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Original Article

Flooring Assemblies as Layered Control Systems: Area-Based Mapping of Stone/Porcelain Tile Systems in Wet Enclosures and Exterior Decks

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Abstract *- This paper develops a practical method to specify and coordinate flooring by classifying spaces according to exposure and interface constraints, then assigning a repeatable assembly stack to each class. Using a de-identified multi-zone building program as the working basis, the method distinguishes conditions driven by continuous wetting and vapor, intermittent wetting at room perimeters, rigid stone floors in dry interiors, thin-build threshold conditions, cyclic exterior decks, constant-wetting pool surfaces, wash-down service areas, and built components inside wet enclosures. For each condition, the paper defines the minimum functional layers required for reliable performance and identifies the interface nodes that most strongly govern outcomes (drains, curbs, perimeter returns, openings, and fixed-geometry thresholds). The paper further specifies the minimum content a shop drawing package must carry to make the intent executable, including layout control, seam governance, movement-joint planning, slope/drain definition, and elevation checkpoints. The result is a product-agnostic, teachable specification approach that improves predictability by standardizing assemblies by risk class and enforcing interface closure through documentation.*

Keywords *- Flooring Assemblies, Stone Tile Systems, Waterproofing And Vapor Control, Crack Isolation, Movement Accommodation Joints, Thresholds And Elevation Control, Exterior Deck Drainage, Shop Drawing Requirements, Interface Detailing; Case Study.*

1. Introduction

A lobby floor looks perfect at turnover. Six weeks later, a few tiles sound hollow near the doorway, hairline cracks appear in the grout at a corner, and the transition starts catching shoes. Nothing "wrong" with the tile. The breakdown started earlier, inside the invisible parts of the system, where movement, moisture, and geometry were never given a controlled path. When the assembly does not tell stress where to go, the finish becomes the messenger that gets blamed.

That is the central idea of this paper: a floor is not a finish selection, it is a layered control system [1], [2]. Each layer exists to do a specific job that the finish cannot do by itself, such as flattening the substrate, managing moisture, isolating cracks, accommodating movement, controlling sound, or resolving height at thresholds. When one of those jobs is skipped, substituted, or left undefined, the project does not "save a layer." It simply relocates risk into a failure mode that shows up later as hollow spots, lippage, cracking, tenting, staining, callbacks, and schedule churn [1]. Treating assemblies as controls turns those outcomes from surprises into preventable conditions.

The challenge is that not all areas behave the same. A dry interior zone is governed by flatness, bond, and traffic. A wet bathroom introduces water management and edge terminations. A continuous-use steam space adds vapor drive and higher consequence at seams and penetrations [1]. Exterior terraces add thermal cycling, drainage behavior, and exposure [1]. Thresholds at doors and elevators add geometry and elevation constraints that can defeat an otherwise correct material stack. In practice, projects often reuse a "standard detail" across these zones without explaining why it works in one place and fails in another. That gap is not a material problem. It is a reasoning problem, and it shows up as inconsistent shop drawings, unclear scope boundaries, and field improvisation at the most sensitive interfaces.

This paper addresses that gap with a compact, training-focused framework that is brand-free and intended for both technical and broader audiences. First, it states a small set of engineering rules that explain what changes an assembly, and what should never be assumed. Next, it applies those rules through an area-based assembly map that links each zone to its dominant risks and to the minimum layers needed to control those risks. Finally, it defines the minimum information a flooring shop drawing should show so the assembly intent survives coordination, sequencing, and procurement. The goal is simple: make the "why" visible, so the "what" becomes consistent, buildable, and repeatable.

This paper is presented as a de-identified case study based on a multi-zone stone, tile, and resinous flooring program, using anonymized details to illustrate area-dependent assembly selection and interface control.

2. Engineering Rationale for Area-Dependent Flooring Assemblies

Flooring assemblies are frequently specified as if the finish material is the system [1], [2]. In reality, the finish is

only the visible layer of a multi-layer control stack that must manage several competing physical behaviors: water transport, vapor drive, substrate movement, construction tolerances, and interface geometry. The most persistent field failures occur when the assembly is treated as a static "recipe" and repeated across areas that do not share the same risk class. This section establishes the engineering rationale for why assemblies must change by location, and why those changes are not aesthetic preferences but control necessities.

A primary divider between assembly types is the presence of water as a service condition. Where water can reach the floor surface repeatedly or remain present long enough to seek edges, the assembly must include a deliberate waterproofing boundary [1], [2]. The key concept is not simply "use a membrane," but "define the boundary." Water rarely defeats a floor through dramatic leakage in the open field; it defeats floors through discontinuities at corners, thresholds, penetrations, and terminations, where the system transitions from protected to unprotected conditions. Without a defined boundary, the assembly behaves like an unfinished circuit: a water pathway only needs one weak point to activate secondary damage mechanisms, including loss of bond, swelling at adjacent materials, staining, and chronic rework cycles.

Steam and high-vapor environments introduce a different physics regime and therefore a different assembly priority [1]. In steam conditions, the dominant mechanism is often vapor pressure and diffusion through small defects rather than bulk water migration. This shifts the engineering focus from "drainage and splash management" to "continuity under vapor drive." Assemblies that perform well in ordinary wet bathrooms can become fragile in continuous-use steam exposures because vapor seeks the smallest discontinuity, stresses seams and penetrations, and exploits incompatible interfaces. In such environments, a successful assembly is designed as a vapor-control strategy first, and only then as a waterproofing strategy. The reason is straightforward: bulk water is visible and tends to follow gravity; vapor is invisible and follows gradients, meaning it attacks the assembly in places crews commonly underestimate.

A second divider is substrate movement, which includes both anticipated behavior (shrinkage, thermal strain, structural deflection) and unavoidable uncertainty (future cracking) [1], [17]. The engineering problem is not to guarantee a crack-free substrate; the problem is to prevent substrate behavior from expressing itself as brittle failure in the finish layer. When rigid finishes are installed without a movement-management strategy, stresses accumulate until the system releases them through the least forgiving component: tile edges, grout lines, or the plane change at a restraint. A robust assembly therefore must make an explicit decision about how movement is handled: either by isolating cracks, by uncoupling the finish from substrate behavior, and by providing movement accommodation locations that act as pressure-release paths. If the assembly does not provide a controlled path, the floor will create an uncontrolled one.

Geometry is a third divider, and it is often treated too casually. Rigid finishes do not tolerate local deviations the way resilient finishes can. Flatness is not a cosmetic preference; it is an engineering requirement tied to support uniformity and stress distribution [9], [16]. When the substrate is not brought into plane prior to finish installation, crews are forced to compensate inside the bond layer. That approach tends to create nonuniform thickness, inconsistent coverage, and variable support, which seeds future hollow sounds, localized cracking, and edge loading. A reliable assembly treats plane creation as a system responsibility through an appropriate bedding or leveling strategy, not as an installer "skill problem" solved by extra effort at the point of placement.

Moisture conditions within concrete introduce another non-negotiable constraint because they govern material compatibility and long-term bond stability [5], [6]. Slab moisture is not simply a pre-install test item; it is a lifecycle condition influenced by slab age, environmental control, ground contact, and building operations. Assemblies that ignore moisture behavior frequently fail late, after finishes are installed and schedules have moved on. This produces a predictable pattern: symptoms are discovered at the surface, but the cause originates in an incompatibility between the slab's moisture condition and the selected bonding or underlayment system. The engineering requirement is therefore early: the assembly must be selected for the slab that will exist, not the slab the project hopes for. When moisture is treated as a compatibility constraint rather than an inconvenient detail, the assembly becomes predictable instead of reactive.

Exterior and exposed areas add a compounded set of loads that fundamentally change assembly behavior [1]. Wet-dry cycling, thermal expansion and contraction, ultraviolet exposure, and wind-driven wetting create repeated stress reversals at interfaces. Interior assemblies rely on relatively stable temperatures and controlled environments; exterior assemblies must function under cyclic strain and drainage demand. The practical implication is that exterior floors require drainage-aware logic and robust movement accommodation, and they cannot be treated as interior floors with an exterior finish applied on top. Many exterior failures begin at edges and transitions because those locations concentrate restraint, temperature gradients, and water pathways simultaneously.

