and door threshold.

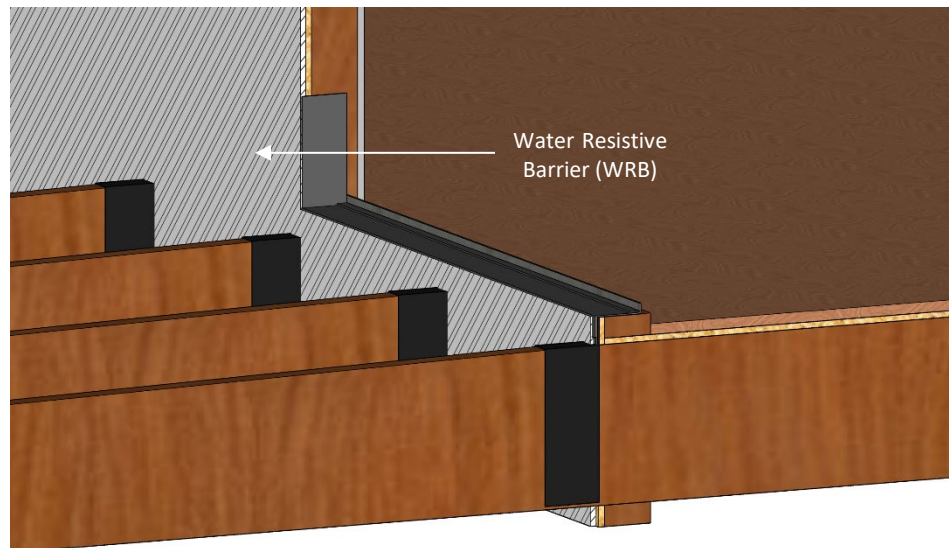
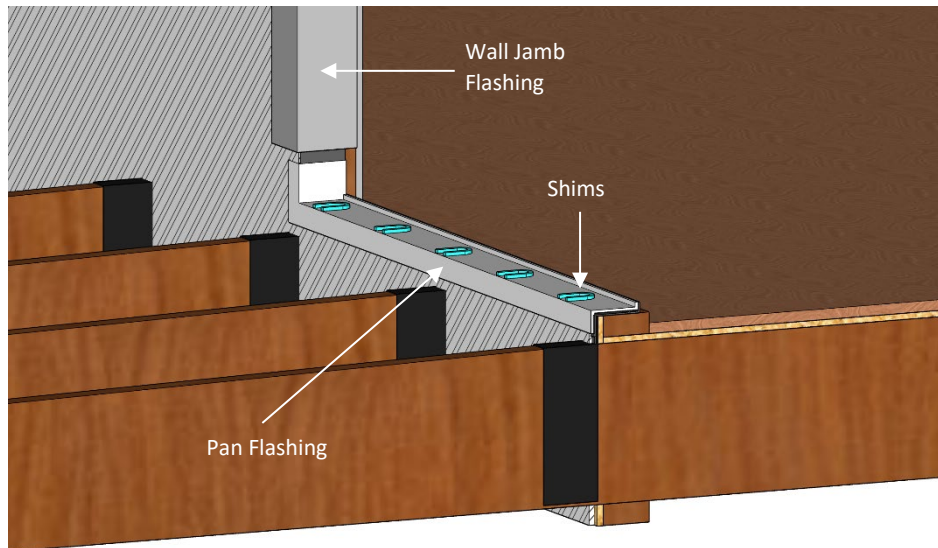


Figure 25. Install Water-Resistive Barrier

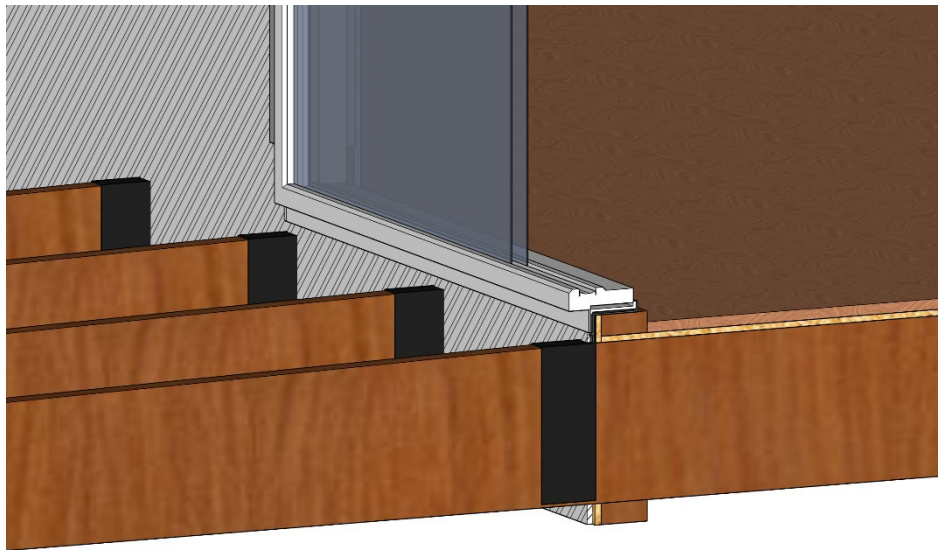
WALL INTERSECTION: Pan Flashing & Door Installation



PRINCIPLE TWO Flashing & Drainage

Pan flashing and shims protect the door threshold and allow water to be directed away from the interior of the building.

Figure 26. Install Wall Jamb and Pan Flashing



PRINCIPLE TWO Flashing & Drainage

The door frame should be installed with the walking surface height in mind.

Figure 27. Install Door Frame and Door

WALL INTERSECTION: Drainage

PRINCIPLE TWO **Flashing & Drainage**

The wood or composite boards must be installed with spacing between the boards to promote drainage.

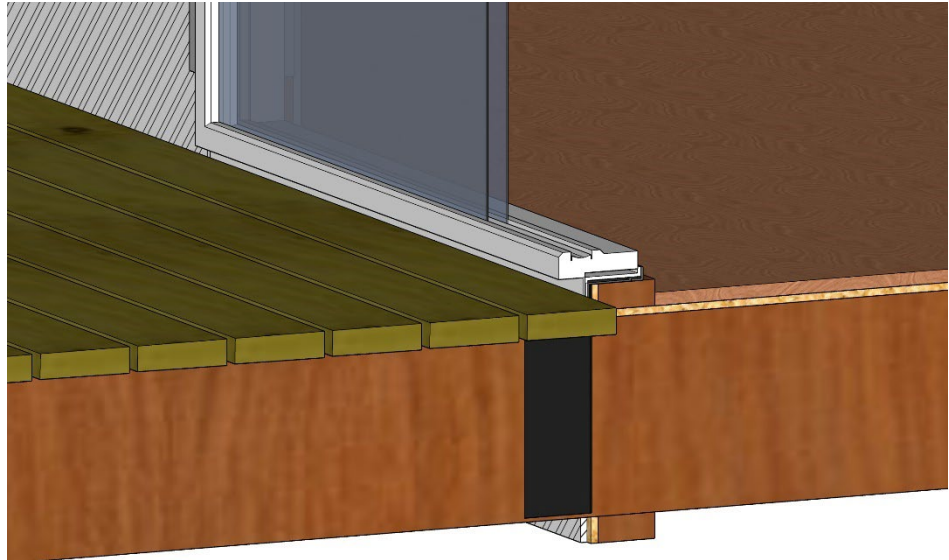


Figure 28. Install Wood or Composite Walking Surface

WALL INTERSECTION: Accessibility

Typical multifamily residential building projects must comply with the disabled access requirements of the Fair Housing Act (FHA). These regulations allow a maximum threshold height of 3/4 in. Publicly-funded housing will require adaptable units complying with the FHA and accessible units complying with the Americans with Disabilities Act (ADA). These require a maximum of 1/2 in. high threshold. Both sets of regulations allow sloped transitions. The design professional must verify the applicable access provisions with the local Authorities Having Jurisdiction (AHJ).

In some cases, using a door complying with the FHA or ADA requirements may be the best solution to ensure a low threshold without the need for an entryway sloped transition. Depending on the size of the back dam or the pan flashing, the design professional may need to specify a sloped transition on both sides of the balcony or deck door (see Figure 31).

