

1.0 INTRODUCTION

A natural stone finish is a system comprising no less than substrate, adhesive, stone, grout and movement joints. All components are equally important and intimately related to one another. Adequate compatibility must exist among the components as they could only function collectively. The system could only be as strong as the weakest component, if not worse.

Therefore, material selection, system design, method identification, installation execution and maintenance must take into consideration the performance characteristics of each individual component, and the in-situ environmental conditions that prevail during the installation process as well as the long term usage. These considerations are similar for new technologies and materials in Design for Manufacturing and Assembly such as Prefabricated Prefinished Volumetric Construction (PPVC) and Prefabricated Bathroom Unit (PBU). It is recommended to refer to the respective guides for natural stone installation in these technologies.

Due to the volume constraint, this guide will focus on interior installation and finishes of natural stones.

2.0 DESIGN

To achieve good stone finishes, it is critical to take into account the material selection besides proper installation and quality control. It is important to understand the characteristics of the selected materials as well as their compatibility with one another to achieve optimal performance.

2.1. STONES SELECTION

Natural stones are cut into blocks at the quarry and then transported to a processing plant where they are cut into slabs. Modern tools such as the wire diamond cutter has improved the precision and quality of cutting blocks of stone into slabs. The slabs undergo further processing such as polishing, drying, being further cut into different sizes and dry laying in factory before getting packed for delivery.

Natural stones are formed under varying conditions, hence no two pieces bear the same composition and appearance. Besides geological types, stone names have been greatly compounded from commercial trades and quarry origins, making them very difficult to comprehend. To aid selection, the only characteristics that are relevant to the performance of the stone finishes are discussed here.

2.1.1. Types of Stone

Stones are classified into 3 categories:

- **Sedimentary stone:** Formed from sediments in rivers or glaciers broken off from organic or inorganic elements, accumulated and consolidated to form rock beds. Limestone and sandstone are examples of sedimentary stone.
- **Metamorphic stone:** Originated due to transformation of existing rocks under very high heat, pressure and fluid. Marble and slate are examples of metamorphic stone.
- **Igneous stone:** Formed from volcanic material such as magma which cooled and solidified. Granite and basalt are examples of igneous stone.

2.1.2. Characteristics of Stone

The characteristics of stone are dependent on the way they were geologically formed, as such, each type of stone is unique. Variations of grain and vein formed differ from stone to stone. Some stones show very little variations in colour but may show variations in pattern and grain density while others may show wide variations in colour, vein formations and porosity.

2.1.3. Types of Surface Finishes

Surface finishing is another factor that influences stone selection. Different surface finishes provide different characteristics such as slip resistance, chemical resistance, maintenance, etc. Consequently, the surface appearance of processed stone differs markedly from that of unprocessed surface. The different types of surface finishes and its applications are as follows:

- **Polished:** A shiny glossy surface is achieved by using diamond abrasives grit followed by polishing powder. The surface is very smooth and has a mirror-like effect. Polished stone is not porous and has higher resistance to humidity and chemicals. Typically used for internal floorings.
- **Honed:** Diamond abrasives are used for honed finishes as well. The surface is smooth, non-reflective and is more porous, unlike a polished finish. Typically used at both internal and external areas with less exposure to chemical or moisture.
- **Sandblasted:** A matte textured surface with no gloss as a result of a pressurised flow of sand and water. Typically used for exterior walls.
- **Abrasive:** A flat, non-reflective surface with no gloss. Typically used for areas exposed to weather such as entries, foyers, etc.
- **Exfoliated (Flamed):** A rough and very porous surface that is produced by applying a high temperature flame to the surface of the stone causing crystals to pop. Typically used for external areas where slip resistance is prioritised.
- **Others:** Includes antique, bush hammered, natural cut, etc.

2.1.4. Wet Areas

Wet areas are areas within a building that are exposed to water splashing or direct wetting. Wet areas are commonly installed with discharge outlets and provided with water inlet supply. Installation of stones in wet areas require good design and planning. Due to their natural properties such as porosity and vulnerability to moisture ingress, it is important to seek the supplier's recommendation when selecting stones in wet areas. Marble, Limestone, Quartzite and Slate are some of the suitable choices of natural stones in wet areas.

Fall in wet areas should be laid towards the discharge outlet in accordance to specification and drawings. Insufficient gradient, uneven laying of stones and lippages in wet area may lead to ponding and possibly staining of the stones.

