

HORIZONTAL ABOVE GRADE WATERPROOFING

by

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INTRODUCTION

This paper is limited to protected type waterproofing membrane assemblies such as plaza decks, split slabs and concrete over wood decks assemblies. Trafficable waterproofing membrane systems like deck coatings and traditional protected roof assemblies such as inverted roof membrane assemblies are excluded from this discussion.

Plaza decks are defined as exposed pedestrian surfaces constructed over parking or other occupied space, often built over structural concrete. IBC defines garages as a type of occupancy, so technically plazas built over garages are over occupied space. Plaza decks can have many features such as driveways, pools, lawns, large mature trees, terrazzo and concrete toppings, glass screens, pavers over gravel or pedestals, planters, etc.

Also discussed are protected waterproofing membranes over wood decks surfaced with many of the same types of permanent surfaces such as concrete topping slab, tile planters, etc. Typical Type V Podium assemblies are 4 to 5 stories of wood framed construction over a concrete podium, commonly used in California and other states for multi-family construction. These elevated wood assemblies also have exposed, horizontal waterproofing with hard wearing surfaces like concrete which are integrated to the exterior wall claddings such as, masonry, stucco, siding, dimension stone, etc. Because these assemblies are surfaced with permanent landscape and hardscape features and integrated with doors, ramps and claddings elements, the wood framed waterproofed assemblies are also built with a life expectancy equivalent to the “life of the building”.

While properly designed and constructed plaza deck assemblies such as these can and do last the lifetime of the building (50+ years), poor quality construction often causes premature failures within 10 years and requires very expensive repairs, costing well over \$100/SF. The focus of this presentation is to explore the actual performance of these types of assemblies, explore causes of premature failures, and learn what seems to work and what to avoid. Explored are failures related to sloping issues, drainage issues, use of galvanized versus stainless flashings, issues with integration to sliding doors and man

doors, and issues related to degradation and failure of waterproofing membranes under certain conditions.

COMPONENTS OF PROTECTED ASSEMBLIES

There are several base components of any protected system, as demonstrated in Figures 1 & 2: the wearing or traffic surface, a protection layer that sometimes doubles as isolation and drainage layer, a waterproofing membrane and the structural deck or substrate. Additional systems may be necessary and the order of the systems can vary depending on the purpose and design of the deck, but the base components remain consistent across various deck types.

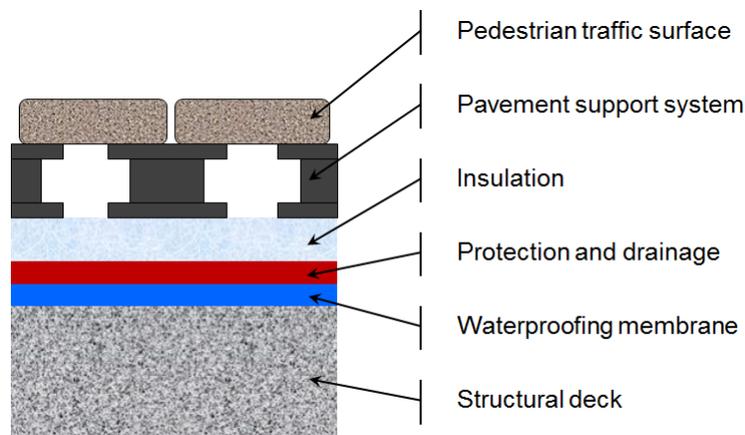


Figure 1: Protected Membrane Components



Figure 2: Typical Podium under construction with waterproofing complete inside of planters. Due to the heavy construction traffic, waterproofing membrane is phased and installed last, before the wearing course.

STRUCTURAL SYSTEMS

CONCRETE

Concrete slabs are the most common structural substrate for podiums. Slabs are either reinforced with mild steel or post-tensioned steel (Figures 3 & 4). The advantage of post tensioned steel is reduced thickness, therefore less concrete and less cost. However, the labor associated with tensioning cables is higher and overall the cost of post tensioned slab can be competitive depending on sub-contractors.