Interfaces deserve separate treatment because they are where most "small" issues become project problems. Doors, elevators, wet-to-dry thresholds, and material changes compress multiple requirements into a narrow band: height alignment, edge support, movement accommodation, and sometimes a waterproofing termination [1], [2]. These locations are not accessories to be resolved after finishes are chosen; they are engineering details that must be decided early because they define elevation targets and scope boundaries across trades. A floor can be technically correct in the field and still be experienced as a failure if the interface catches shoes, scrapes doors, traps dirt, or presents an abrupt

elevation change. Interface performance is therefore both structural and human: it must satisfy loads and tolerances while also satisfying use.

Finally, assembly reliability depends on how well intent is communicated. Even a correct design will degrade if drawings do not explicitly communicate boundaries, joint locations, transitions, and elevation targets [1]. In that information gap, the assembly is not "built"; it is inferred. Field inference is not inherently wrong, but it is inconsistent, and inconsistency is the enemy of repeatable performance. Where intent is vague, teams default to habit, which produces a predictable outcome: multiple reasonable assumptions align into one expensive failure mode. For that reason, the engineering objective extends beyond material selection into documentation. The assembly must be legible on paper, so it does not need to be invented at the edge of installation.

In summary, flooring assemblies must vary by area because the governing physics varies by area [1]. Water-dominant zones require explicit waterproofing boundaries. Steam zones require vapor-driven continuity logic. Movement demands intentional strain management rather than optimistic restraint. Rigid finishes demand plane control as a system requirement. Concrete moisture conditions constrain compatibility. Exterior exposure introduces cyclic loads and drainage behavior. Interfaces concentrate tolerances and scope boundaries. Documentation determines whether the intended assembly survives coordination. These principles form the basis for the area-to-assembly mapping presented next, where each space is linked to its dominant risks and to the minimum control layers required to manage them predictably.

3. Area-Based Assembly Mapping and Application Rationale

This section translates the engineering rationale established in Section II into zone-specific assembly descriptions. Each zone is documented using a consistent bottom-to-top layer sequence and a bounded scope per subsection. The intent is to make the minimum required layers explicit for each exposure class so that performance is governed by defined controls rather than by implied practice. Subsection III.A addresses only the steam-shower wet core (floor, wall-to-floor interface, and drain interface). Transition conditions to adjacent zones are intentionally addressed separately to prevent overlap.

3.1. Steam-Shower Wet Core: Floor Build-Up, Wall-to-Floor Interface Continuity, and Linear-Drain Interface

The steam-shower wet core is characterized by continuous wetting and vapor exposure combined with a rigid finish system [1]. Accordingly, the assembly assigns three responsibilities to specific layers: (i) slope geometry is established in the build-up layer, (ii) water/vapor boundary continuity is established in the membrane layer, and (iii) load transfer and finish support are established in the bonding mortar layer [1], [2]. The stone finish is treated as a protected surfacing layer rather than as a functional water barrier.

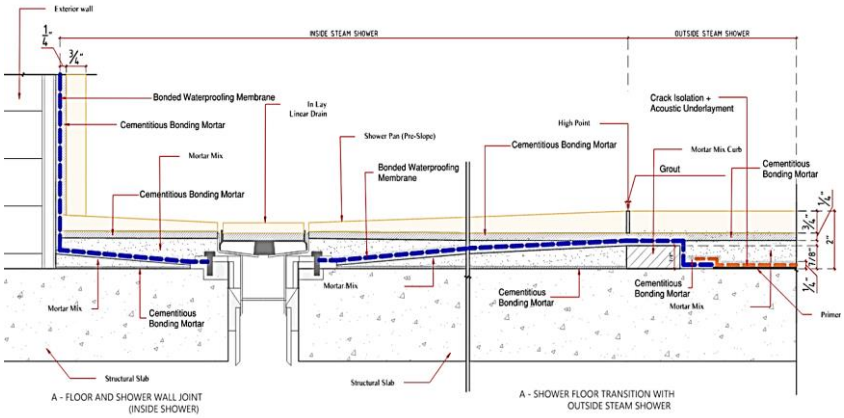

Fig 1: Steam-Shower Floor Section Showing Sloped Mortar Build-Up to A Linear Drain and Continuous Waterproofing at the Wall-To-Floor Interface and Curb Transition

Floor assembly sequence (bottom → top). The build-up begins at the structural slab. Above the slab, a mortar build-up forms a sloped plane that directs flow from the high point toward the linear drain location [1], [2]. Over the sloped mortar surface, a bonded waterproofing membrane is applied continuously across the floor plane and returned up at the wall-to-floor interface to maintain continuity through the change of plane [1], [2]. A cementitious bonding mortar is then used to install the stone finish. The floor finish thickness is indicated as 3/4 in stone, with grouted joints at the exposed surface.

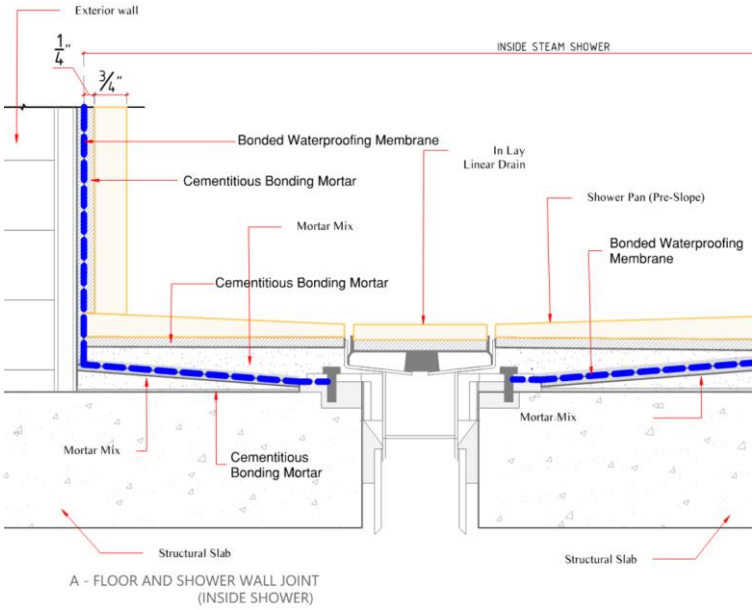

Fig 2: Zoomed Steam-Shower Wet-Core Section Showing Sloped Mortar Build-Up to A Linear Drain and Continuous Bonded Waterproofing at the Wall-To-Floor Interface

Wall-to-Floor Interface Continuity (vertical extension of the wet-core boundary). At the floor-to-wall interface, the waterproofing membrane is shown returning up the wall behind the wall finish, providing a continuous boundary through the most failure-sensitive joint in the assembly [1], [2]. The wall build-up comprises the same functional layers: a bonded waterproofing membrane behind the finish and a cementitious bonding mortar supporting a tile/stone wall finish at the surface (finish thickness as specified for the wall system). In this arrangement, the exposed joint at the wall-to-floor interface functions as a maintainable finish joint, while the waterproofing membrane behind the finish provides the primary boundary continuity.

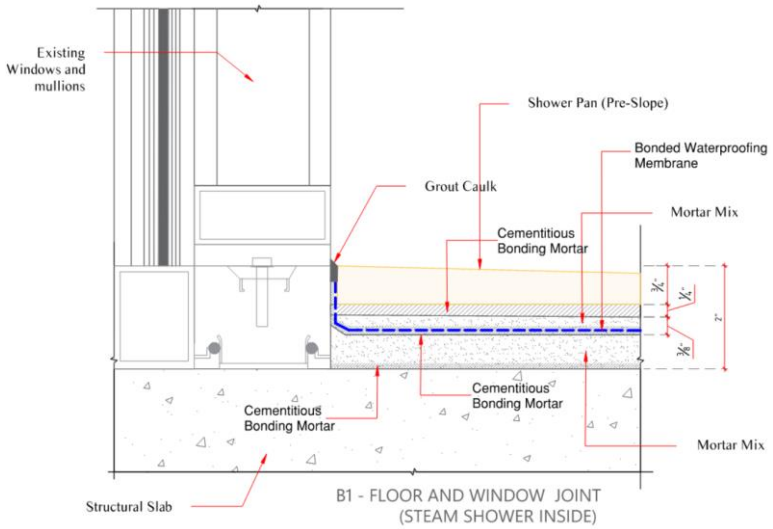

Fig 3: Steam-Shower Interior Window Joint Detail Showing Bonded Waterproofing Return at the Vertical Interface and Sealed Finish Joint at the Perimeter

Linear-drain interface (controlled termination and connection zone). The linear drain is integrated at the low point of the sloped build-up as the intentional collection point for water [1]. The waterproofing membrane is carried to the drain interface so that the boundary does not terminate short of the highest water-concentration location [1], [2]. This detail treats the drain region as a controlled connection zone between geometry (slope) and boundary (membrane), rather than relying on the stone finish or grout to provide waterproofing performance.