PRINCIPLE TWO Flashing & Drainage

Critical Design Feature Accessibility and Drainage

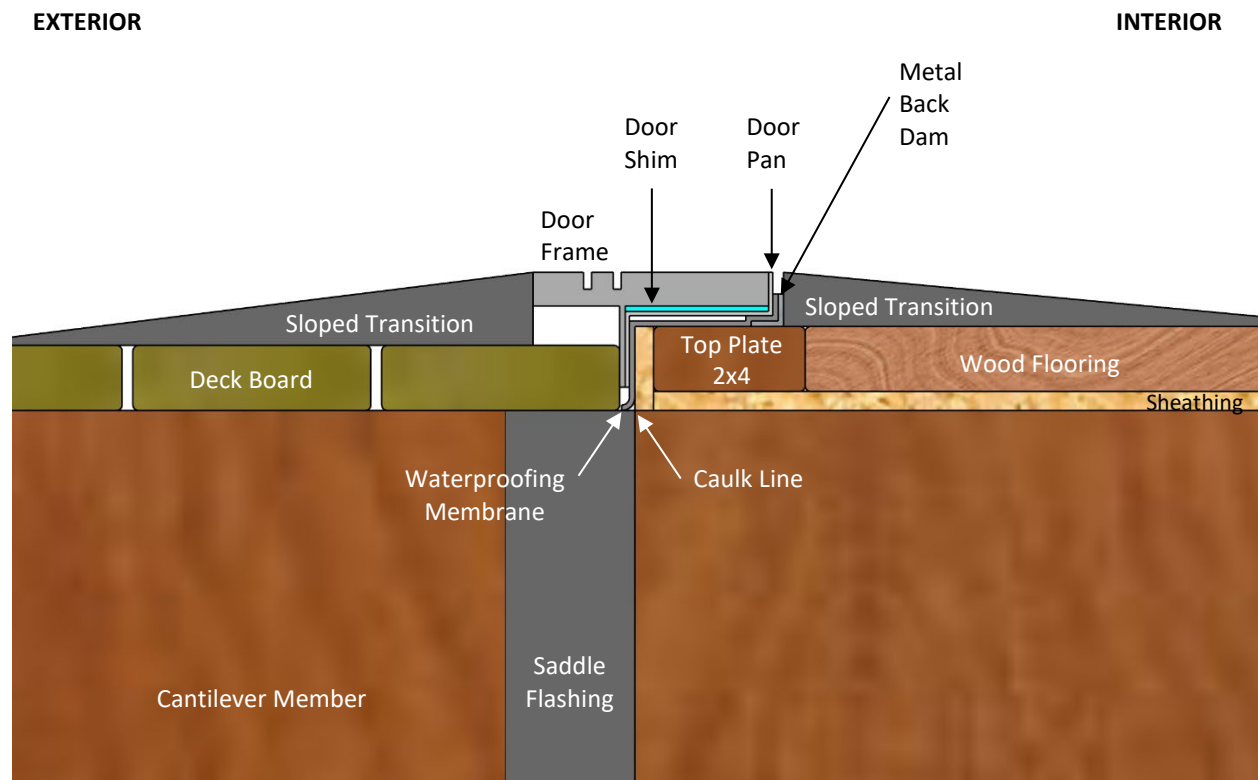


Figure 29. Sloped Transition for Accessibility

SUBSTRUCTURE MOUNTED WOOD RAILING: Blocking

Railing posts can be installed into the wood substructure. In addition, we illustrate a method of sealing fastener penetrations when railing brackets are installed directly to the exterior wall of the building. When this is done, the bracket should be anchored to a structural member and saddle flashing should be used to seal penetrations and protect the wall structure from water infiltration. The railing product and design must meet or exceed the local building code requirements. The rail design in this Guide is provided to illustrate the principle and should not be a substitute for design and drawings provided by a licensed design professional.

PRINCIPLE TWO

Flashing & Drainage

Saddle flashing is used to seal fastener penetrations and protect the building envelope from water infiltration.

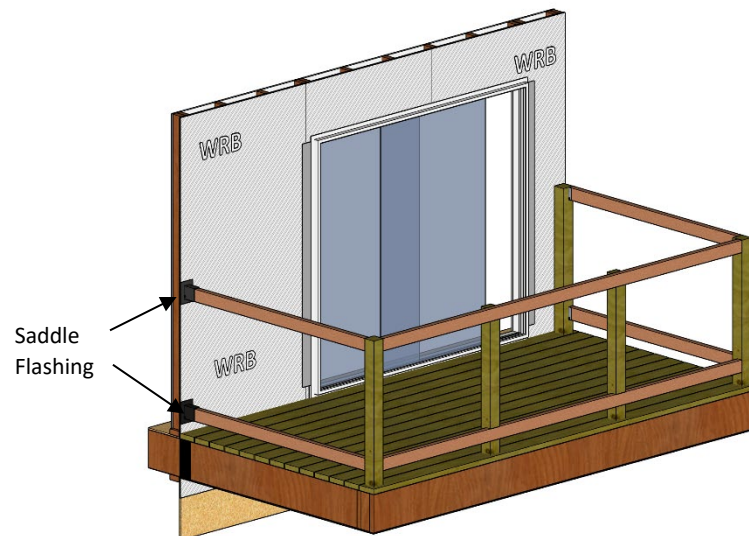


Figure 30. Install Wood Posts into Substructure

PRINCIPLE TWO

Flashing & Drainage

The anchoring and blocking details must be provided by a licensed design professional or product manufacturer for proprietary railing systems.

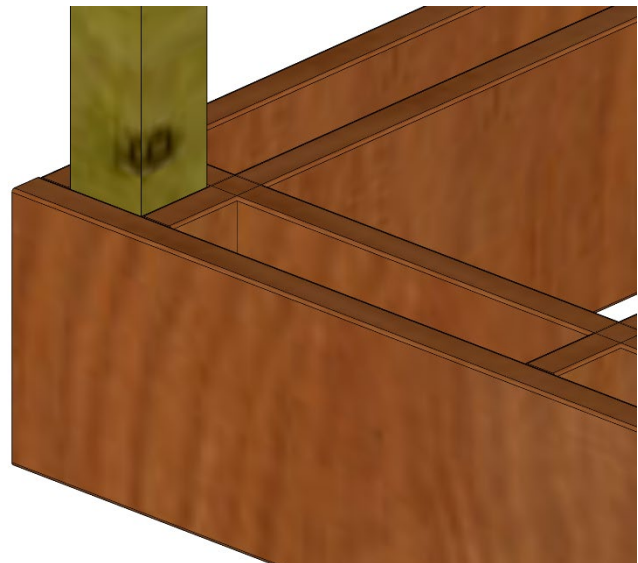


Figure 31. Blocking

SUBSTRUCTURE MOUNTED WOOD RAILING: Flashing

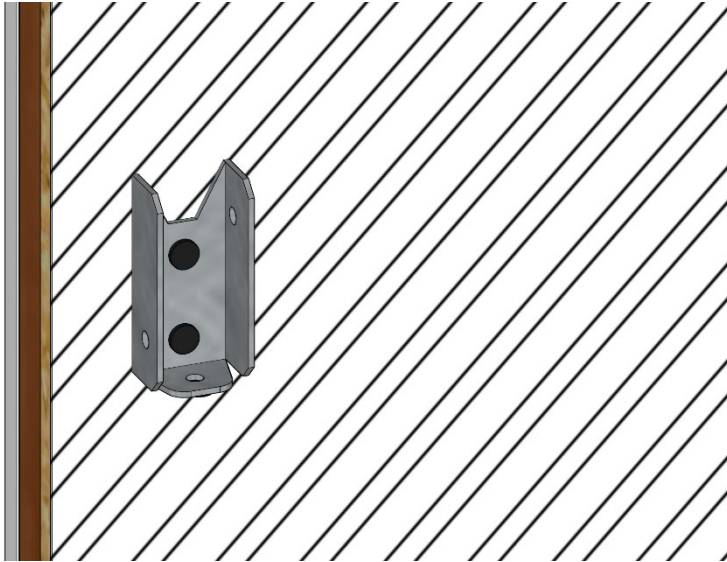


Figure 32. Connect Bracket to Wall

PRINCIPLE TWO Flashing & Drainage

Install the railing bracket to the exterior wall and add blocking or structural member to the wall framing.

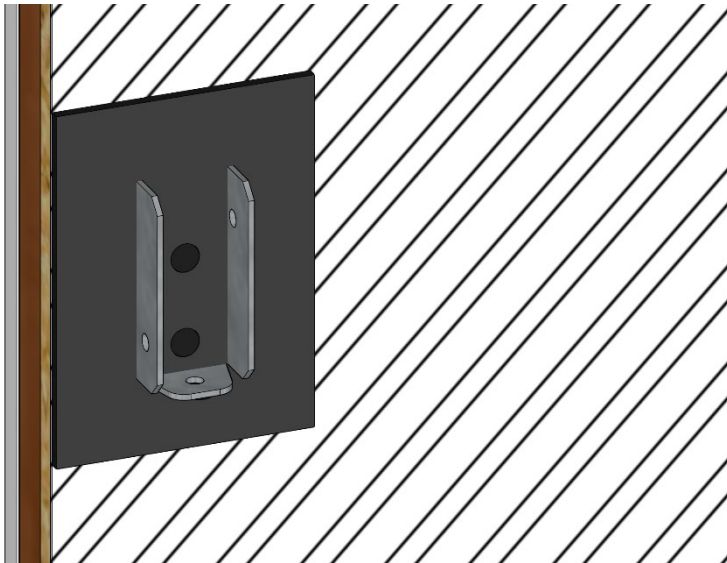


Figure 33. Seal Fastener Penetration to Wall

PRINCIPLE TWO Flashing & Drainage

Use liquid flashing or membrane flashing product to protect the wall from water infiltration at penetrations.