Figure 3: Podium slab with tensioning cables and reinforcing steel



Figure 4: Post-tensioned reinforced concrete slab under construction

Also common in steel structures is steel pan deck, with mild steel reinforced concrete. Prior to the adoption of reinforced concrete, the 2-way flat plate and one-way slab over beam systems were common however, not used as much anymore.

Often Type V structures are built with wood framing over concrete podium. Often elevated exterior wood structures are waterproofed and may have permanent features such as protective concrete topping slab, public walkways, stair landings, exercise equipment, private decks, bicycle racks, planters and other features similar to podium decks.

DECK SLOPE AND PROPER DRAINAGE

One of the keys to lifetime performance of horizontal, protected waterproofing assemblies is proper design of slope and drainage. Because these types of assemblies have a substrate and topping surfaces, both layers of surfaces require proper design and construction of slope. Also since these assemblies not only drain from the surface but also from within the protected assembly, it is important to understand the mechanism of drainage, especially at the membrane level. Proper construction of both slope and drainage is critical to the long term performance of these assemblies.

International Building Code requires slopes under the waterproofing/roofing membrane to be a minimum of $\frac{1}{4}$ " per foot. In some geographic areas, we commonly see that the common practice is to not slope the structural slab, and provide slope only in the topping material, which may not meet the intent of the code. In my opinion, primarily the slope requirement is for the waterproofing substrate. IBC Section 1402.3 states, "Balconies, landings, exterior stairways, occupied roofs and similar surfaces exposed to the weather and sealed underneath shall be waterproofed and sloped a minimum of $\frac{1}{4}$ " unit vertical in 12 units horizontal (2% slope) for drainage."

Slope is best achieved by being built into a structural deck because it becomes a permanent building feature. Building the structural level and adding slope thereafter adds additional cost and introduces potential for mistakes and premature failures.

Sometimes, porous topping surfaces such as pavers are built with no slope to achieve a level, usable floor. When a level surface is desired, pavers, natural stone, gravel and other porous concrete surfaces are used to allow water to completely drain through the topping material and travel on the membrane level. In those instances, it is important to install primary and overflow drains at the membrane level to accommodate the extra flow of water.

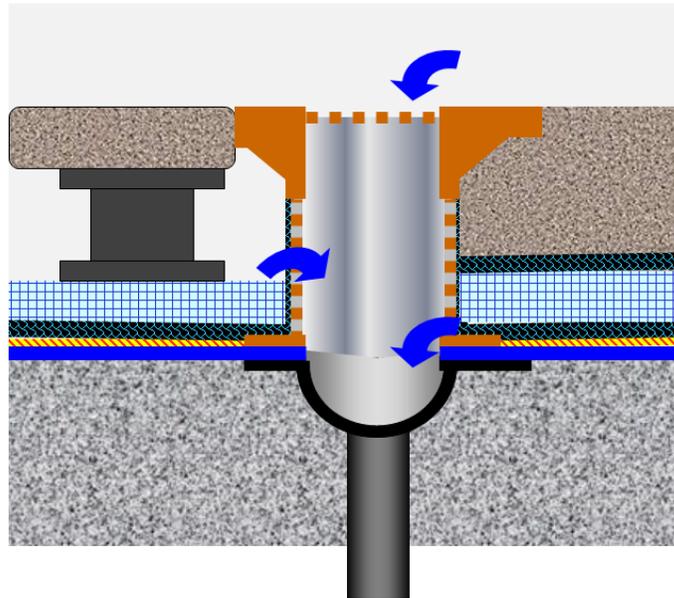


Figure 5: Typical Plaza Drain Configuration

On less porous surfaces such as concrete topping slab, the topping surfaces have to be sloped 2% to drain, in addition to the substrate to be sloped to drain as well. Such surfaces require main drains to be located at the topping level and secondary weeps to be located at the membrane level. Proper functioning of both drainage methods is very important to the success of plaza and elevated outdoor type assemblies.