For natural stones that are exposed to weather or outdoor conditions, it is important to follow the recommendation of the designers, manufacturers or suppliers on the suitability of stones, types of adhesive, types of stone sealer, and types of grout (if any) etc. to achieve the optimum performance of these materials.

2.1.5. Slip Resistance

Most natural stones would have good slip resistance under clean and dry condition regardless of their surface finishes. However, when wet and/or contaminated, the slip resistance may deteriorate or drop, especially so if stone is of a polished finish. For safety, the slip resistance class of the selected stone can be established in accordance to SS 485:2011 for testing of dry floor friction.

Mineral or resin polymer floor coating may be applied to improve slip resistance of an existing floor. Resin polymer floor coating dries to a matt sheen and requires 3 days of curing. Mineral floor coating is virtually translucent and the usage is immediate when it dries but has a lower Slip Resistance Value as compared to resin polymer.

2.1.6. Selection Criteria

Prior to starting stonework, it is important to ensure that the selected stones are able to meet the project specifications. Table 2.1.6 provides guidance on the selection criteria.

Table 2.1.6. Stone selection criteria

Stone selection criteria	Requirements
1. Stone condition	<ul style="list-style-type: none"> - Variations in colour, shade, texture and vein patterns are unavoidable. - Inherent variations, geographical location and climate of the country of origin should be taken into consideration when selecting stones.
2. Traffic and load conditions	<ul style="list-style-type: none"> - Appropriate types of stone should be used for light and heavy traffic areas depending on the load conditions. Harder stones are preferred for heavy traffic condition such as loading and unloading areas. - For heavy traffic condition, based surface of stones should be flat to ensure sufficient adhesion and stability.
3. Abrasion resistance	<ul style="list-style-type: none"> - For flooring application, harder stones should be used. - Minimum abrasion resistance for stone floors used in: <ul style="list-style-type: none"> a) Public areas such as lift lobby, stairway and entrance, shopping mall and MRT station shall be 10 ~ 12 in accordance to ASTM C241. b) Residential areas with light foot traffic shall be 8 in accordance to ASTM C241. - To prevent uneven wear, the abrasion resistance shall not differ by more than 5 in accordance to ASTM C241 if different stones are used together.
4. Chemical stability	<ul style="list-style-type: none"> - There shall be no chemically unstable minerals, especially in white stones, that may impair the durability of the stones or cause objectionable staining. - If in doubt, petrographic examination is recommended to be carried out to identify potentially unstable minerals such as mica, pyrite etc. before installation.
5. Slip resistance	<ul style="list-style-type: none"> - For safety reason, the slip resistance classification needs to be established based on usage of the location. Reference can be made to SS 485:2011.
6. Thickness	<ul style="list-style-type: none"> - Stones must be sufficiently thick to resist load due to traffic and impact. The thickness of: <ul style="list-style-type: none"> a) Stone tiles are up to 12mm thick and no greater than 610mm along any dimensions in accordance to EN 12057. b) Stone slabs are greater than 12mm up to 80mm thick and of any dimensions in accordance to EN 12058. - If different thickness of floor and wall stones are used, inconsistent tonality could occur even if it is of the same colour tone. If it is necessary to have the same matching colour for both floor and wall, stones of the same thickness should be used. - Table 2.1.7 describes the dimensional stability of stones.
7. Durability	<ul style="list-style-type: none"> - Stones exposed to high levels of moisture such as in bathrooms, outdoors and floorings shall be evaluated for durability in terms of salt crystallisation damage and efflorescence. - Capillary porosity, saturation coefficient and salt crystallisation tests shall be carried out to ascertain whether the stone is durable. - Even if the stone selected has proven durability, excessive wetting could still cause deterioration.
8. Stone supplied	<ul style="list-style-type: none"> - The supplier should specify the country where the stones are cut, processed and polished. - Stones should be polished in the factory. Stones with chamfered edges are recommended as they tend to minimise the problems of lippage. - However, with chamfered edges, there may still be some degree of jagged edges and slight accumulation of dirt at the joint between stones.

2.1.7. Dimensional Stability

Modern production technology has made it possible to cut natural stones into slices as thin as 8mm to 10mm. These stone veneers can be installed as a pre-finished surfacing material just as easily as ceramic tiles.