SUBSTRUCTURE MOUNTED WOOD RAILING: Flashing

PRINCIPLE TWO

Flashing & Drainage

Install the wood rail into the bracket.

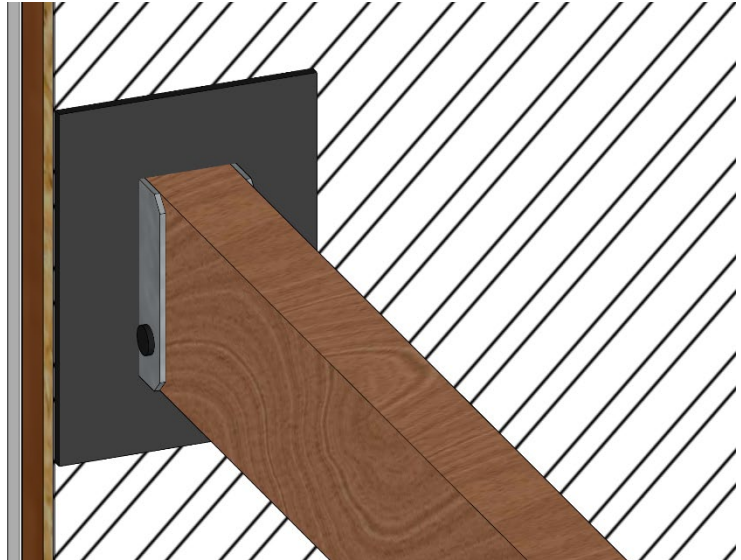


Figure 34. Connect Railing to Bracket

PRINCIPLE TWO

Flashing & Drainage

Use liquid flashing or membrane flashing product to protect the rail at the fastener locations.

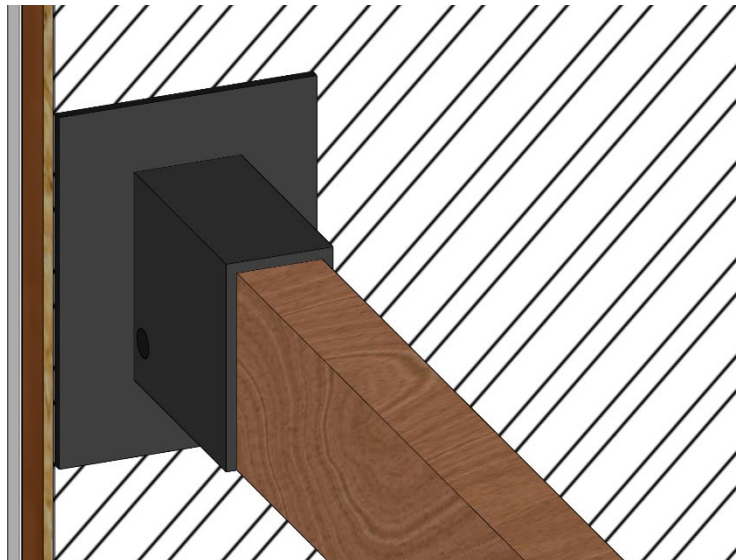


Figure 35. Seal Fastener Penetrations to Rail

SUBSTRUCTURE MOUNTED WOOD RAILING: Drainage

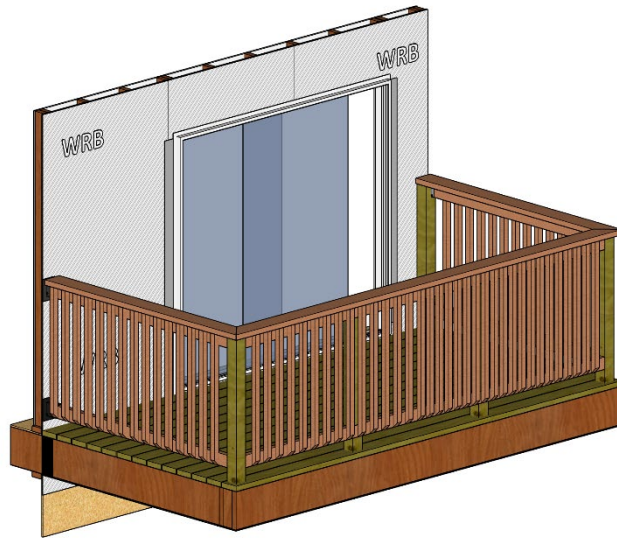


Figure 36. Complete Wood or Composite Rail Installation

PRINCIPLE TWO **Flashing & Drainage**

The remaining wood or composite railing system is installed.

VENTILATION & DRYING

PRINCIPLE THREE

Ventilation & Drying

Option 1:

Keep the substructure open to allow for ventilation and drying.

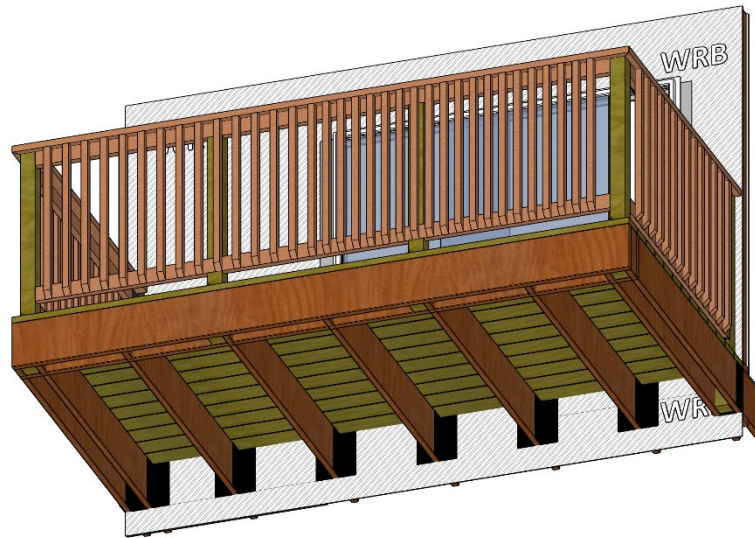


Figure 37. Open Substructure

PRINCIPLE THREE

Ventilation & Drying

Option 2:

Enclose the substructure with a vented soffit to enhance the aesthetic appearance.

Vented soffits must have adequate openings for drainage and be maintained.

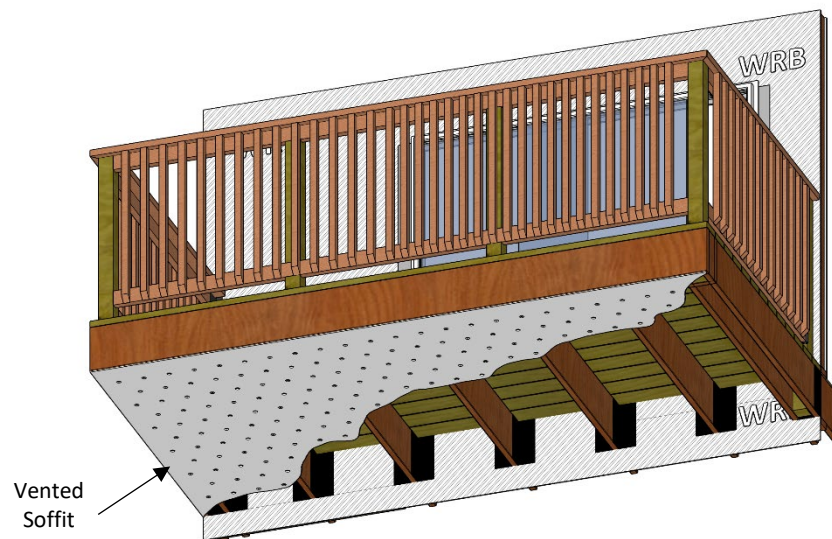


Figure 38. Enclosed Substructure

3.2 ALTERNATIVE BALCONY DESIGNS

While this Guide focuses on cantilevered balcony and deck designs of low- and mid-rise multifamily buildings, there are alternative balcony designs that are common in these types of buildings, as well. The key principles described herein apply to alternative balcony designs including sloping the walking surface and waterproofing membrane (or having a dedicated surface drain [9]); flashing at the intersection of the exterior wall and balcony; and ventilating the underside of the structure or using a perforated soffit product to achieve a ventilated enclosure.