In summary, the steam-shower wet-core assembly consists of a sloped mortar build-up over the structural slab, a bonded waterproofing membrane continuous across the floor plane and returned up the wall-to-floor interface, a cementitious bonding mortar, and a 3/4 in stone finish at the floor surface, with a tile/stone wall finish installed over the

waterproofed wall assembly per the wall system specification [1]. This subsection establishes the wet-core baseline only; transitions to adjacent assemblies are addressed separately.

3.2. Wet-to-Dry Transition at the Curb: Boundary Termination and Build-Up Control

The wet-to-dry transition is governed by two simultaneous requirements: (i) the wet-core boundary must terminate without a discontinuity at the curb, and (ii) the outboard floor build-up must maintain a controlled elevation while adopting a different control stack appropriate for the outside-shower field [1], [2]. The detail resolves this by forming a mortar curb, wrapping the wet-core membrane over the curb geometry, and aligning the outboard assembly layers to meet that termination with a defined build-up thickness [1], [2].

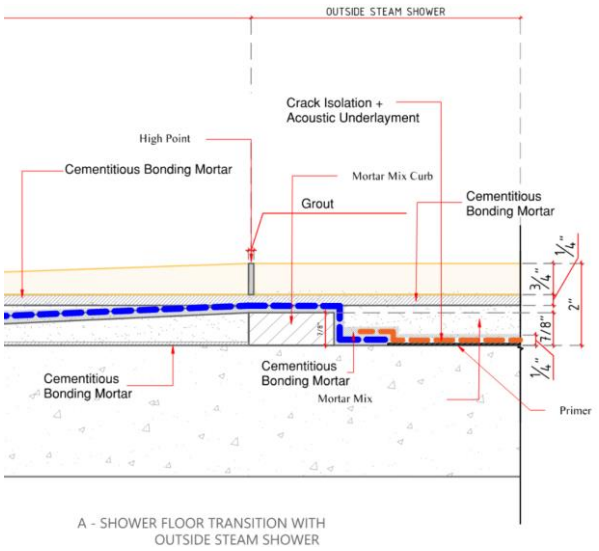

Fig 4: Curb Transition Detail Showing Wet-Core Membrane Wrap and Adjacent Outside-Shower Build-Up With Crack-Isolation/Acoustic Underlayment and Controlled Thickness

At the curb, the assembly introduces a geometric step that separates the wet core from the outside-shower floor. The curb body is formed as a mortar build-up, and the waterproofing layer from the wet core is carried up and over the curb and returned down the outboard side [1], [2]. This "over-and-down" wrap is the termination mechanism: the boundary does not end at the top surface of the curb, and it does not end at a cut edge within the floor plane [1]. Instead, it is continued through the change of plane, so the curb becomes the controlled boundary line between exposure classes. The detail dimensions a vertical curb-related drop/step of 7/8 in at the transition, indicating that the curb geometry is coordinated as part of the assembly build-up rather than being treated as a finish-only feature.

On the outside-shower side of the curb, the floor build-up is shown as a controlled stack over the structural slab that begins with a primer at the slab surface, followed by a sheet membrane providing crack isolation and acoustic underlayment at the floor plane [1], [2]. Above the membrane, a mortar bed/build-up provides elevation and plane control, and a cementitious bonding mortar is used to install the stone finish. The dimension stack at this location indicates an overall build-up of approximately 2 in from slab to finished surface, with the stone finish indicated at 3/4 in, the mortar bed/build-up indicated at 7/8 in, and a remaining allowance at the slab interface (dimensioned at 1/4 in) associated with the bond/primer/membrane zone. These explicit dimensions are the critical point for the transition: they show that elevation control is engineered at the curb, rather than being left to variable mortar thickness during stone placement.

The curb therefore performs two technical functions at once [1]. First, it provides a governed termination geometry for the wet-core boundary by wrapping the waterproofing layer over and down the curb. Second, it provides an elevation-control checkpoint by fixing the outside-shower build-up thickness at the boundary, so the adjacent floor assembly can proceed with predictable plane and finish height.

The next subsection documents the outside-shower bathroom field in full, including the recurring perimeter terminations at walls and recessed base conditions that carry the outboard assembly intent through the remainder of the room.

3.3. Bathroom Floor Outside the Shower: Field Assembly and Perimeter Terminations (Wall Joint, Recessed Base, and Entry Threshold)

The outside-shower bathroom floor is a rigid stone floor system intended for intermittent wetting, routine cleaning, and long-term serviceability at edges [1]. The governing requirement in this zone is not wet-core boundary continuity, but predictable plane and elevation control, managed transfer of minor substrate movement, and maintainable perimeter joints at walls, bases, and openings [1], [2]. The details depict a consistent field build-up carried through multiple perimeter conditions, with localized geometry adjustments (recessed base and entry threshold) used to protect terminations and preserve finish alignment.

Field floor assembly sequence (bottom → top). The build-up begins at the structural slab with a primer applied to the substrate surface. Above the primer, a sheet membrane providing crack isolation and acoustic underlayment is installed continuously across the floor plane and returned vertically at the perimeter (L-shaped return) [1], [2]. Above the membrane, a cementitious mortar build-up establishes the required plane and elevation. A large-and-heavy stone bonding mortar is then used to set the stone finish. The stone finish thickness is dimensioned as 3/4 in, and the total build-up from slab to finished surface is dimensioned at approximately 2 in in the wall-joint detail. A 1/4 in bedding allowance is explicitly dimensioned at the finish interface, with the remaining build-up thickness carried within the mortar layer to satisfy the elevation target.

Perimeter wall joint (outside shower, including mullion/edge condition). At the floor-to-wall interface

adjacent to glazed/mullion geometry, the sheet membrane is depicted turning up behind the wall finish plane, indicating that the assembly treats the perimeter as a controlled termination rather than an exposed edge [1], [2]. The exposed finish joint at the wall line is detailed as a serviceable sealant joint (grout-to-sealant termination) [1]. This is the correct functional division: the sheet membrane provides the underlying control layer at the perimeter, while the exposed joint is maintained as a sealant interface at the surface. This arrangement avoids assigning boundary performance to grout or to a rigid corner condition and reduces the likelihood of edge debonding and staining driven by intermittent moisture and differential movement at the perimeter.

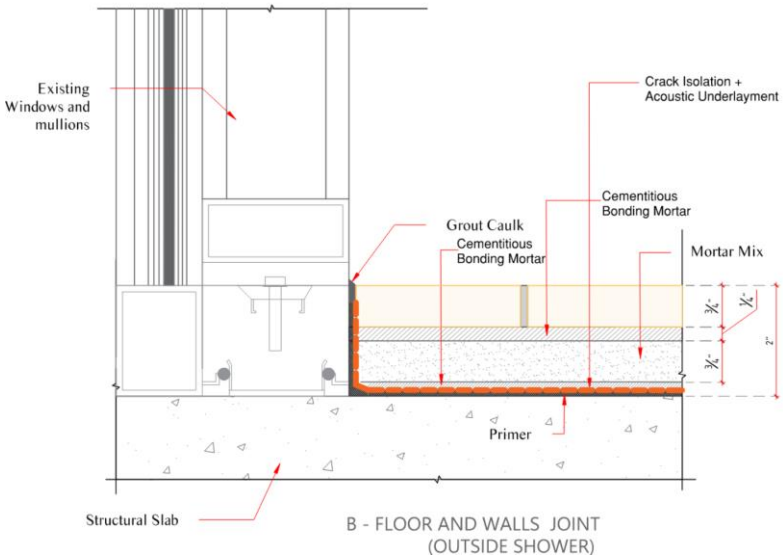

Fig 5: Outside-Shower Floor-To-Wall (Mullion) Interface Showing Membrane Upturn and Maintainable Perimeter Sealant Joint.