It is easiest to achieve slope via cast-in-place concrete because it can be directly cast into the deck surface and is easier to resolve slopes for decks with complex shapes and geometry. Slopes can also be achieved in plywood decks by tilting the framing members to slope and installing plywood crickets for cross slopes. Sometimes, wood joists are ripped on the top to achieve slope and the bottom of the joist can remain level. In split slab systems with steel pan decks are sloped similarly, sloping the steel framing and steel deck and or sloping the concrete slab cast on the steel pan. Using tapered insulation to create gradient is not recommended for split slab assemblies because it limits the types of waterproofing membranes that can be used, can be more readily damaged, and if punctured can allow water to travel within the assembly.

With new construction, slope is often indicated on architectural drawings but sometimes neglected in structural drawings. Sometimes, podium slopes are indicated on civil drawings, instead of structural or architectural drawings. In new construction projects, proper review and coordination of slope on Civil, Structural, Architectural and Landscaping drawings is important. It is important to check for conflicts between the various disciplines and to make sure proper slopes are clearly shown and the contractor(s) are aware of the requirements. On new construction projects, the best place to show

slopes is on the structural drawings (in addition to architectural) because the slab/structure needs to be engineered by the structural engineer. Also, framing and structural sub-contractors often build from information conveyed on the structural drawings and mistakenly ignore slopes shown on architectural drawings, so it's important that the structural and architectural drawings are in sync. It's also important to review the structural substrate as some light weight concrete substrates and sloping courses are not suitable for waterproofing membranes.

DRAINS

A typical plaza deck drain, as pictured in Figure 5, consists of a top mounted inlet drain for surface drainage in addition to a secondary inlet located at the membrane level for membrane level drainage. The podium drain body typically has an adjustable height and threads for proper installation and function. The location of the drain is important in preventing ponded water both on the wearing surface and at the waterproofing membrane level. Standing water at the membrane level can damage certain types of waterproofing membranes and cause the system to fail. Certain waterproofing membranes such as asphalt modified polyurethane membranes are very susceptible to water damage from standing water.

Drains must have weep ports at the membrane level to allow the water to drain off the surface of the waterproofing. A typical plaza drain will handle majority of the drainage and water runoff from the top inlet. However, podium assemblies that have pavers on gravel/sand bed or pedestal pavers should have their primary drains at the structural slab level because majority of the water will be travelling on the membrane level. If primary drains are installed at the membrane level, the concealed drains should be identified on top with pavers that are marked to indicate where the drains are located. Overflow drains should also be provided to prevent flooding and sub-drains should be maintained regularly to prevent clogging.

SUB-SLAB DRAINAGE

A drainage board or air gap between the surface and waterproofing layers serves as drainage and occasionally as additional protection for the overburden during construction. Its main purpose is to conduct sub-surface water to the drain, gutter or edge, and provide mechanical protection from the overburden.

Manufacturers of the waterproofing materials will often allow the designer to omit the drainage layer. However, drainage layers work best when the substrate is built with proper drainage and pathways towards the drains and gutters are not obstructed or blocked. Lack of slope or reverse slope leads to long term standing water on the waterproofing membrane. The drain board cores are made from polypropylene, polystyrene and polyethylene which are vapor barriers or vapor retarders. The vapor barrier nature of the drain board can trap standing water, prevent it from evaporating and drying and can lead to damaging some types of waterproofing membranes due to being

immersed in water. The same is true for some types of protection boards and XEPS insulation boards, as both can restrict drying if proper slope and drainage are not present.

INSULATION LAYERS

Insulation is usually applied over the waterproofing membrane or under the structural deck, as it should be independent of the two. In cold or high-humidity climates it is best to locate insulation above the waterproofing membrane to prevent freeze-thaw damage.