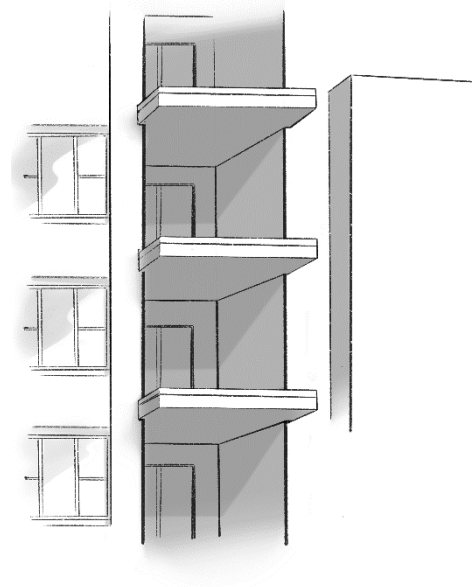


Figure 39. Supported on Three Sides

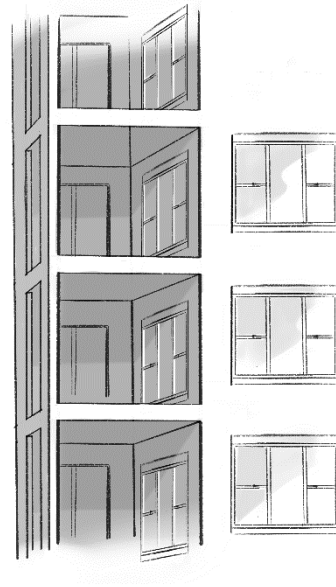


Figure 40. Supported on All Corners



Figure 41. Dedicated Floor Drainage for Each Balcony

4. BUILDING MATERIAL SELECTION

Generally, design professionals specify building materials for construction using many resources such as guidelines outlined in *The Project Resource Manual: CSI Manual of Practice* or the *Architect's Handbook of Professional Practice*. Given the complexity of the flashing details required to ensure the durability of balconies and decks, your licensed design professional should confirm that each component is compatible with the adjacent component in the assembly.

4.1 MATERIAL COMPATIBILITY

A design professional must review the technical data (or contact the manufacturer of each building material component) to determine the compatibility of the materials. In some cases, product testing may be necessary for special, “one-of-a-kind” building designs.

When considering the assembly illustrated in Figure 44, your design professional should identify the waterproofing membrane, flashing materials, and caulks or adhesives. Flashing materials can be fluid/liquid applied, tapes, or pre-formed materials with adhesives integrated into the product. Some manufacturers make waterproofing product systems that work together to ensure compatibility, but you must still confirm the materials are compatible with all the other components in the assembly.

First, determine if the flashing and waterproofing materials are compatible with the wood and sheathing products that make up the structure. In some cases, a fire-resistance-rated wall and balcony/ deck assembly is needed, your design professional may need to specify fire-retardant lumber and sheathing products, and the flashing materials must be compatible. As an alternative to fire-retardant-treated wood, the design professional may decide to use special intumescent paints or coatings that provide both fire resistance and waterproofing – again, you must ensure those products are compatible with the other materials.

Second, the “layering” shown in Figure 44 is as important as the material that is specified. When installed correctly, the overlapping of the materials will direct bulk water and moisture away from the building envelope and the door threshold. In most cases, the moisture control system will be compromised if the layering is done incorrectly; or if one material is inadvertently placed next to an incompatible one. Either of these situations can lead to a durability issue.

Third, the design professional must confirm that the walking surface is compatible with the waterproofing membrane, especially when using masonry products. The concrete, mortar, and other cementitious materials must all be compatible with the waterproofing and flashing materials. If masonry tile products are installed, be mindful of how they are secured, adhered, or fastened to the waterproofing membrane or substructure.

Fourth, the design professional must ensure the railing installation does not damage or compromise the moisture control system. If a fastener must penetrate the waterproofing membrane to anchor the railing into the wood substructure, be sure you know how that penetration is sealed

and if the fasteners are compatible with the wood materials. You must also understand how the structural brackets are secured to the railing post or wall structures.

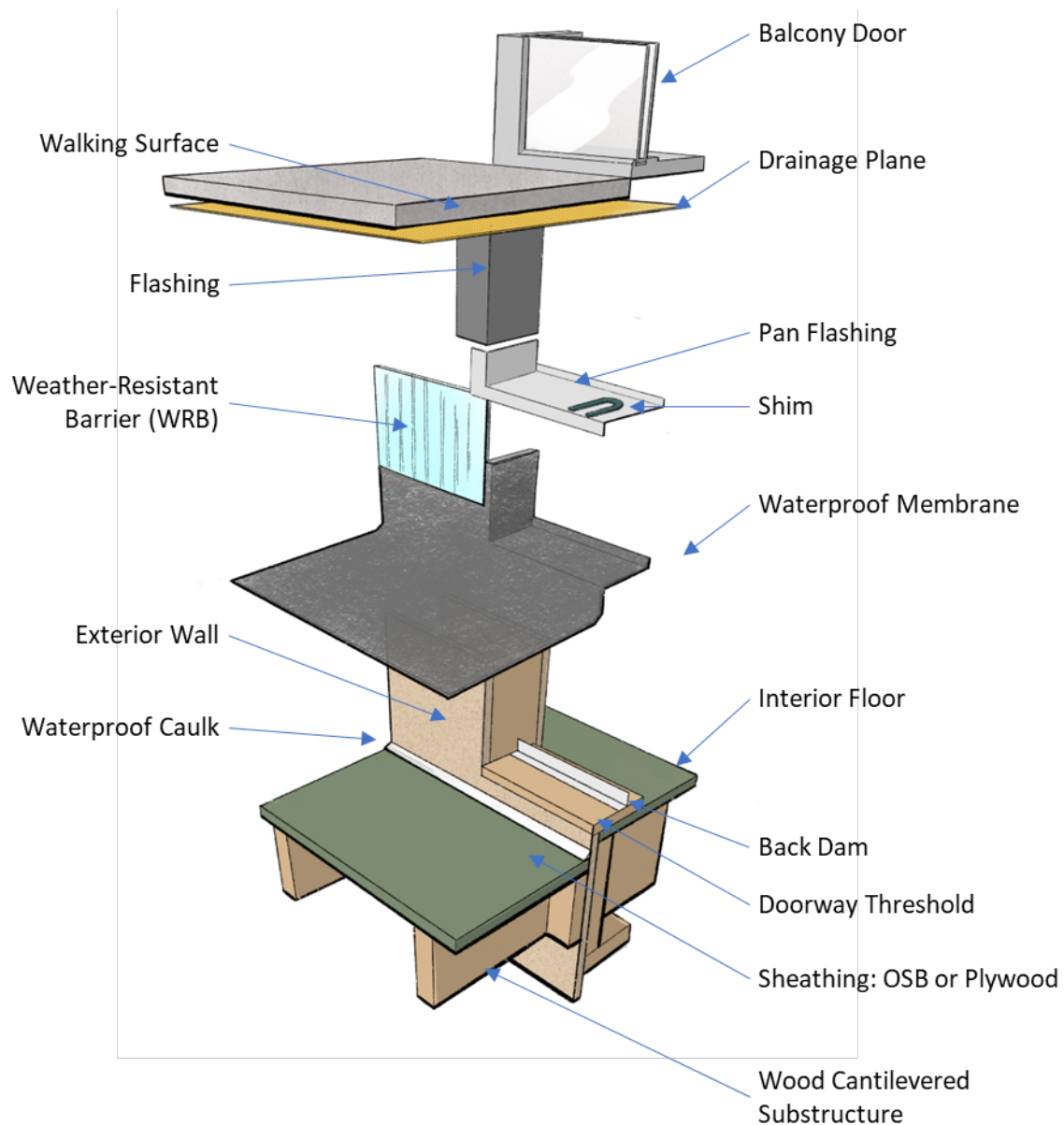


Figure 42. Confirm the Compatibility of the Components in the Assembly

4.2 FASTENER OPTIONS

The design professional must select fasteners [10] that are compatible with preservative-treated [11] (for decay resistance) or fire-retardant-treated [12] lumber. If applying intumescent paint or coating, those chemicals must also be compatible with the fasteners and other components.

5. FIELD MODIFICATIONS

According to the Berkeley Balcony Investigation report [1], there were several deviations from the construction details and material specifications that led to the dry rot, water damage, and catastrophic failure of the balcony's substructure. Specifically, upon inspection of the failed balcony investigators found:

1. Several key material components that were specified in the construction documents were not used;
2. The balcony substructure was not protected from the rainy weather (for 9 months) before the flashing and waterproofing work was completed (the Berkeley report notes that it is unclear if framing members and OSB were saturated with moisture before the waterproofing was done);
3. The “overlapping” of several flashing components was not done correctly;
4. Incorrect fasteners were used to install the railing;
5. Some substituted building materials did not appear to be compatible with other elements of the system; and
6. No ventilation of the substructure was provided.