However, these thin materials are sensitive to moisture; in essence, water contained in the adhesive may react with these stones and cause them to warp. The supplier should furnish the performance data and provide warranty for these products.

Stone veneers are classified into 3 groups. Table 2.1.7 classifies the stones base on their dimensional stability.

Table 2.1.7. Classifications of stone based on dimensional stability

Group	1	2	3
Warping (under specific condition for 6 hours)	Less than 0.3mm	Between 0.3mm to 0.6mm	More than 0.6mm
Suitable adhesive	Normal setting adhesive	Fast-setting and high gripping adhesive	Reaction-resin adhesive that contain no water

2.1.8. Confirmation of Stones Selection

Where consistent colour tones and patterns are required, it is recommended that the following procedures be carried out to confirm the quality of stones selected:

- A. Mock-up at site
- B. Pre-lay at factory
- C. Dry lay at site

As these procedures are labour intensive with time and cost implications, they should be specified prior to the finalisation of negotiations of price and completion dates.

A. Mock-up at Site

A sample floor or wall selection of a suitable size should be installed, grouted and cleaned using specified materials in a pre-selected location on site, as agreed by all concerned. The mock-up sample should be representative of the approved design and the eventual finished work. It shall be retained as a reference standard throughout the execution of the stonework.

Representatives from all concerned parties (project developer, architect, designer, supplier, contractor and sub-contractor) should be present at the time of installation of the mock-up. They should notify their approval of the completed mock-up in writing prior to commencement of the actual stonework.

The sub-contractor involved should know the exact standard of quality which they are expected to deliver. The contractor should also ensure the client's quality requirements especially on the project's acceptable tolerances are fully understood.

B. Pre-lay at Factory

It is recommended to verify the method and machinery used in the factory to process the stones. Visiting the factory would be the most immediate and efficient way to witness the natural stones' characteristics, patterns of the veins and varying colour tones. Pre-laying should be done in an area with appropriate and adequate lighting. The owner or owner's representative should be given the opportunity to suggest re-adjustments but should also bear in-mind that colour variations and natural veins are intrinsic to natural stones. The stones selected should be marked and packed in appropriate containers. The containers should also be marked to identify the intended location that the stone materials were selected for.



Figure 2.1.8.b. Pre-lay at factory

Note: Natural stones having consistent character and colour tone such as granite, may not require a pre-lay procedure.

C. Dry Lay at Site

Procedure of dry lay at site is similar to pre-lay at factory. The stones selected should be marked in accordance to the intended setting out design, packed in appropriate containers and delivered to the location where they are to be fixed. At the fixing location, stones should be stacked on an appropriate material to prevent any rising dampness that might affect the stones. The stones should be laid in accordance to the dry layout marking.

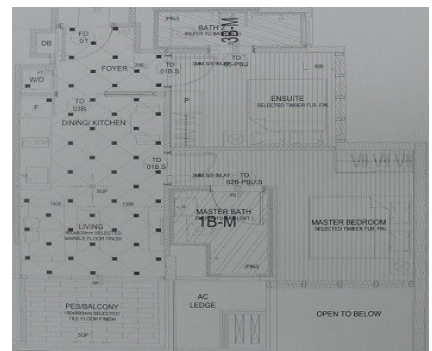
Dry lay in units is the best simulation of installation as the stones are exposed to the actual conditions (such as natural light from windows and balconies) as seen by unit owners. Dry lay at site also offers an additional verification of the factory pre-lay materials. However, the fragility of some natural stones and the possibility of damage due to multiple handling (during dry lay), site condition and space constraints, it is recommended to consult the suppliers on the appropriate option to choose.



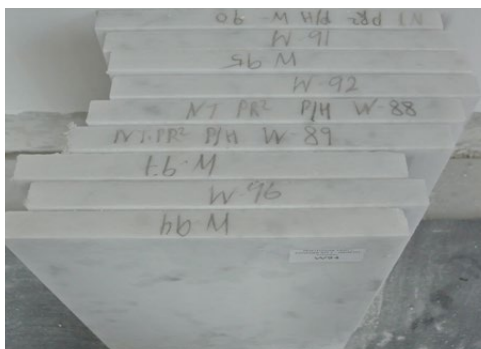
Dry lay at site



Tonality sorted out



Stone to lay in accordance to approved drawing



Stones marked in accordance to dry lay sequence



Stones stacked after dry lay

Figure 2.8.1.c. Dry lay at site

2.2. ADHESIVE

Adhesive or also known as thin-bed mortar, is used to provide cohesion between substrate and stone prior to grouting. To ensure good quality finishes and problem-free installation, it is important to select a compatible adhesive. If in doubt or unsure of the performance of the adhesive, it is a good practice to consult the manufacturer.