Recessed base joint (protected termination geometry). At the recessed base condition, the field build-up remains consistent while the wall/base geometry is modified to create a protected termination zone. The sheet membrane providing crack isolation and acoustic underlayment continues across the floor plane and returns at the perimeter behind the recessed base line, with the stone finish installed over the mortar build-up and bonding mortar [1], [2]. The recessed base pocket and drywall trim provide clearance, so the stone edge is not left as a vulnerable exposed termination. Functionally, this converts a high-impact perimeter into a managed interface: the membrane return remains continuous at the edge, the finish termination is protected within the recess, and the visible joint remains serviceable [1].

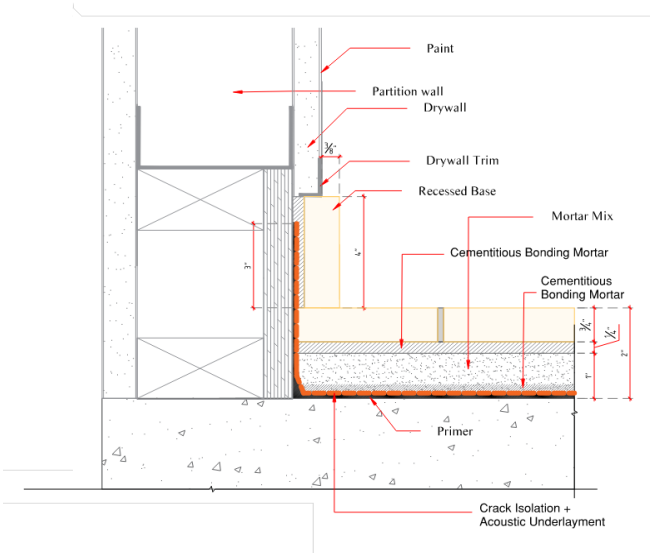

Fig 6: Recessed Base Joint in an Outside-Shower Bathroom Field Showing Membrane Return, Mortar Build-Up, and Protected Perimeter Termination

Entry door threshold within the bathroom floor class. The entry-door detail depicts a localized raised threshold geometry within the same outside-shower floor class. The build-up again begins at the structural slab with primer and a continuous sheet membrane providing crack isolation and acoustic underlayment; the membrane is shown wrapping the threshold geometry (up and over) before continuing across the adjacent plane [1], [2]. Above the membrane, the mortar build-up and bonding mortar support the stone finish. The detail dimensions the overall build-up at 2 in and indicates 3/4 in stone finish thickness, with intermediate thicknesses called out to control the step geometry at the threshold. This threshold condition functions as an elevation-control interface at a high-traffic opening, preventing the doorway from becoming a location where stone build-up, edge support, and jointing are solved through field improvisation.

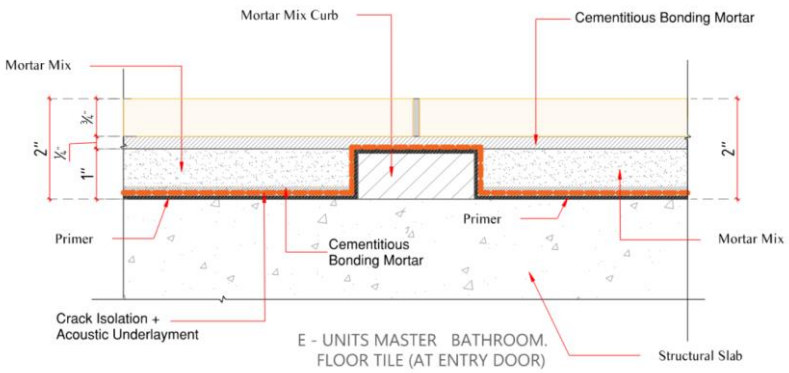

Fig 7: Outside-Shower Entry Threshold Detail Showing Controlled Build-Up Thickness and Continuity of the Isolation Layer across the Threshold Geometry

This subsection establishes the outside-shower bathroom floor as a repeatable field assembly carried through multiple perimeter conditions by consistent layering and deliberate termination geometry [1]. The next subsection extends the mapping to dry interior stone floors, where the assembly remains rigid-finish-based but the exposure class changes, allowing simplification without sacrificing plane and movement control.

3.4. Dry Interior Stone Floors: Repeatable Field Assembly for Plane, Movement, and Acoustic Control

Dry interior stone floors are designed for serviceability and repeatability under a rigid finish, without the boundary-continuity requirements that govern wet cores [1]. In these zones, the controlling risks shift to (i) substrate-driven movement transfer, (ii) impact-sound transmission, and (iii) plane and elevation consistency under large rigid units [10], [12]. The assembly is therefore configured as a field-reliability stack that can be repeated across multiple rooms with the same exposure class.

Field floor assembly sequence (bottom → top). The build-up begins at the structural slab with a primer at the substrate surface. Above the primer, a sheet membrane providing crack isolation and acoustic underlayment is installed as the primary control layer between slab behavior and the rigid finish system [1], [2]. A cementitious mortar build-up (mud bed) is then placed above the membrane to establish plane and to control finished elevation. A cementitious bonding mortar is used to set the stone finish. The section indicates an overall build-up of approximately 2 in from slab to finished surface, with intermediate thickness distribution allocated within the mortar build-up and bedding layers to satisfy the elevation target without forcing thickness correction into the stone-setting step.

This dry-interior assembly is intentionally conservative in one specific way: it assigns distinct responsibilities to distinct layers. The sheet membrane reduces the direct transfer of minor slab movement and dampens impact sound [10], [12]. Where acoustic performance is a governing requirement, impact and airborne isolation should be specified using IIC and STC metrics, with impact testing performed in the laboratory or field and classified per ASTM E492, E1007, and E989, and airborne testing performed in the laboratory or field and rated per ASTM E90, E336, and E413 [10]–[15]. The mortar build-up establishes plane and protects the finish from localized geometric variability, and the bonding mortar is reserved for load transfer and bedding of the stone rather than being used as a leveling medium [9], [16]. As a result, the assembly is repeatable across dry interior rooms with consistent performance expectations and without importing wet-core boundary layers that are unnecessary in this exposure class.

The next subsection extends the mapping to vertical stone interfaces, where wall build-ups and terminations become the governing constraint for floor edges and finish alignment.

3.5. Stone Wall Interfaces: Build-Up Control at Openings and Returns

Stone wall systems introduce a coordination constraint that directly affects floor performance: the floor-to-wall perimeter can only terminate cleanly when the wall build-up is known, stable, and dimensioned [1], [2]. In practice, many perimeter floor issues are not caused by the floor field layers,

but by unresolved interface geometry at door jambs, trims, returns, and edge conditions where stone thickness, bonding mortar thickness, and substrate transitions compress into limited space. This subsection documents a representative stone wall edge condition and extracts the interface controls that must be coordinated with adjacent floor assemblies.

Wall interface assembly sequence (substrate → finish). The section depicts a stone wall finish installed over a bonding mortar layer and supported by a substrate that includes a gypsum board layer (dimensioned as 5/8 in drywall) and a foam/backing component at the opening zone. The stone finish is shown returning at the edge with a mitered connection, indicating that the exposed corner is resolved as a controlled finish geometry rather than a raw termination. At the interior side, the stone finish is installed with a cementitious bonding mortar; at the outside side of the opening, the wall transitions to a framed opening/door interface, where the substrate and trim tolerances become the governing constraint.

Dimensional control at the edge condition. The detail includes explicit build-up dimensions at the stone edge: the stone plus bonding build-up is shown as a layered stack at the return, with dimension callouts in the 1/4 in to 5/8 in range used to control how the stone aligns with adjacent drywall and trim planes. These dimensions matter because they define where the finish plane lands relative to the opening frame and the finished corner. Without this control, the opening becomes a tolerance sink: small variances in mortar thickness and substrate flatness accumulate at the edge, and the "solution" is often field grinding, excessive caulk, or misaligned returns. Each of those outcomes degrades the intended assembly behavior by creating inconsistent edge geometry and unpredictable sealant joints [1].