5.1 CONTRACTOR-REQUESTED DESIGN CHANGES

Every construction project has construction drawings, specifications, and a binding contract of some type. Within the contract, there is typically a provision for how to make changes to the design. The request for a design change can come from the owner (or their representative) or the contractor (or their subcontractors) hired to complete the work. Generally, design changes come in the form of a change order, which is defined within the contract. The following organizations have standard documents that can be incorporated into the contract and used as part of the project management process:

- American Institute of Architects (AIA), Document A201[®] – 2017 *General Conditions of the Contract for Construction* [13]
- Associated General Contractors of America (AGC), *ConsensusDocs Guidebook—ConsensusDocs 200 – Agreement and General Conditions Between Owner and Constructor (Lump Sum)* [14]
- National Society of Professional Engineers (NSPE), *An Owner's Guide to Successful Project Management* [15]



Figure 43. Communication between Design Professional, Owner/Project Manager, and Contractor

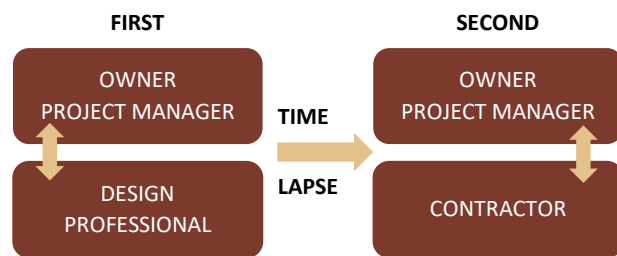


Figure 44. Typical Two-Step Process for Construction

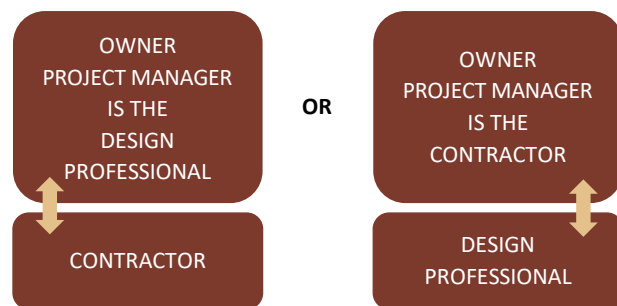


Figure 45. Owner's Project Manager is the Design Professional or Contractor

Ideally, the design professional, owner/ project manager, and contractor must work together to ensure that all elements of the design are constructed correctly. In some cases, the owner will hire an independent project manager to oversee the entire project, including communication between the design professional and the contractor(s). When there is a project manager, Figure 45 illustrates how communication should flow between the parties. The owner/ project manager should ensure that any design changes initiated by the contractor are reviewed and approved by the design professional. This usually means additional costs beyond the design work, but it is a critical step to ensure safety and durability of design elements like balconies on low- or mid-rise buildings.

In other cases, the owner's project manager will first work with the design professional to develop the construction details and specifications; then the owner's project manager will work with a contractor to complete the construction. Figure 46 illustrates this two-step process, which is common when funding is uncertain, and the owner simply wants to get the design package done first.

In some cases, the owner will hire either the design professional or the contractor to be the project manager. This option might be the best to ensure the necessary communication takes place when considering change order requests. Figure 47 illustrates the communication achieved with this contract arrangement.

5.2 MATERIAL SUBSTITUTION

All projects should have a change order process by which material substitution requests can be implemented with written approval from the design professional. It is especially critical for the architect or engineer of record to approve substitutions for balcony and deck components as incompatibility of materials can cause failure of the assembly.

6. MOCK-UPS DEMONSTRATE BEST PRACTICES

Generally, a mock-up is primarily used by the contractor to demonstrate to the owner and design team that they understand the design intent during construction. A mock-up can also be used to clarify any construction details that are new or unique to the project with a pre-construction demonstration by the design team with the contractor. This step requires some additional cost, but it may reduce the chance of contractor errors in the field due to incorrect interpretation or misunderstanding of the drawings. A mock-up may be used to test conceptual design ideas before construction. Several A&E firms offer this service, and some test laboratories offer full-scale mock-ups along with testing services.

Home Innovation Research Labs created two mock-up demonstrations to illustrate the Key Principles in Section 3 of this guide.



Figure 46. Test House for Mock-Up at Home Innovation Research Labs

6.1 MOCK-UP 1: MASONRY SURFACE WITH METAL RAILING

6.1.1 KEY PRINCIPLE ONE: 2% SLOPING



Figure 47. Cantilevered Structure and Plywood Sheathing

PRINCIPLE ONE **Sloping the Walking** **Surface & Waterproofing** **Membrane**

Cantilevered Structure:
The 2% Sloping of the
walking surface can be
achieved when the
drainage surface is
installed.



Figure 48. Install Blocking

PRINCIPLE ONE **Sloping the Walking** **Surface & Waterproofing** **Membrane**

Installing blocking at the
structural member and
exterior wall intersection.

PRINCIPLE ONE
Sloping the Walking
Surface & Waterproofing
Membrane

The blocking must be sealed with caulk and flashing, then the WRB.



Figure 49. Caulk and Flash the Wall Intersection

PRINCIPLE ONE
Sloping the Walking
Surface & Waterproofing
Membrane

The 2% Slope of the
Waterproofing membrane
and drainage mat (not
shown in photo).



Figure 50. 2% Slope (1/4 in. per ft.) Away from Wall

6.1.2 KEY PRINCIPLE TWO: FLASHING & DRAINAGE

Wall Intersection: Flashing, Drainage, Threshold, and Accessibility



Figure 51. Caulk at Substructure and Wall Intersection

PRINCIPLE TWO Flashing & Drainage

Masonry surface mock-up.

Install back dam and seal/caulk at the wall intersection on walking surface.



Figure 52. Install Waterproofing Membrane

PRINCIPLE TWO Flashing & Drainage

Masonry surface mock-up.

Install waterproofing membrane at the door threshold, wall intersection, and walking surface.



Figure 53. Install Metal Rail Post

PRINCIPLE TWO Flashing & Drainage

Masonry surface mock-up.

Install metal rail post through the waterproofing membrane.

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Seal the post anchors with liquid-applied flashing.



Figure 54. Seal with Liquid-Applied Flashing

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Install rail post cover.



Figure 55. Install Rail Post Cover

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Install metal railing system.



Figure 56. Install Metal Railing System



Figure 57. Install Drip Edge

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Cross-section view –
install drip edge.



Figure 58. Install Drainage Mat

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Cross-section view –
install drainage mat.



Figure 59. Install Masonry Surface

PRINCIPLE TWO
Flashing & Drainage

Masonry surface mock-up.

Cross-section view –
install masonry surface.

NOTE: Integration of
flashing and drip edge
detail with cladding (or
fascia board/trim) is not
shown. This detailing is
important and can be a
source of failure.

For multifamily buildings, the mock-up must also identify how to address FHA requirements for accessibility, specifically Requirement #3: Usable Doors. The interior or exterior threshold does not require a transition.

NOTE: A compliant door threshold must not exceed $\frac{3}{4}$ in. in height for exterior doors or any change in height between $\frac{1}{4}$ in. and $\frac{1}{2}$ in. must have a beveled slope equaling 1:2. For any change in height greater than $\frac{1}{2}$ in., the threshold will need a sloped transition (1:12 or more). The floor or ground surface within the maneuvering clearances at the doorway must not have a slope steeper than 1:48.

PRINCIPLE TWO

Flashing & Drainage

Masonry surface mock-up.

Cross-section – threshold
PVC pan flashing and
membrane end dam.



Figure 60. Install Pan Flashing at Threshold

PRINCIPLE TWO

Flashing & Drainage

Masonry surface mock-up.

Measure height at the
threshold.

No sloped transition is
needed with finished floor
on interior.



Figure 61. Measure Height of Threshold for Accessibility

6.1.3 KEY PRINCIPLE THREE: VENTILATION & DRYING



Figure 62. Install Perforated Soffit Panels

PRINCIPLE THREE
Ventilation & Drying
Masonry surface mock-up.
Ventilation of substructure using perforated soffit panels.



Figure 63. Installed Masonry Surface Mock-Up

PRINCIPLE THREE
Ventilation & Drying
Masonry surface mock-up.
Fully installed mock-up.

6.2 MOCK-UP 2: WOOD OR COMPOSITE SURFACE & RAILING

6.2.1 KEY PRINCIPLE ONE: 2% SLOPING (EXCEPTION)

When installing a wood or composite deck surface, the substructure does not need to be sloped because the space between the deck boards provides drainage. Note: the building code does not allow dimensional lumber to be ripped to create the slope.