2.2.1. Types of Adhesive

Based on EN 12004/12002 and ISO 13007-1, there are primarily 3 types of adhesive:

- Cementitious (Type C): Mixture of hydraulic binding agents, aggregates and additives which is mixed with water or liquid latex admix before use.
- Dispersion (Type D): Mixture of binding agent in the form of polymer dispersion, additives and other mineral fillers which is ready for use.
- Reaction-resin (Type R): Mixture of synthetic resins, mineral fillers and additives in which hardening occurs by chemical reaction.

2.2.2. Classifications of Adhesive

The above types of adhesive can be further divided into the following classes and characteristics:

- Normal adhesive (Class 1)
- Improved adhesive (Class 2)
- Fast-setting with early tensile strength adhesive (F)
- No vertical slip (T)
- Adhesive with extended open time (E)
- Deformable characteristic (S1)
- Highly deformable characteristic (S2)

For cementitious adhesives used in stonework, they are available in single component or two component products.

- 1-component adhesive: Requires only water to be added to a powdered polymer.
- 2-component adhesive: Requires liquid latex additive to be added rather than water.

Both 1-component and 2-component cementitious adhesives are available in normal-setting and fast-setting. For natural stones that are prone to moisture ingress, when using normal-setting cementitious adhesives, 2-component adhesive is preferred over 1-component. Nevertheless, fast-setting adhesive will be most ideal for such stones. Table 2.2.2 shows examples of classifications of adhesive.

Table 2.2.2. Classifications of adhesive

Type of adhesive	Adhesive classes and characteristics	Classified as
a) Adhesive 'X'	Cementitious (C), normal (1)	C1
b) Adhesive 'Y'	Cementitious (C), improved (2), slip resistant (T), with extended open time (E)	C2TE

2.2.3. Adhesive Selection

In selecting an adhesive for stonework, factors such as location of the work (e.g. external or internal of the building), types of substrate (e.g. concrete wall/floor, drywall, etc.) and condition of area (e.g. dry or wet area) should be considered. Although there are established criteria for selecting adhesive for different types of stone, substrate and location, it is a good practice to consult the manufacturer for technical support on the product selected. Table 2.2.3 provides a quick guide on the selection of adhesive.

Table 2.2.3. Selection of adhesive

Type of stone	Location	Substrate	Recommended type of adhesive based on EN 12004/12002 & ISO 13007-1
Natural Stones (less-absorbent)	Internal / External (Wall & Floor)	Concrete / Cement Render / Screed	C2TE
Natural Stones (porous, moisture sensitive and staining)	Internal (Wall & Floor)	Concrete / Cement Render / Screed	C2 F/S1 2-component
Natural Stones with size 600mm x 600mm or more	Internal (Wall & Floor)	Concrete / Cement Render / Screed	C2 FTE/S1
		Deformable substrates e.g. drywall	C2 FTE/S2

2.3. GROUT

Grout is used to fill up the space between stones. Selecting the right type of grout is as important as selecting the right stone and adhesive. Grout should be of suitable fineness and consistency. These would allow the grout to fill the designed joint width successfully.

Adequate grout joint is important as it accommodates for slight sizing difference from one stone to another and prevent them from cracking or 'popping-up' due to incompatibility. It also helps to minimise the appearance of inconsistencies in the stones. The grout joint width may vary depending on the type of stone used. The grout joint width should be in accordance to the supplier's recommendation or BS 5383-3 in the interest of achieving optimum grout performance.

2.3.1. Classifications of Grout

There are 2 types and classifications of grout in accordance to EN 13888 and ISO 13007-3:

- Cement-based grout (CG) : available in Sanded Grout or Non-sanded Grout
 - ❖ Normal Performance (CG1)
 - ❖ Improved Performance (CG2)
- Epoxy-based grout (RG)

Grout is visible and can be water-resistant. However, in most Portland cement based grouts, water or other liquids can still be absorbed into the joints due to its capillary pores. Table 2.3.1 describes different types of grout and applications.