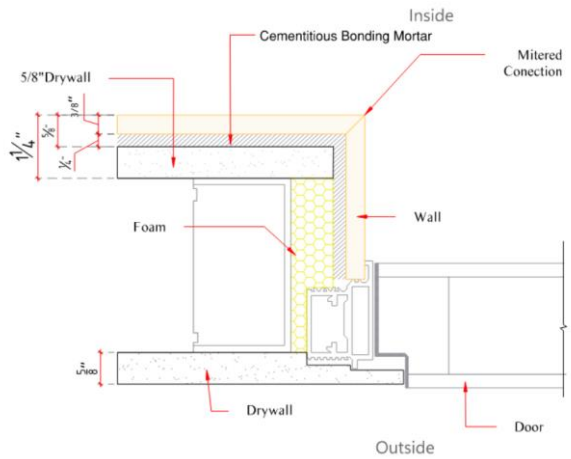

Fig 8: Stone Wall Opening/Return Detail Showing Mitered Edge Condition and Controlled Wall Build-Up at the Door Interface

Interface rationale for floor coordination. This wall condition is included in a flooring paper for one reason: the floor assembly must terminate into a stable boundary [1], [2]. When the wall build-up is not coordinated, the floor perimeter becomes an improvised interface, and improvised interfaces are where rigid finish systems lose their reliability. A stone floor can be correctly assembled in the field and still experience perimeter distress if the wall return thickness forces an uncontrolled joint width, creates restraint at the edge, or eliminates the intended membrane upturn/termination space behind base or trim [1]. Conversely, when the wall build-up is dimensioned and repeatable, the floor perimeter termination can be designed as a controlled joint with predictable geometry, allowing movement accommodation and sealant behavior to function as intended.

In summary, the stone wall edge detail demonstrates that perimeter performance is governed by build-up control, not by finish appearance [1]. The wall return, drywall substrate thickness, and opening interface collectively define whether the adjacent floor system can terminate with a maintainable joint and without unintended restraint. The next subsection continues this interface theme in high-constraint locations, where tolerances and fixed geometry (elevator/door thresholds) further compress the available build-up and amplify the importance of controlled layer allocation.

3.6. High-Constraint Interfaces: Elevator Floor Assembly Under Fixed Geometry and Thin-Build Requirements

Elevator floors represent a high-constraint interface condition in which the allowable build-up is governed by fixed geometry rather than by preferred assembly thickness. Unlike open room floors, the elevator saddle and door system define non-negotiable clearances and finished elevation limits. Consequently, the assembly is intentionally configured as a thin-build system that preserves movement management and bond reliability while remaining within a controlled thickness envelope [1], [2].

Elevator floor assembly sequence (bottom → top). The detail indicates a rigid finish installed over a thin movement-management layer (generic crack-isolation/uncoupling function) placed directly on the elevator floor plate/substrate [1], [2]. Above this layer, the bonding mortar thickness is explicitly limited (a maximum thin-set thickness is indicated in the cut sheet), and the finish is installed as a rigid surface layer aligned to the surrounding metal floor plate and perimeter conditions [2]. This sequence is a deliberate allocation of responsibilities: the isolation layer reduces stress transfer into the rigid finish, while the limited bonding mortar prevents uncontrolled build-up that would violate saddle elevations and door clearances.

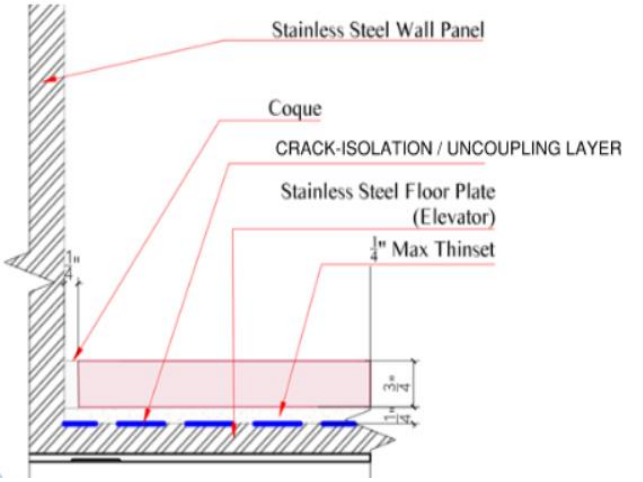

Fig 9: Elevator Threshold Section Showing Thin-Build Rigid Finish over A Crack-Isolation/Uncoupling Layer With A Controlled Maximum Bonding-Mortar Thickness at the Floor Plate Interface

Interface rationale and performance consequence. The elevator condition illustrates why interface detailing must be treated as an engineering problem rather than a finish selection problem. In elevator thresholds, small deviations in build-up thickness or edge geometry produce outsized outcomes: a minor elevation mismatch can create a trip edge; an overbuilt finish can create door interference or scraping; an underbuilt finish can create a recessed condition that collects debris and visually reads as a defect. These outcomes are not merely aesthetic. They affect safety perception, usability, and turnover acceptance, even when the interior field installation is technically competent.

Early coordination requirement. The practical implication is that elevator floor assemblies must be engineered early with explicit thickness limits and edge conditions, because late-stage corrections are structurally constrained [1]. If the thin-build requirement is not defined before installation, the finish layer is often forced to absorb geometry conflicts it cannot resolve with craftsmanship alone. In such cases, the visible finish becomes the "blamed layer," while the true root cause is an ungoverned interface constraint.

This elevator assembly class therefore supports a broader mapping principle: high-constraint thresholds require controlled build-up, explicit thickness governance, and edge-condition discipline [1]. The next subsection extends this interface-driven logic to exterior floor assemblies, where the governing constraints shift from fixed geometry to cyclic exposure, drainage behavior, and termination control.

3.7. Exterior Balconies and Terraces: Drainage, Cyclic Exposure, and Termination Control

Exterior balcony and terrace floors operate under a different governing regime than interior floors [1]. The controlling loads are not limited to occupant traffic and minor substrate movement; they include repeated wetting, drying, and temperature cycling, with direct exposure to wind-driven rain and solar heat gain. In this regime, the assembly must perform as a drainage-aware surface over a protected structural slab. The details indicate an exterior system in which waterproofing continuity, protection/drainage layers, and edge terminations are treated as primary controls, while the tile finish is treated as a sacrificial wearing surface that must not be asked to provide the primary water barrier [1], [2].

Balcony tile finish assembly sequence (bottom → top). The section depicts a structural concrete slab supporting an exterior tile finish installed with a cementitious bonding mortar. A waterproofing layer is indicated beneath the tile assembly as the controlling boundary for the structural slab [1], [2]. The finish layer is a porcelain tile surface with grouted joints at the exposed plane [1], [3]. Although the finish and bonding layers are similar in category to interior tile systems, the design intent differs: the exterior tile finish is not relied upon to stop water; water exclusion is assigned to the waterproofing layer below.

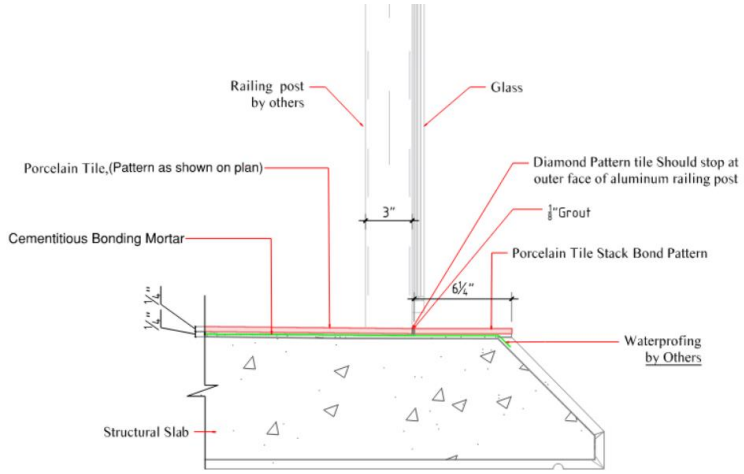

Fig 10: Balcony Edge and Guard-Post Interface Showing Exterior Porcelain Tile Assembly Over A Waterproofing Boundary and Controlled Termination at the Post

Primary waterproofing system with protection and drainage. The waterproofing note indicates a continuous fluid-applied waterproofing system installed on the structural slab and paired with a drainage and protection board placed above the waterproofing layer [1]. This configuration is a critical exterior distinction. In exterior assemblies, water is expected to enter the tile and grout network during service [1]. The drainage/protection layer provides a controlled path for that water to migrate without saturating the slab interface or damaging the membrane, and it protects the membrane from mechanical stress during installation and service. The note also indicates that the waterproofing layer is carried continuously under adjacent concrete curbs and terrace dividers, and it is turned up at adjacent walls to a defined height above the finished surface. These are termination controls: they prevent water that migrates beneath the finish from escaping into adjacent assemblies and they keep the waterproofing boundary continuous through the highest-risk edges [1], [2].