For plaza surfaces that receive live loads such as foot and vehicular traffic, it is important for the insulation layer to have a high compressive strength. Due to immersion in water, it is important that insulation materials such as closed cell extruded materials be used as opposed to expanded polystyrene, to prevent water absorption. The most typical extruded polystyrene foam has a compressive strength that ranges from 20 to 100 psi and an R value of 5.0/inch. The required compression strength of the insulation board will depend on the dead load as well as the type of live load (foot traffic versus vehicular traffic). The board needs to be protected from the sun during construction to prevent permanent damage. Foamed glass is another insulating material that is not as commonly used but it does have a high compressive strength (90 psi), R value (3.44/inch) and melting point (1800°F) making it very dimensionally stable.

WEARING SURFACE

The upper most layer (also referred to as the wearing, pedestrian or traffic surface) is usually composed of concrete or pavers that is subject to traffic by either pedestrians, vehicles or both (public walkways - Figures 6 & 7). This is the first line of defense against damage to the membrane and assembly and can be the primary means of drainage for the assembly. Concrete topping is often sloped to shed the majority of surface water but significant amounts of water can get under the concrete.



Figure 6: Elevated public walking surfaces on wood deck with colored concrete and porcelain tile wearing surfaces, integrated with handrails, doors, exterior walls, elevators, etc.



Figure 7: Typical podium with concrete topping and pavers, shade structures, fences, planters, trees, pool, spa, light pole, free standing walls etc. integrated with building walls, fences, doors, pools and planters

WATERPROOFING MEMBRANES

The waterproofing membrane serves as the main water barrier and the selection of the system is critically important to the success of the project. Our forensic experience has shown that standing water is often present on the membrane for months or in some cases, all the time. Therefore, it is important that the selected membrane can handle continued immersion in water. While a drainage mat may help move the water towards the drains, when proper slope is not present, drain mats can serve as an unwanted reservoir of water to stand on the membrane. The standing water does not dry for a very long time, in freezing climates, can freeze, cause freeze thaw damage. Generally, even without freezing climate, standing water does accelerate the decay and degradation of waterproofing membranes, and some membranes are more affected by it than others.

Some of the most common fully adhered membranes in use today are hot-fluid applied rubberized asphalt (HRA), modified bituminous membranes (Figure 8), modified bitumen sheets, and PVC (Figure 9). Many of these systems have been in service for over 40 years and are still performing well today.

Asphalt modified polyurethane cold fluid-applied membranes (Figure 10) tend to be some of the least expensive products, very simple to install requiring little or no equipment, making them very popular. However, asphalt modified polyurethanes have a very poor track record and tend to suffer from premature failure due to higher permeability under standing water, which causes premature failure, swelling and blistering (Figure 16).

Another common membrane selection is modified bitumen, which can be adhered, torched or fluid applied. Some self-adhesive SBS membranes use a combination of cold, asphalt modified polyurethane, deck prep and the self-adhered sheets (Figure 8).



Figure 8: Combination self-adhered modified bitumen membrane with fluid applied waterproofing



Figure 9: PVC membrane



Figure 10: Asphalt modified polyurethane

HOT APPLIED FLUID SYSTEMS - RUBBERIZED ASPHALT (HRA)

Based on my forensic review of many different types of waterproofing systems, HRA is one of the most reliable waterproofing membranes in service (Figure 11 & 13). Due to its reliability and relatively low cost, HRA systems have become very popular in new construction and are often used on large podium type projects. HRA's require a specialized double jacketed kettle to heat the asphalt and for remedial construction, the smell of asphalt is sometimes a deterrent for occupied buildings. HRA's have the ability to be phased and joined seamlessly. Due to its recent surge in popularity, and low failure rate, new material manufacturers have jumped into the market. Many waterproofing contractors that historically did not have the required hot jacketed kettles have bought new equipment and are now offering this system. Overall, more competition has driven the cost of the system lower bringing the price on par with cold applied asphalt modified polyurethanes.