Unlike a masonry surface, which requires a subfloor installation along with waterproofing and a drainage mat, a wood deck or composite surface is installed directly onto the cantilevered wood joists. As shown in Figure 66, blocking for the post is necessary when the railing will not be surface mounted (like the previous metal railing example). Since the wood deck or composite boards will be installed onto the cantilevered wood joist, ventilation, drying, and drainage should be accomplished more easily because of the spacing between the wood deck or composite boards.

The American Wood Council and Wood Works provide resources for those designing balconies [16] and decks [17] comprised of wood products. Both organizations have developed instructional materials that include discussion about fire ratings, structural design, and flashing details.

PRINCIPLE ONE **Slope Exception**

Wood or composite surface mock-up.

Railing systems can be structurally fastened into the cantilevered structure. The surface does not need a 2% slope to promote drainage.



Figure 64. Anchor Wood Post into the Substructure

6.2.2 KEY PRINCIPLE TWO: FLASHING & DRAINAGE

There is caulking and flashing at the interface between the cantilever beam and the exterior wall, which adds additional protection to the sheathing and blocking. For a wood or composite deck board surface, water drainage happens through the spacing between the boards.



Figure 65. Caulk the Intersection Area

PRINCIPLE TWO Flashing

Wood or composite surface mock-up.

Use caulk to seal the intersection between the cantilevered member and exterior wall.



Figure 66. Seal Intersection with Liquid-Applied Flashing

PRINCIPLE TWO Flashing

Wood or composite surface mock-up.

Use liquid-applied flashing or saddle flashing membrane (tape) to seal the intersection between the cantilevered member and exterior wall.



Figure 67. Use Flashing Tape at Threshold and Intersection

PRINCIPLE TWO Flashing

Wood or composite surface mock-up.

For additional protection against moisture use flashing tape at the intersection between the cantilevered member and exterior wall.

PRINCIPLE TWO
Drainage

Wood or composite surface mock-up.

Create uniform spacing between the wood or composite boards to promote drainage.



Figure 68. Space Boards to Promote Drainage

PRINCIPLE TWO
Flashing

Wood or composite surface mock-up.

In this installation, the height difference between the door threshold and the walking surface exceeds the accessibility requirements, therefore, a sloped transition was installed.



Figure 69. Sloped Transition for Accessibility

INSTALL WOOD RAILING

Although the metal railing system was mounted into the masonry surface of the balcony in this mock-up, we have mounted the wood rail to the exterior wall. We used liquid-applied flashing to protect the fasteners and exterior wall from water infiltration. A flashing membrane product (tape) could be used to achieve similar protection. Fasteners should be specified for the project and have corrosion resistance recommended by the manufacturer for the exposure and type of wood used.



Figure 70. Mount Rail Bracket on Exterior Wall

PRINCIPLE TWO Flashing

Wood or composite surface mock-up.

When installing an exterior wall-mounted railing bracket, the flashing details are important.



Figure 71. Install Wood Rail

PRINCIPLE TWO Flashing

Wood or composite surface mock-up.

Install the wood rail into the exterior wall mounted bracket.

PRINCIPLE TWO
Flashing

Wood or composite
surface mock-up.

Use liquid-applied flashing
or a flashing membrane
product (tape) to seal
fasteners and intersection
between the bracket and
the exterior wall.



Figure 72. Seal With Liquid-Applied Flashing

PRINCIPLE TWO
Flashing

Wood or composite
surface mock-up.

Install spindles to
complete the railing
system.



Figure 73. Install Spindles in Rail System

6.2.3 KEY PRINCIPLE THREE: VENTILATION & DRYING

The wood or composite deck board balcony shown in Figure 76 has a fully open substructure that allows ventilation and drying to occur. For reasons of design aesthetics, the owner may want to install a perforated soffit to enclose the substructure area, which should include appropriate drainage. Design solutions must also consider fire code requirements.



PRINCIPLE THREE Ventilation & Drying

Wood or composite surface mock-up.

The substructure must be ventilated to allow for drying whether the substructure is open or enclosed.

Figure 74. Installed Wood or Composite Surface Mock-Up

7. CONTINUOUS MAINTENANCE

After construction is complete, the building owner must implement a continuous maintenance program that includes both inspection and repair of any parts of the balcony and deck that have experienced deterioration or damage. The balcony and deck should also be inspected after severe weather events to ensure no damage has occurred.

In addition to highlighting the areas of the balcony to inspect, a basic inspection checklist is included at the end of this section. This checklist can be customized for the balcony or deck that is installed on the building. For example, if the balcony includes a floor drain, the maintenance team should inspect that periodically. If the maintenance staff does not have the expertise to inspect the balcony or deck, the building owner should hire a design professional or subject matter expert with commissioning and inspection experience.

7.1 INSPECTION DURING SERVICE

The figures and checklist in this section are grouped based on the key principles of sloping, flashing (or drainage), and ventilation (or drying). Other areas of maintenance can be included based on the materials used because the deterioration of wood is different from masonry materials.

Step #1: Verify the slope of the walking surface is away from the exterior wall and water flows away from the building (Exception: deck board surfaces).

Step #2: Inspect the interface areas between the exterior wall and the cantilevered joists.

PRINCIPLE ONE **Sloping the Walking** **Surface & Waterproofing** **Membrane**

Any Surface Type.

The intersection between the exterior wall and the cantilevered structural members is critical to performance. Inspect intersection areas and note any excessive deflection, water damage, or rot observed.



Figure 75. Inspect Intersection Between Wall and Structure Members

Step #3: Inspect the door threshold on the interior for water damage and rot.



Figure 76. Inspect Interior Door Threshold

PRINCIPLE ONE
Sloping the Walking
Surface & Waterproofing
Membrane

Any Surface Type.

The interior door threshold may have evidence of water damage or caulk or flashing that is deteriorating. Continuous maintenance is important to the long-term performance of the balcony.

Step #4: Inspect the door threshold on the exterior for water damage and rot.



Figure 77. Inspect Exterior Door Threshold

PRINCIPLE ONE
Sloping the Walking
Surface & Waterproofing
Membrane

Any Surface Type.

The exterior door threshold may have evidence of water damage or caulk or flashing that is deteriorating. Continuous maintenance is important to the long-term performance of the balcony.

Step #5: Inspect all railing connections to ensure they are secure and do not have water damage.

PRINCIPLE TWO
Flashing & Drainage

Metal Railing.

Inspect all metal railing connections to the deck surface, posts, and substructure.



Figure 78. Inspect All Metal Railing Components

PRINCIPLE TWO
Flashing & Drainage

Wood Railing.

Inspect all wood railing connections to the deck surface, posts, and substructure.



Figure 79. Inspect All Wood Railing Components

Step #6: Inspect the entire substructure for water damage or rot. Remove the soffit or any other ventilated covering that is installed. Pay close attention to the blocking and where the cantilevered beams penetrate the exterior wall. The inspector must be able to remove a portion of the exterior cladding to inspect behind it for any signs of moisture damage or rot.



Figure 80. Remove Enclosure and Inspect Substructure

PRINCIPLE THREE
Ventilation & Drying

Enclosed Substructure.

Remove the soffit or enclosure and inspect the substructure for evidence of water damage or other deterioration.



Figure 81. Inspect Open Substructure

PRINCIPLE THREE
Ventilation & Drying

Open Substructure.

Inspect the substructure for evidence of water damage or other deterioration.

7.2 INSPECTION CHECKLIST

The Inspection Checklist below can be customized for the user's specific project. In addition, many local building code departments may have an inspection checklist for balconies and decks. The maintenance staff should be trained to inspect and perform minor maintenance of the balconies and/ or decks. If issues are discovered, the owner should hire a licensed design professional or forensic engineer to complete a comprehensive evaluation of the balcony or deck to determine if any major repair or replacement is needed.

INSPECTION CHECKLIST FOR BALCONIES & DECKS		
KEY PRINCIPLES	PASS / FAIL N/A	NOTES
SLOPING		
1. Check the slope of the balcony/deck to confirm the walking surface slopes away from the building.		
2. Test the slope by using a level and pouring water onto the walking surface. Does the water drain properly?		
3. Verify that the railing system is securely mounted in place. Are any parts of the railing system loose?		
FLASHING & DRAINING (if visible)		
1. Are there visible gaps, damage or displacement of flashing?		
VENTILATION & DRYING		
1. The cross-ventilation area must be at least 1/150 of the area of each separated space of the wood balcony or deck structure in order to allow the substructure to dry.		
2. Dryer vents must be vented away from the substructure of wood balconies and decks to minimize condensation on the underside.		
3. Any sidewall vented gas appliances must be vented away from the substructure of wood balconies and decks to minimize condensation on the underside.		
4. Gutters and downspouts must not discharge directly onto the wood balcony and deck walking surface. If this cannot be avoided, splash pads and protection mats must be used.		
5. Is water damage or rot visible on any part of the balcony, deck, or soffit?		