Termination discipline at posts and guard interfaces. The railing/guard post region is a concentrated interface condition where geometric tolerances, water pathways, and finish alignment converge. The balcony tile detail indicates explicit tile stop locations relative to the guard post geometry and defines the jointing condition at that termination. This is not a cosmetic layout decision. It is an interface control. Exterior failures frequently initiate at "small" discontinuities because those locations combine restraint, penetrations, and localized wetting [1]. When the tile termination and waterproofing intent at posts are not explicitly controlled, water migrates toward the path of least resistance and accumulates at the interface where drying is slow, and restraint is high. The detail's emphasis on stop locations and interface jointing reflects a broader requirement: exterior assemblies must treat penetrations and posts as engineered terminations, not as field-fit trim conditions [1].

In summary, the balcony/terrace assembly is governed by a protected-slab concept: the waterproofing boundary is continuous across the structural slab, it is protected and supported by a drainage/protection layer, and it is terminated through turn-ups and continuity under curbs and dividers [1]. The tile finish and grout provide the walking surface and visual plane, but the assembly's long-term performance depends on the continuity and protection of the waterproofing system and on disciplined termination control at edges and posts.

3.8. Pool Decks: Constant-Wetting Exposure and Joint-Critical Performance

Pool decks represent a higher exterior exposure class than typical terraces because the surface is subjected to frequent, long-duration wetting and repeated cleaning cycles [1]. In addition to thermal cycling and wind-driven rain, pool environments sustain moisture at joints and edges, which increases the consequence of small discontinuities at coping lines, corners, penetrations, and terminations. For this reason, pool deck assemblies must be treated as joint-critical systems in which waterproof continuity, robust bonding, and maintainable edge conditions are primary design requirements [1], [2].

Pool deck assembly sequence (genericized, bottom → top). The build-up begins at the structural slab. A bonded waterproofing layer is provided as the controlling boundary for the structural substrate [1], [2]. Above this boundary, a cementitious layer is used to establish plane and, where required, drainage geometry. A polymer-modified bonding mortar is then used to set the stone or tile surfacing units. The exposed joints are completed using a high-performance grout or jointing system suitable for sustained wet service, and sealant is used at designated movement and perimeter joints [1], [2]. Stated by function, the pool deck assembly allocates responsibilities as follows: waterproofing membrane (boundary control) → leveling/slope layer (plane and drainage control) → bonding mortar (load transfer and bedding) → surfacing units (wear layer) → grout/sealant strategy (joint durability and maintainability).

Why pool decks are distinct from general exterior terraces. In many exterior floors, wetting is intermittent, and drying is relatively rapid, allowing minor imperfections to remain dormant for long periods. Pool decks repeatedly activate the joint network because water is present routinely, edges remain wet longer, and cleaning cycles reintroduce moisture into the same perimeter regions [1]. As a result, the assembly must be biased toward durability at joints and edge conditions. The controlling performance question is not whether the surfacing looks correct at installation, but whether the waterproof boundary remains continuous and whether the joint system remains stable under sustained wet service [1], [2].

Edge and coping interfaces as governing details. Pool deck distress commonly initiates at edges because edges combine restraint, geometry transitions, and high-water residence time [1]. Coping, caps, or perimeter bands should therefore be treated as assembly interfaces rather than as finish accessories [1]. A reliable pool deck design provides uniform support at perimeter elements, establishes a maintainable joint condition at transitions, and avoids forcing the surfacing layer to compensate for missing elevation or termination logic [1], [2]. When these edge conditions are not engineered, the surface may still appear acceptable at turnover, but service conditions will concentrate stress and moisture at the perimeter, accelerating joint degradation and localized debonding.

The next subsection transitions to interior wood-floor zones, where the governing constraints change from sustained wet exposure to flatness tolerance and adhesive-driven performance, requiring a different control stack and a different set of interface priorities.

3.9. Wood Flooring Zones: Flatness Control and Adhesive-Driven Performance

Wood flooring zones operate under a different governing mechanism than rigid tile or stone finishes. The primary risks are not brittle cracking or grout distress; they are plane

irregularity, localized deflection under footfall, and adhesive-related performance at the bond line [16]. As a result, the control stack in wood zones prioritizes substrate flatness and adhesive compatibility so that the finished surface behaves uniformly under service loads without developing squeaks, hollow feel, or localized debonding.

Wood flooring assembly sequence (bottom → top). The build-up begins with a subfloor layer per project design thickness. Above the subfloor, a primer is applied to prepare the surface for a leveling operation. A cement-based self-leveling underlayment is then installed to correct plane deviations and provide a uniform substrate suitable for adhesive application [7], [9], [16]. The finished floor is then installed as a glue-down wood flooring system, where the adhesive layer functions as the primary load-transfer interface between the wood planks and the leveled substrate.

This assembly class is intentionally distinct from membrane-dominant rigid-finish stacks. In rigid stone/tile floors, crack isolation and movement accommodation are often emphasized because the finish is brittle and telegraphs substrate behavior. In wood floors, performance is governed more directly by whether the substrate provides continuous support and whether the adhesive bond line is uniform. A leveling layer therefore becomes the principal reliability control: it reduces localized high spots and low spots that would otherwise force the wood planks to bridge gaps, flex under traffic, and progressively degrade the adhesive bond line [9], [16]. The primer and underlayment are not "extra steps"; they are the mechanism that converts an imperfect subfloor into an adhesive-ready plane [4], [18].

Including this zone in the mapping reinforces the central thesis of the paper: assemblies are selected by governing failure modes, not by finish category. A single project may contain both stone and wood floors, but the control stacks should differ because the service behavior and failure sensitivities differ. The next subsection addresses service/commercial wet-area floors, where cleanability, slope-to-drain intent, and monolithic edge conditions become the governing requirements.

3.10. Service and Commercial Wet Areas: Resinous Floors as Wash-Down and Drainage Systems

Service and commercial wet areas, such as kitchens and back-of-house corridors, operate under an exposure class dominated by frequent wash-down, cleaning chemistry, grease residue, and persistent moisture at perimeters and equipment zones. In this environment, the primary performance objective is not a visually seamless finish; it is a maintainable sanitation surface that drains predictably and does not create edge geometries where water and contaminants accumulate. The assembly therefore functions as a cleanability and drainage system rather than as a conventional "finish layer."

Assembly sequence (substrate → finish). The system begins with mechanical substrate preparation to create a bondable concrete surface [18]. Concrete surface preparation by abrasion prior to coating/resin application should conform to ASTM D4259 [19]. A bonded waterproofing layer is then installed as the controlling boundary and returned vertically at perimeter walls, establishing continuity at the most moisture-sensitive interface [1], [2]. A cementitious topping/build-up layer is used to control finished elevation and to form the required slope-to-drain geometry, ensuring that drainage behavior is assigned to the assembly rather than being improvised at the wearing surface [16]. Over this sloped substrate, a resinous floor system is installed as a monolithic wearing layer. The floor is terminated with an integral cove base at wall intersections to eliminate the internal corner condition.

Perimeter interface control (why the cove is functional). In wet service areas, the floor-to-wall intersection is repeatedly activated by cleaning water and residue migration. A sharp 90-degree corner creates a capillary pocket and a residue trap, and it is difficult to clean consistently under operational constraints. An integral cove converts that corner into a continuous return, improving cleanability and reducing water residence time at the perimeter. In system terms, the cove is an interface control: it removes the highest-maintenance geometry and replaces it with a stable, cleanable transition that supports sanitation performance.