Unreinforced HRA membranes typically have had more failures and installation defects such as pinholing and leaks. These membranes are unable to bridge cracks as effectively and can fail as the underlying concrete or substrate shrinks and cracks or moves over time. Whereas, polyester fabric reinforced HRA system are more forgiving and redundant and have fewer construction issues, and if properly constructed can last for the life of the building. Therefore, it is recommended to provide reinforced systems for long term performance.

However there are multiple challenges to successfully installing HRA, the four most common being: Adhesion failure to concrete; material and flashing build up at base flashings, flashing around rebar and substrate acceptance.



Figure 11: Adhesion of membrane with sheet neoprene



Figure 12: HRA Challenge – Flashing Build Up

HRA is typically about a quarter inch thick (215 mils) with the embedded neoprene at around 60 mils. The protective flashings used at seams and joints are about 110-180 mils so when overlap occurs, as depicted in Figure 12, the membranes can build up to about $\frac{3}{4}$ of an inch, resulting in problems at the base flashing of doors and storefronts.



Figure 13: Typical HRA application

Waterproofing around rebars is always challenging because the membrane prevents concrete from bonding directly to the reinforcing steel (Figure 14). Proper care needs to be taken to detail the reinforcing steel to both waterproof the area and allow the rebar to serve its primary function.



Figure 14: Waterproofing around reinforcing steel

And finally, HRA does not always properly adhere to the substrate, so regularly performing peel tests for testing adhesion is important. It is also important to check for moisture escaping the structural deck, using a Mat test (ASTM C-4263 to check for capillary moisture in concrete) and by mopping some hot asphalt to see if it fizzes or pinholes.



Figure 15: Mat test (Right) and various samples for pull test about to be performed

Manufacturers of HRA don't offer specific guidelines for adhesion testing but the most common method is using a reinforcing fabric or neoprene to perform a pull test (Figure 15). Pass/fail is best defined with cohesive/adhesive failure. Water based primers are always tricky and not as reliable as solvent based primers. Water based primers are sensitive to cold temperature, and can re-emulsify with high alkalinity and water. Solvent based primers are also sensitive to application rates, curing time and temperature.

COLD FLUID-APPLIED FLUID SYSTEMS

A common cold applied fluid system material is asphalt modified polyurethane. Due to its ease of installation and relatively low cost, it has been a very popular option for protected waterproofing membrane assemblies. However, our forensic experience has shown that most fluid applied polyurethane type coats don't work very well in plaza type applications and where constant immersion is water may be present. Typical failure modes are, membrane absorbing large amounts of water and swelling and water filled blisters.

Most waterproofing manufacturers list very low water absorption rates after testing for just 3 days of immersion. However, water may be present on the membrane for months at a time, sometimes for the life of a system. Impact of long term standing water can be very different than a standard 3 days test. Some membranes absorb more than 100% of water per weight of the material, excessively swell and look like the brain, often called "brainiac" effect (Figure 24).

Most polyurethane membranes have some level of permeability, which ultimately causes them to transmit water through the membrane and result in failure. The

most common and dramatic types of permeability failures are large water filled blisters over concrete decks and damage to sheet metal flashings though permeability. It is best to select a membrane that has a perm rating of 0. But, permeability of membrane must always be less than the permeability of the substrate. Most concrete slabs have permeability of 3.2 perms per inch. A 10” slab would have an approximate permeance of 0.32.

It is also important to check the “wet permeability” any type of fluid applied membrane being used in a protected assembly. Manufacturers of fluid applied membranes often publish permeability rates that only measure permeance with vapor transmission and that test is not valid. The membrane is subjected to standing water therefore, the proper test method is the water methods that measures permeance through standing water which closely mimics the actual conditions.

If the wet permeability of the waterproofing membrane is higher than the permeability of the slab, water will start to accumulate on the concrete surface and not dry through the slab fast enough. This leads to moisture filled blisters. Moisture filled blisters mix with salts that are naturally occurring in concrete and the saline solution creates an osmotic action and draws fresh water through the membrane. In reinforced concrete slabs, we have seen these blisters grow to the size of baseballs and footballs. Unreinforced membrane blisters are generally smaller, size of a dime or silver dollar before they burst or break.