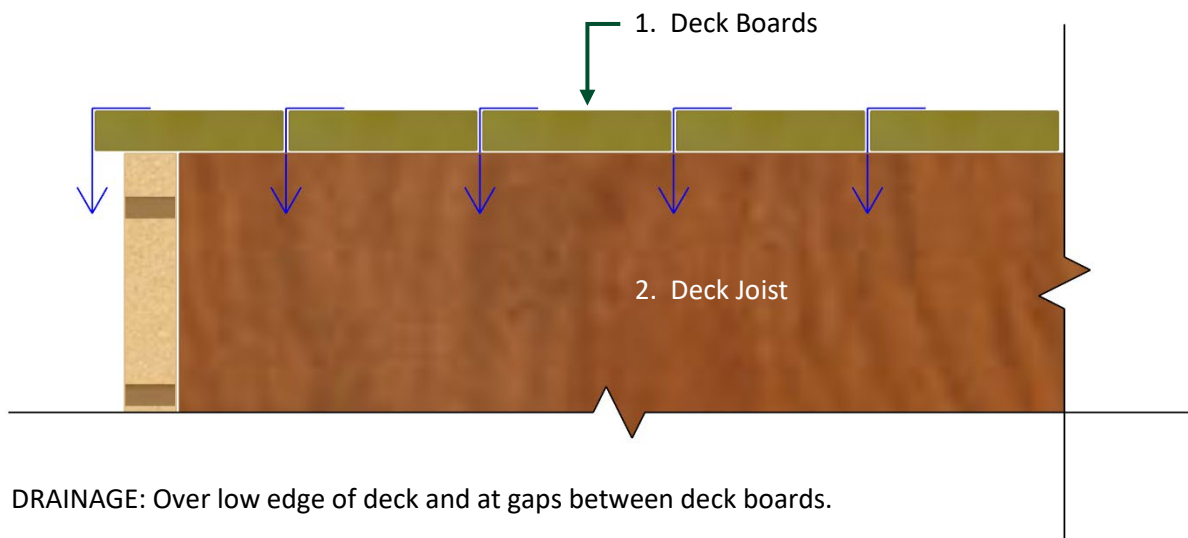
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APPENDIX A: Drainage Drawings

DRAINAGE EXAMPLE 1: DECK BOARDS

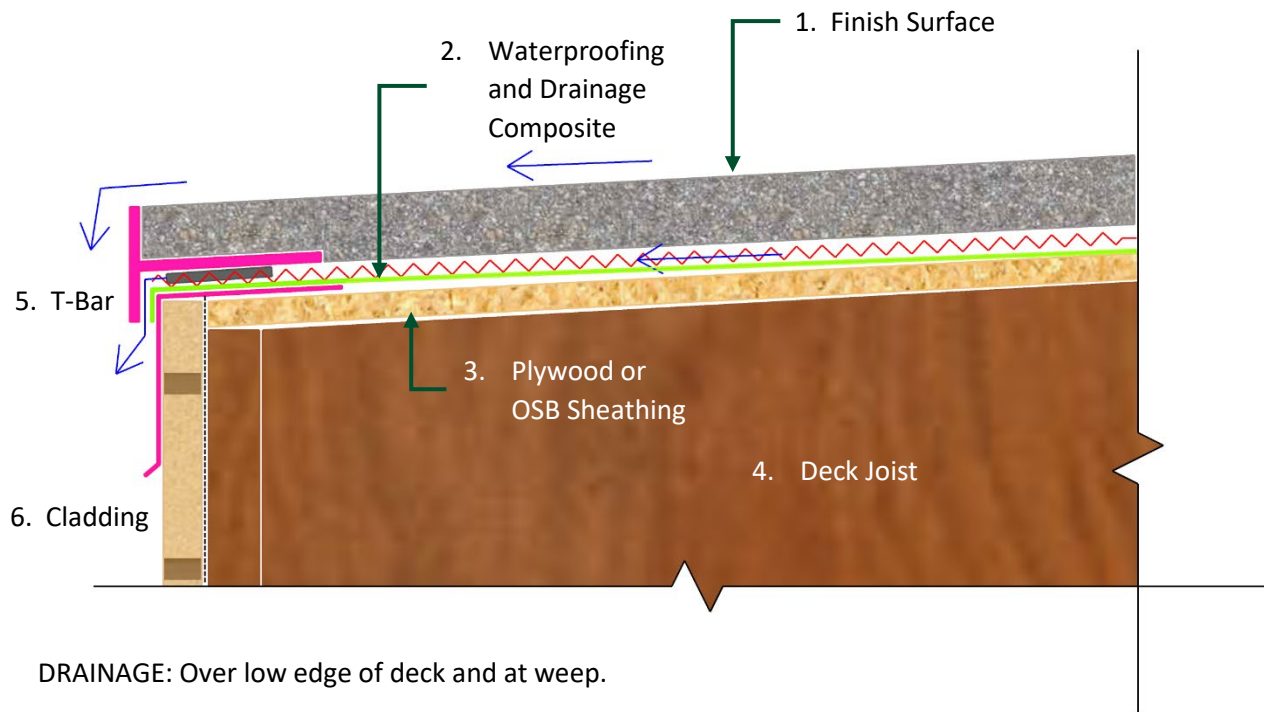


DRAINAGE: Over low edge of deck and at gaps between deck boards.

NOTES:

1. Deck boards are installed with space to drain between boards.
2. Deck joist is installed level or sloped toward low edge of deck.

DRAINAGE EXAMPLE 2: WATERPROOFING WITH SEPARATE FINISH

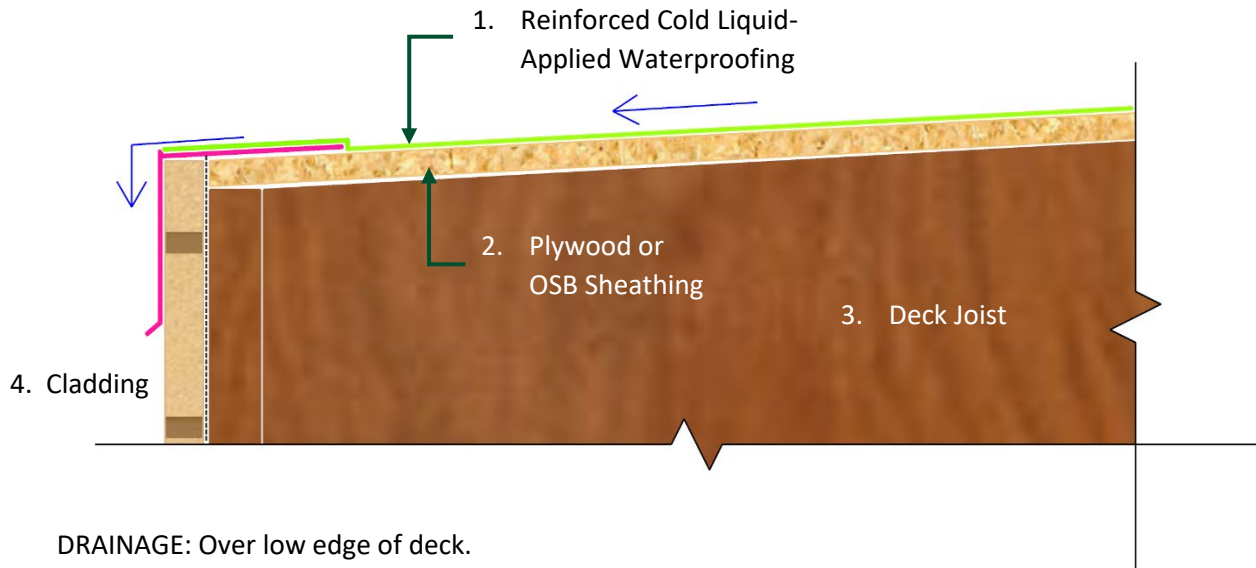


DRAINAGE: Over low edge of deck and at weep.

NOTES:

1. Finish surface of masonry or concrete.
2. Waterproofing and drainage composite. Integrate waterproofing with edge flashing as recommended by waterproofing manufacturer.
3. Plywood or OSB sheathing. Coordinate sheathing type with waterproofing manufacturer.
4. Deck joist installed with slope toward low edge of deck.
5. T-bar with gasketed fasteners through intermittent water-durable cement board shims at fasteners. Set shims in sealant. Coordinate sealant with waterproofing manufacturer. Coordinate shim thickness with drainage composite thickness.
6. Cladding over water-resistive barrier.