Drainage behavior as the governing requirement. Unlike residential interiors, where incidental wetting can be localized, service environments impose repeated saturation and demand rapid drainage recovery. The assembly must therefore treat slope formation as a primary layer responsibility and must maintain a continuous boundary at the slab and perimeter, so water is directed to drains rather than migrating into adjacent finishes or wall bases [1], [2], [16]. When drainage and perimeter continuity are not explicitly engineered, symptoms typically appear as persistent dampness at edges, staining at base conditions, premature deterioration of joints, and recurring slip hazards.

This assembly class is included in the mapping to demonstrate a distinct control regime: where wash-down and sanitation govern, a monolithic resinous wearing surface combined with perimeter boundary continuity, slope-to-drain geometry, and a coved termination provides a more predictable maintenance and drainage outcome than systems that rely on dense joint networks and untreated internal corners.

3.11. Built Elements Inside Wet Enclosures: Preformed Benches as Continuity-Critical Boundary Components

Built benches within steam rooms and other continuously wet enclosures must be treated as part of the waterproofing boundary, not as independent fixtures installed after the enclosure is "complete" [1], [2]. In this assembly class, the bench element is a preformed, high-density foam component with a factory-applied waterproof facing that is ready to receive tile. However, a waterproof-faced bench does not, by itself, make the enclosure waterproof; system performance still depends on continuous boundary tie-in at the bench perimeter, underside, and changes of plane [1].

Assembly and sequencing control (substrate → boundary → finish). The enclosure waterproofing membrane is first installed continuously across the floor plane and extended up adjacent walls and into the bench zone before the bench is placed [1], [2]. The preformed bench is then installed as a rigid substrate element. After placement, the bench is field integrated by applying a waterproofing membrane layer over the bench surfaces and returning it onto the surrounding waterproofed areas, creating a continuous boundary across the bench top, face, returns, and adjacent wall transitions [1]. The finish system is then installed using a cementitious bonding mortar and tile finish, with sealant-treated joints at maintainable interfaces [1], [2].

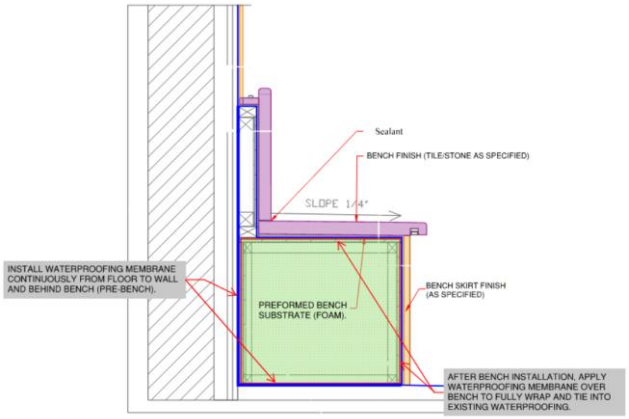

Fig 11: Wet-Enclosure Bench Waterproofing Sequence Showing Pre-Bench Membrane Continuity and Post-Installation Wrap-And-Tie Integration at Bench Interfaces

Why integration is required even with a waterproof-faced bench. The bench introduces additional planes and inside corners where water residence time is higher and drying is slower [1]. The controlling risk is not bulk water passing through the bench core; it is discontinuity at interfaces: seams at the bench-to-wall line, bench-to-floor line, and bench returns can become preferential moisture paths if the boundary is not tied together [1]. The wrap-and-tie sequencing converts these junctions into governed overlaps, so the enclosure behaves as a single continuous system rather than as separate waterproofed surfaces that merely touch [1], [2].

This bench assembly class reinforces the wet-core principle established earlier: in steam exposure, durability is governed by boundary continuity through geometry-intensive built elements, with the finish layer treated as the wear surface rather than the primary water barrier [1].

3.12. Synthesis: Core Implication of the Mapping

The mapping shows that flooring performance is determined by the layer stack selected for each exposure class and by the way that stack terminates at interfaces [1]. Wet cores demand boundary continuity through drains, corners, and built elements; adjacent fields shift to plane, movement, and acoustic control under rigid stone finishes [1], [2]. High-constraint thresholds (elevators and doorways) are governed by fixed geometry and thin-build discipline, while exterior decks are governed by cyclic exposure, drainage behavior, and termination control [1]. The practical implication is that assemblies should be standardized by risk class, not by room name, so the same logic can be reviewed, taught, and repeated without relying on brand-specific language.

4. Minimum Shop Drawing Requirements for Flooring Assemblies

Shop drawings for stone and tile floors function as execution controls. Their purpose is to prevent field-driven redesign by making layout intent, interface closures, and performance boundaries unambiguous [1], [2]. A complete shop drawing package must therefore communicate (i) geometry and pattern, (ii) material and fabrication intent, and (iii) interface and movement controls.

4.1. Drawing Controls and Setup Data

- Scope boundary: define the limits for floor stone/tile, bases, and wall stone, including start/stop lines at all transitions.
- Reference datum: identify the primary control line(s), grid reference, and a stated “starting point” so the layout is reproducible.
- Revision discipline: revision log, clouded changes, and explicit callouts for impacted areas/details.

4.2. Material, Finish, and Piece Schedule

- Material key: each stone/tile type assigned a unique code tied to a schedule.
- Thickness and finish: stone thickness (only where controlled), finish type (polished / honed / leathered / etc.), and any surface treatment limits per area.
- Edge profiles: define edge treatment by condition (eased, chamfer/bevel, pencil, bullnose/half-bullnose, laminated edge, mitered return).
- Corner strategy: identify corner closure method (mitered, returned pieces, trim profile) and where each applies.

4.3. Floor Layout Definition (Pattern Control)

- Pattern type and module: running bond, stack bond, herringbone, diamond, grid, etc., including offset rules and repeat module.
- Directionality: show layout direction arrows where pattern or veining direction matters.
- Termination intent: identify where cuts are permitted to land and where cuts are prohibited (door centers, focal lines, fixture centering rules).

4.4. Fabrication Mapping and Seam Governance

- Piece identification: unique mark for each major piece/panel, including orientation arrows.
- Seam map: seam locations and seam type (butt seam vs joint), with a stated rationale (panel size, access, movement, geometry).
- Oversize rules: where pieces must be fabricated oversize for field scribing, state the oversize side and allowable trim direction.

- Cutouts and penetrations: all openings dimensioned (drains, fixtures, anchors), with clearance rules and edge finish expectations.

4.5. Jointing, Movement, and Perimeter Control

- Grout joint width: joint width by area and any joint alignment rules across rooms.
- Grout category and color: grout type category (cementitious vs epoxy where required), color, and cleaning/protection notes if relevant [1], [2].
- Movement joints: layout of perimeter and field movement joints, including width, location logic, and continuity requirements across the finish [1], [2].
- Sealant joints: identify all change-of-plane and perimeter sealant joints, with joint location, sealant color, and backer/geometry intent [1], [2].

4.6. Wet-Area Boundaries, Slopes, and Drains

- Wet boundary lines: define where wet-rated assemblies begin/end (wet core vs adjacent field), including curb/threshold boundary logic [1], [2].
- Drain plan: drain type and exact location; tile-insert direction rules where applicable [1].
- Slope control: slope arrows, high points, and low points; identify which layer is responsible for slope (build-up vs finish) [1], [2].
- Waterproofing limits: show membrane extents in plan (and in section where needed), including required upturns/returns at walls and curbs [1], [2].

4.7. Elevations, Thresholds, and Interface Closures

- Finish elevations: finished floor elevations at doors, elevator interfaces, curbs, and transitions to other finishes [1].
- Threshold and reducer details: profile type, flush side, ramp side, and edge support requirements.
- Door and frame coordination: clearance confirmation notes and interface detail references (no field guessing at the doorway) [1].
- Base and wall terminations: base heights, returns, recessed base conditions, and closure at mullions/openings.

4.8. Acceptance and Construction Controls

Substrate readiness should include surface preparation and bond verification where required [4], [8], [18].

- Substrate readiness criteria: define the required substrate flatness/plane expectation and the method of verification before installation [9], [16].
- Hold points: list the minimum pre-install confirmations (drain location verified, boundary limits confirmed, elevation checkpoints approved) so the drawing is executable, not merely descriptive.