Brian Hubb, P.E. conducted permeability tests of polyurethane membranes and published a paper in RCI Building Envelope Symposium Technology October 2009. Brian reported permeability of modified polyurethane membranes with the inverted wet cup method to range from 0.20 to 0.50 perms with membrane thickness ranging from 150 mils to 30 mils. In comparison, most podium slabs are 18” or thicker with permeability of 0.18. This disparity allows water to accumulate on the slab and start the osmotic cycle. As water slowly permeates through the membrane and doesn’t dry through the slab fast enough, it starts to accumulate on the surface of the slab. Salts from the concrete mix with the water to form an ionic solution. Due to the ionic potential across fresh water (standing on top of the membrane) and salty water (on the surface of the concrete) the membrane allows the fresh water to be drawn through and create water filled blisters (Figure 16).

While permeability can allow for water to dry through the membrane, it can be detrimental to roofing and horizontal waterproofing applications.

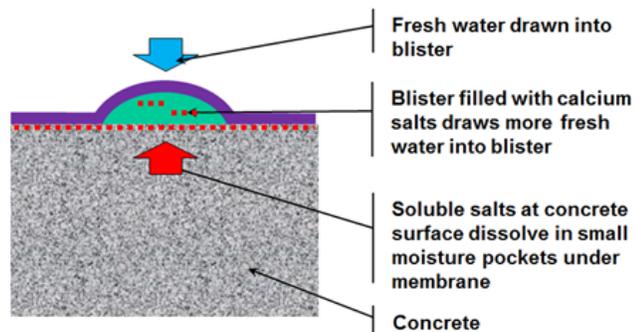


Figure 16: Osmotic water filled blisters



Figure 17: Corrosion of galvanized sheet metal flashings under 90 mils of fluid applied membrane

Due to high permeability of these membranes, we have also seen high levels of moisture permeation and damage in plywood substrates and sheet metal flashings. Standing water on modified polyurethane membranes can raise the moisture levels in plywood and cause corrosion of galvanized steel flashings (Figure 17). We have seen moisture content above 19% in many plywood substrates due to standing water and corrosion on sheet metal through 90+ mils of membrane thickness.

WATER TESTING AND WARRANTIES

Warranties do not prevent roofs and plaza decks from leaking. The biggest difference between roofing and waterproofing warranties are that, membrane manufacturers exclude overburden replacement. While most membranes cost about \$10/SF or less, podium replacements can range from \$60/SF to \$200/SF, depending on the overburden. Most warranties exclude removal and reinstallation of the overburden. In a plaza deck, 90% or more of the cost of replacement is the overburden, and removal of doors, window walls and facades, to perform the proper tie-in. Most membrane manufacturers only warrant the material cost, which could be less than 2% of horizontal waterproofing replacement cost.

Water testing only tells part of the picture. Just because a horizontal waterproofing assembly is water tight, from an industry standard ASTM D5957 test (depicted in Figure 20), doesn't mean a system is built watertight for the life expectancy of the system. Most systems may pass the ASTM 5957 test even if the system had a slow leak. Field Vector Mapping is a better way to test for water tightness because often, the penetrated water doesn't leak and drip through the ceiling in a regular flood test. Conversely, some leaks that can be detected through a flood test cannot be detected through an EFVM test, under conditions that require elevated water such as expansion or seismic joints.

Despite both methods of testing, premature failures can occur years after the system is in place due to inherent construction defects or membrane failure. Water tests are no substitute for proper design and quality assurance.