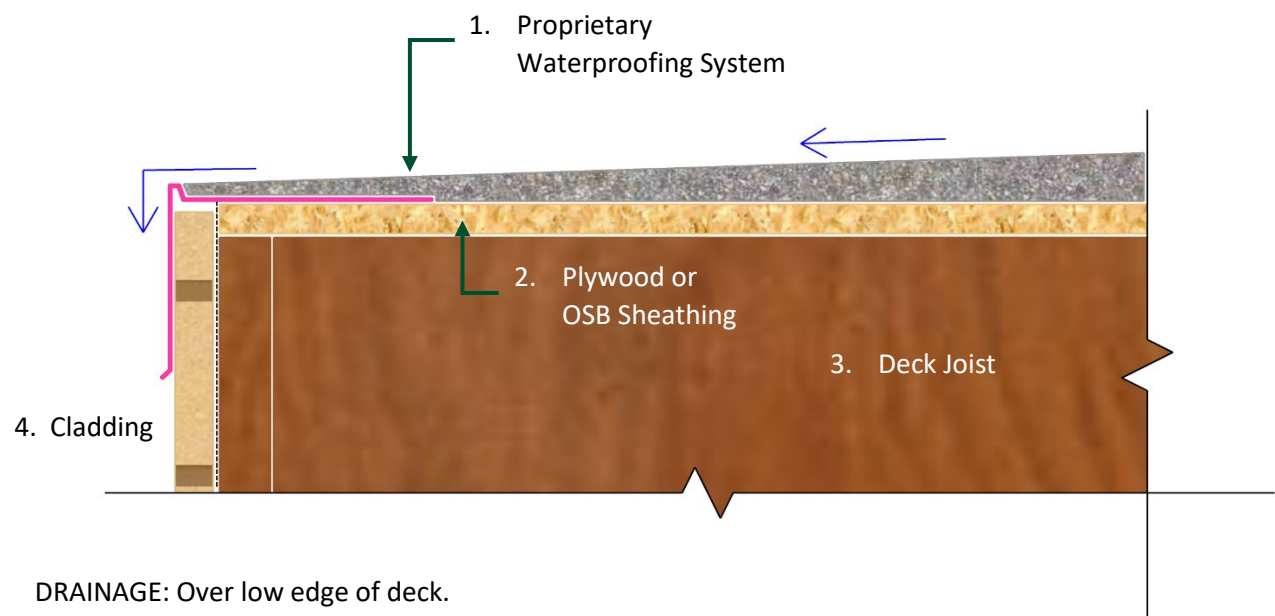
DRAINAGE EXAMPLE 3: WATERPROOFING WITH INTEGRAL FINISH SURFACE



NOTES:

1. Reinforced cold-liquid-applied waterproofing with integral wearing surface. Integrated with edge flashing as recommended by waterproofing manufacturer.
2. Plywood or OSB sheathing. Coordinate sheathing type with waterproofing manufacturer.
3. Deck joist installed with slope toward low edge of deck.
4. Cladding over water-resistive barrier.

DRAINAGE EXAMPLE 4: PROPRIETARY WATERPROOFING AND SLOPING SYSTEM



NOTES:

1. Proprietary waterproofing system with capacity to create slope to drain. Integrate with edge flashing as recommended by waterproofing manufacturer.
2. Plywood or OSB sheathing. Coordinate sheathing type with waterproofing manufacturer.
3. Deck joist installed level or with slope toward low edge of deck. Coordinate joist slope with slope of proprietary waterproofing system.
4. Cladding over water-resistive barrier.

APPENDIX B:

Additional Design Guidance

1. No Tapering (Ripping) Solid-Sawn Structural Framing

2021 IBC 2303.1.1 requires grading by an accredited agency. Lumber for use in accordance with the building codes are graded in accordance with the U.S. Department of Commerce Voluntary Product Standard PS20 “American Softwood Lumber Standard.” PS20 states: “7.3.7 *Remanufacture (ripping, resawing or surfacing) of graded or grade marked lumber negates the grade or grade mark and the design values of the original product and the original grade mark shall be removed, by any appropriate means. 7.3.7.1 When grade marked dimension lumber is resawn or remanufactured in such a way as to potentially alter the grade indicated by the grade mark, the original grade mark shall be obliterated.*” As a result, tapering or ripping of solid-sawn structural framing, such as balcony or deck joists or beams, should not be used to achieve a slope to drain for the balcony or deck surface. Ripping of a solid-sawn shim or nailer that is continuously supported and not relied on for strength is acceptable because preservation of the grade is not needed. For engineered framing, the manufacturer's instructions govern permissible tapering or ripping.

2. No Notching Solid-Sawn Structural Framing

The American Wood Council's National Design Specification states “For Wood Construction, in 3.2.3, permits limited notching for single or multiple span lumber. For solid-sawn lumber, Section 4.4.3 does not include notching on cantilevers. For engineered framing, the manufacturer's instructions govern permissible notching. As a result, notching of solid-sawn structural framing, such as balcony or deck joists or beams, should not be used to achieve a step down to a lower floor surface for the exterior portion of cantilevered balcony joists.

3. Our suggestion for showing engineered lumber in figures

As noted by others, designers may taper engineered lumber to provide slope, but we should say that tapering should only be done if specifically allowed by the manufacturer. The use of engineered lumber should be limited to balcony assemblies with waterproofing membranes, unless permanent weather exposure is permitted by the manufacturer. Figures 5 through 14 which show floor joists continuing out as tapered balcony supports have the same hatch, kind of a vertical grain, as the (most likely) sawn lumber in Figures 24 through 30. Different hatches for the two types of materials would improve clarity.

4. Our suggestion for showing sawn lumber at balcony with board decking

In a typical installation the assembly shown in Figure 24 through 30 would have level cantilevered supports of the balcony (which might, for example, be 4x8 sawn lumber) sistered onto floor joists (which might, for example, be 4x10 sawn lumber). The difference in vertical dimensions between floor and balcony joists would allow the surface of the board decking to be

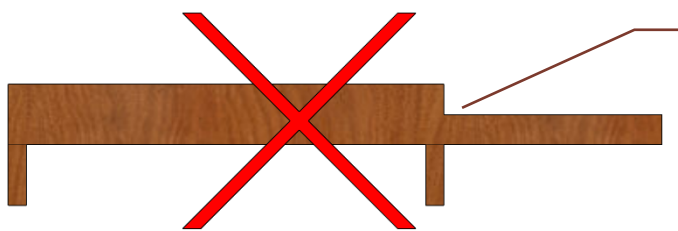
close to the elevation of the interior floor. The IRC Table, “CANTILEVER SPANS FOR FLOOR JOISTS SUPPORTING EXTERIOR BALCONY” provides back span and other design data. (We are not finding other industry standards to reference.) We suggest showing a level cantilever with sistering fasteners over the supporting exterior wall and at the end of the required back span.

APPENDIX C:

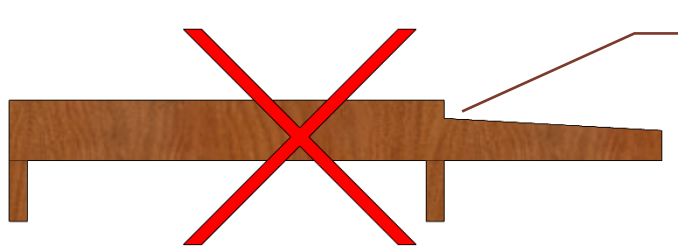
Cantilevered Balcony Deck Framing Dos & Don'ts



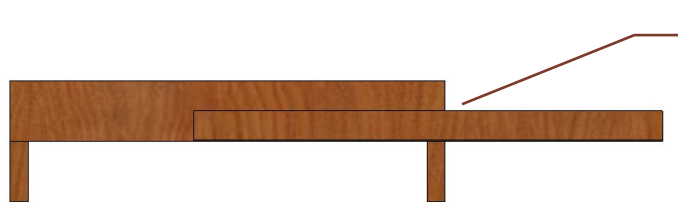
Do not rip structural framing to achieve slope, this invalidates wood grade.



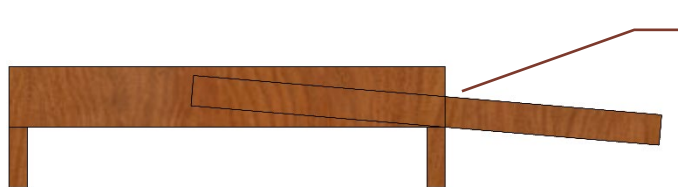
Notching of cantilevered sawn framing is prohibited by NDS. Do not rip structural framing to achieve slope, this invalidates wood grade.



Notching of cantilevered sawn framing is prohibited by NDS. Do not rip structural framing to achieve slope, this invalidates wood grade.



Step down of balcony framing can be achieved by lapping narrower balcony joist with typical floor framing.



Step down and slope of balcony framing can be achieved by lapping narrower balcony joist with typical floor framing.