5. Discussion

5.1. Scope, Assumptions, and Limits

The framework presented in this paper is intentionally practical: it treats flooring as a layered control system and selects assemblies by exposure class and interface constraints. Its scope is therefore strongest where performance is governed by predictable mechanisms that can be assigned to layers, such as boundary continuity in wet enclosures, elevation governance at thresholds, and drainage behavior in exterior conditions [1], [2]. The approach does not replace structural design, substrate evaluation, or code compliance; it assumes that the supporting structure, deflection limits, and base building conditions have been evaluated independently. It also assumes that when thickness values are shown, they are treated as project-specific controls rather than universal prescriptions, since thickness is a coordination variable tied to elevation targets, not a performance guarantee by itself.

5.2. Why Field Failures Persist Despite "Correct Materials"

A recurring industry pattern is that teams select technically acceptable materials but still experience avoidable rework because the assembly's governing boundary conditions were never made executable. The mapping results suggest that the dominant failure driver is often not material selection but interface governance: joints, terminations, and elevation transitions are the locations where multiple trades and tolerances converge into a small geometry [1], [2]. When these interface nodes are not engineered early and carried through shop drawings, the assembly is completed by inference in the field. The consequence is predictable: the finish layer is forced to absorb responsibilities it cannot reliably perform (slope correction, boundary sealing, or elevation conflict resolution), increasing sensitivity to workmanship variability and increasing the probability of localized distress at edges rather than in the field.

5.3. Transferability and a Testable Path Forward

Because the framework is brand-neutral and expressed as layer functions, it can transfer across projects by re-running the same decision logic against a new exposure map and a new set of interface constraints. The primary adaptation step is not rewriting assemblies room-by-room; it is reclassifying zones by governing physics (wet, vapor, cyclic exterior, high-constraint thresholds, sanitation wash-down) and then standardizing a small set of repeatable assembly classes that match those classes [1]. A clear next step for future work is empirical validation using a controlled dataset. Alongside interface nodes, the dataset should record substrate readiness and verification results (surface preparation category, moisture test outcomes, and flatness/levelness checks), since these upstream conditions directly affect assembly performance and rework risk [4]–[6], [9], [16], [18]. The study can then define an 'interface criticality register' (drains, curbs, thresholds, perimeters, penetrations) and measure outcomes such as rework frequency, defect concentration, and closeout cycle time before and after applying the mapping and shop-drawing minimums. This would convert the paper's central claim, that failures concentrate at governable interfaces when boundaries are implicit, into a quantifiable performance result without changing the underlying engineering logic.

6. Conclusion

This paper reframed flooring as a layered control system and demonstrated, through an area-based mapping, why assemblies must change when exposure class and interface constraints change [1], [2]. The resulting method replaces finish-driven selection with a small set of repeatable assembly classes defined by functional layer roles: slope and plane control, boundary continuity in wet and vapor environments, movement and acoustic moderation under rigid stone finishes, thin-build governance at fixed-geometry thresholds, and drainage and termination discipline in exterior and constant-wetting conditions [1], [2]. To ensure the assembly intent survives coordination, the paper also defined minimum shop drawing requirements that make layout, interfaces, movement accommodation, and wet-boundary limits executable rather than implied [1], [2]. The practical outcome is a brand-neutral framework that improves predictability by assigning each performance requirement to a specific layer and by engineering the interface nodes where failures most often initiate [1].

Acknowledgment

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References

[1] Tile Council of North America (TCNA), "2024 TCNA Handbook for Ceramic, Glass, and Stone Tile Installation," ANSI Webstore, 2024. [Online]. Available: https://webstore.ansi.org/standards/tca/2024tcnahandbookceramicglass (accessed: Mar. 03, 2026).

[2] Tile Council of America (TCA/TCNA), "ANSI A108/A118/A136.1:2024-08 American National Specifications for the Installation of Ceramic Tile (Aug. 2024)," ANSI Webstore, 2024. [Online]. Available: https://webstore.ansi.org/standards/tca/ansia108a118a136202408 (accessed: Mar. 03, 2026).

[3] Tile Council of America (TCA/TCNA), "ANSI A137.1:2021 American National Standard Specifications for Ceramic Tile," ANSI Webstore, 2021. [Online]. Available: https://webstore.ansi.org/standards/tca/ansia1372021 (accessed: Mar. 03, 2026).

[4] ASTM International, "ASTM F710-22 Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring," ASTM International, West Conshohocken, PA, USA, 2022. [Online]. Available: https://store.astm.org/f0710-22.html (accessed: Mar. 03, 2026).

[5] ASTM International, "ASTM F2170-19a Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes," ASTM International, West Conshohocken, PA, USA, 2019. [Online]. Available: https://store.astm.org/standards/f2170 (accessed: Mar. 03, 2026).

[6] ASTM International, "ASTM F1869-16a Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride," ASTM International, West Conshohocken, PA, USA, 2022. [Online]. Available: https://store.astm.org/f1869-16a.html (accessed: Mar. 03, 2026).

[7] ASTM International, "ASTM C1708/C1708M-12(2018)e1 Standard Test Methods for Self-leveling Mortars Containing Hydraulic Cements," ASTM International, West Conshohocken, PA, USA, 2018. [Online]. Available: https://store.astm.org/c1708_c1708m-12e01.html (accessed: Mar. 03, 2026).

[8] ASTM International, "ASTM C1583/C1583M-20 Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)," ASTM International, West Conshohocken, PA, USA, 2020. [Online]. Available: https://store.astm.org/c1583_c1583m-20.html (accessed: Mar. 03, 2026).

[9] ASTM International, "ASTM E1155/E1155M-23 Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers," ASTM International, West Conshohocken, PA, USA, 2024. [Online]. Available: https://store.astm.org/e1155_e1155m-23.html (accessed: Mar. 03, 2026).

[10] ASTM International, "ASTM E492-25 Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine," ASTM International, West Conshohocken, PA, USA, 2025. [Online]. Available: https://store.astm.org/e0492-25.html (accessed: Mar. 03, 2026).

[11] ASTM International, "ASTM E1007-25 Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures," ASTM International, West Conshohocken, PA, USA, 2025. [Online]. Available: https://store.astm.org/standards/e1007 (accessed: Mar. 03, 2026).

[12] ASTM International, "ASTM E989-06(2012) Standard Classification for Determination of Impact Insulation Class (IIC)," ASTM International, West Conshohocken, PA, USA, 2012. [Online]. Available: https://store.astm.org/e0989-06r12.html (accessed: Mar. 03, 2026).

[13] ASTM International, "ASTM E90-23 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements," ASTM International, West Conshohocken, PA, USA, 2023. [Online]. Available: https://store.astm.org/e0090-23.html (accessed: Mar. 03, 2026).

[14] ASTM International, "ASTM E336-25a Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings," ASTM International, West Conshohocken, PA, USA, 2025. [Online]. Available:

https://store.astm.org/standards/e336 (accessed: Mar. 03, 2026).

[15] ASTM International, "ASTM E413-22 Classification for Rating Sound Insulation," ASTM International, West Conshohocken, PA, USA, 2022. [Online]. Available: https://store.astm.org/e0413-22.html (accessed: Mar. 03, 2026).

[16] American Concrete Institute (ACI), "ACI 302.1R-15 Guide for Concrete Floor and Slab Construction," ACI, Farmington Hills, MI, USA, 2015. [Online]. Available: https://www.aciwebstore.com/product/ACI-302-1R-15/ (accessed: Mar. 03, 2026).

[17] American Concrete Institute (ACI), "ACI 224.1R-07 Causes, Evaluation and Repair of Cracks in Concrete Structures," ACI, Farmington Hills, MI, USA, 2007. [Online]. Available: https://www.aciwebstore.com/product/ACI-224-1R-07/ (accessed: Mar. 03, 2026).

[18] International Concrete Repair Institute (ICRI), "ICRI 310.2R-2013 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair," ICRI, Des Plaines, IL, USA, 2013. [Online]. Available: https://store.icri.org/item/3102r2013-english-pdf-selecting-concrete-surface-preparation-sealers-coatings-polymer-overlays-concrete-repair-342521 (accessed: Mar. 03, 2026).

[19] ASTM International, "ASTM D4259-24 Standard Practice for Preparation of Concrete by Abrasion Prior to Coating Application," ASTM International, West Conshohocken, PA, USA, 2024. [Online]. Available: https://store.astm.org/d4259-24.html (accessed: Mar. 03, 2026).