ELECTRONIC FIELD VECTOR MAPPING (EFVM)

EFVM is a non-destructive testing method that uses electricity to precisely test the waterproofing membrane for leaks. EFVM is preferred over other traditional testing methods because it is non-destructive and the membrane can be tested without removing the overburden or ballast. It can be used on both hot and cold liquid applied membranes, coatings, and other sheet membranes in addition to metal, concrete and wood substrates, provided a grounding grid is used with the wooden deck.

Certain types of membranes are incompatible and can't be tested with EFVM. Leaks around drains and penetrations can also be difficult to detect.

The test works by measuring the difference in electric potential between charged water, the non-conductive membrane and the grounded, positively charged,

substrate. First a very thin layer of water, which serves as a conducting medium, is applied to the surface of the membrane and a low voltage pulse, 40V for 1 second every 3 seconds, is introduced into the water using a wire loop that encircles the perimeter of the tested area. The current flow is measured using a potentiometer (Figure 18). If the membrane is watertight the electricity is isolated to the water; however, if there are leaks the electricity will be pulled towards the positively charged substrate. The resulting electrical contact and exact point of entry can be determined by using the potentiometer to follow the electrical pull. Because EFVM is so sensitive, leaks as small as a pinhole can be detected (Figure 19). In some circumstances, the leads and wire loops can remain below the overburden to allow for easier future testing.

One of the drawbacks of EFVM is that not all membranes can be tested due to their conductive nature. Membranes that contain carbon black or aluminized coatings with modified bituminous membranes do not resist enough electricity and thus are not testable using EFVM.



Figure 18: Using potentiometer to discover source of leaks



Figure 19: Pinhole leak discovered using EFVM



Figure 20: ASTM D5957 – Standing Water Testing

FORENSIC CASE STUDIES

The best way to learn is by making mistakes, or by studying failures caused by others. ABBAE has been very fortunate to have had the opportunity to study hundreds of failed podium decks due to numerous types of design, construction and material failures. There are several types of failures and forensic studies presented including:

1. Drainage or slope issues resulting in unpredictable leaks to the interior.
2. Failures due to high permeability rates in waterproofing membranes in:
 - a. Concrete substrates
 - b. Wood substrates
 - c. Sheet metal flashings
3. Issues related to sub-slab drainage such as weep holes being clogged and discontinuous drain board.
4. Impact from root damage due to improper root protection.
5. Impact from construction activities due to lack of protection.
6. Use of galvanized sheet metal versus stainless steel.
7. Failure due to improper surface preparation.
8. Failure due to water based primers used under fully adhered membranes.

CASE STUDY 1 – IMPORTANCE OF PROPER SUBSTRATE SLOPE

We were studying a historic leak in a concrete podium level living area of a large 250+ door, apartment structure. The sliding doors to the private deck were covered with a 10 foot overhang. Since the sliding door was not typically subject to wind driven rain, we were trying to understand why there was considerable damage inside at the base of the doors.

The water testing consisted of placing water on the pavers 20 feet away from the sliding door, in the weather exposed area. Although the water was never placed anywhere near the sliding glass doors and the surface water never made it to the door or the building walls, we observed leaks inside. We observed that the water began to emerge from the door jamb both outside and inside. The leak mechanism and mode of travel of water is depicted below in Figure 21 and 22.



Figure 21: Water flows from the door even though it never flows to it

The weeps at the waterproofing membrane level were small relative to the drain and the weep holes were clogged, allowing water to mostly drain off the topping slab and build a hydrostatic head at the surface. The control joints in the concrete and perimeter joints served as a conduit for water, filling up and crating hydrostatic head at the level of the topping slab.

Lessons learned, it is important to allow the sub-slab to properly slope to drains and the weep holes be clear to allow for proper drainage. It is also important to not have any topping slab surfaces higher than the interior height. In the absence of robust sub-slab drainage, water can build a hydrostatic head equal to the highest surface of the topping slab.

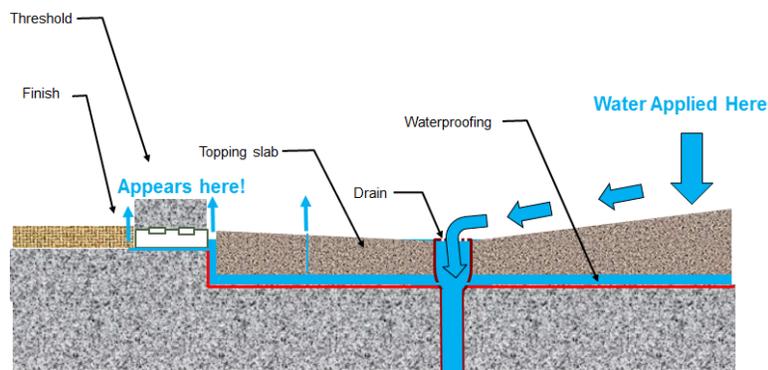


Figure 22: Water flows under the topping slab and appears at door jamb

CASE STUDY 2 – IMPORTANCE OF DRAINAGE MAT PROPERLY INSTALLED

This case study depicts damage and failure caused by standing water on a modified polyurethane membrane (Figure 23). The hospitality project featured private balcony decks, built with plywood substrate sloped to drain in one direction with an internal stainless steel gutter. The waterproofing membrane has a drainage board/mat with 2” of mortar bed and travertine tile.

Generally, the deck was uniformly sloped across towards the gutter. However, due to the drainage mat being discontinuous across the middle of the deck, water ponded on the membrane in pockets of areas. At the standing water areas, water stood on top of the membrane for long periods of time. While the drain mat can facilitate the flow of water, in a standing water condition it can act as a vapor barrier and not allow the water to dry through the surface of the slab. Water standing on the membrane for extended periods of time caused the asphalt modified polyurethane membrane to swell “brainiac” and fail.



Figure 23: On this wood framed balcony deck, the drain mat was discontinuous down the center of the deck. This resulted in water not properly flowing and ponding on the upslope side of the discontinuity.



Figure 24: Modified polyurethane membrane is swollen and looks like the texture of “brain” or brainiac. Prolonged immersion of the membrane results in swelling and water absorption far beyond manufacturer’s published results.

CASE STUDY 3 – ADHESION TESTING AND FAILURE MODES

On a new construction podium style apartment project with over 1500 doors and several acres of podium deck, we observed sporadic failures in HRA membrane adhesion. The failures modes were multiple and complicated.

One of the failure modes was the improper cure of the structural slab surface which resulted in a very soft surface making it easy to fail cohesively (Figure 26). The other type of adhesion failure was due to a water based primer that didn't properly cure due to low temperature or had emulsified in the presence of water (Figures 25 & 27). Even though membranes originally tested passed adhesion tests before application, a month or two later it failed to adhere.

Standard method for testing for adhesion that we use is similar to ASTM D6862 laboratory test modified for use in the field. A flexible fabric is embedded in HRA and an attempt is made to peel the membrane by 90 degree pull test. Primarily, the qualitative information that we are looking for is adhesion versus cohesion mode of failure, rather than actual peel strength.



Figure 25: This sample exhibits failure in adhesion due to a water based primer that was used in the application that was not curing due to cold temperature.



Figure 26: Interestingly, the failure mode is in cohesion of the concrete, as opposed to adhesion of the membrane. The concrete slab surface had improperly cured and was soft and chalky.



Figure 27: Adhesion failure of cold fluid applied membrane to stainless steel flashing due to lack of proper priming and prep work.

CONCLUSION

Unlike traditional roofs, podium waterproofed assemblies are built to last the life of the building because it is extraordinarily expensive to fix them. Replacing failed waterproofing system can require removal and reconstruction of many exposed structures

such as stairs, free standing walls, planters, topping slab pavers, exercise equipment, trails, driveways, walking paths, etc.

Successful podium waterproofing assembly requires proper drainage, both at the surface level and at the membrane level, proper selection of materials that can handle long term exposure to water and moisture, proper construction and design, and testing of the assemblies.