Table 2.3.1. Different types of grout and applications

Type of grout	Descriptions	Applications
Cement grout (CG) – Sanded	Consists of fine graded aggregates, Portland cement, synthetic resins and coloured pigments added with water retentive additive. The water retentive additive allows the grout to stay moist until the cement cured.	<ul style="list-style-type: none"> - Used for larger grout joints (3mm or larger) - Excellent alternative for natural stones and heavier tiles
Cement grout (CG) – Non-sanded	Consists of very fine filler, synthetic resins, coloured pigment and water retentive additive. The water retentive additive allows the grout to stay moist until the cement cured.	<ul style="list-style-type: none"> - Used for smaller grout joints (3mm or smaller) - Easier to apply on dry or vertical surfaces
Epoxy grout (RG)	Consists epoxy resin, silica fillers, pigments and a hardener. Epoxy grout is waterless mix formed by mixing a base material (part A) and a hardener (part B).	<ul style="list-style-type: none"> - Ideal for porous and moisture sensitive stones - Have very low water absorption, higher compressive strength, are resistant to staining and easy to maintain

2.3.2. Grout Performance Criteria

Table 2.3.2.a. Guide on grout performance for CG based on EN 13888 and ISO 13007-3

Fundamental characteristics	Requirement
1. Abrasion resistance	$\leq 2000 \text{ mm}^3$
2. Flexural strength	$\geq 2.5 \text{ N/mm}^2$
3. Compressive strength	$\geq 15 \text{ N/mm}^2$
4. Shrinkage	$\leq 3 \text{ mm/m}$
5. Water absorption after 30 minutes	$\leq 5 \text{ g}$
6. Water absorption after 240 minutes	$\leq 10 \text{ g}$
Additional characteristics	Requirement
7. High abrasion resistance	$\leq 1000 \text{ mm}^3$
8. Water absorption after 30 minutes	$\leq 2 \text{ g}$
9. Water absorption after 240 minutes	$\leq 5 \text{ g}$

Table 2.3.2.b. Guide on grout performance for RG based on EN 13888 and ISO 13007-3

Grout performance	Requirements
1. Abrasion resistance	$\leq 250 \text{ mm}^3$
2. Flexural strength	$\geq 30 \text{ N/mm}^2$
3. Compressive strength	$\geq 45 \text{ N/mm}^2$
4. Shrinkage	$\leq 1.5 \text{ mm/m}$
5. Water absorption after 240 minutes	$\leq 0.1 \text{ g}$

2.4. IMPREGNATORS

The environment where natural stones are installed usually determines the likelihood of staining or discolouring the stones' surface. To prevent stones from surface stains or discolouration, application of a compatible impregnator should be considered. The compatibility may vary from stone to stone, depending on the stone's characteristics.

The main purpose of an impregnator is to block contaminants from seeping into the stones and staining them. Impregnator seals the stones from the inside by penetrating into the stones and chemically interacting through the pores. This process then forms a resistant barrier on the pores surface thus protecting the surfaces from staining and preventing liquids from penetrating through the pores.

Impregnator can be applied on 5 sides (top and 4 sides) or 6 sides of the stone. Moisture ingress from the substrate and occurrence of stains may be a concern for 5-sided applications. In cases where 6-sided applications are requested, precautionary measures should be taken. Applying impregnator on the bottom side of stones may interfere with the bonding performance of adhesive. A 'pull-off' test should be carried out to verify the bonding strength of the stone with the adhesive, or seek recommendations from the adhesive manufacturers.

Impregnators can be either solvent-based or water-based. Solvent-based impregnators penetrate quickly, reaching deep into stones. However, they are not environmentally friendly due to the volatile organic compounds (VOC) contents and they produce a strong smell. On the other hand, water-based impregnators are more environmentally friendly and have little or no smell.

Nevertheless, it is always recommended to seek manufacturer's advice on the selection of impregnators that are compatible to the types of stone used and areas of installation (indoor and outdoor).

2.5. MOVEMENT JOINTS

Movement joints are provided to accommodate movement in large continuous finished areas, or between adjacent building components (e.g. brick wall and concrete column) and dissimilar substrates. It is the responsibility of the designers to identify the various possible movements. These can be:

- in-situ joints which are formed during construction or sawn cut afterwards, filled with filler board and backer rod, and sealed with a suitable sealant or
- prefabricated movement joints which are installed prior to the laying of stones

The backer-rod material in the joint should be compatible with the sealant used. It should be flexible, compressible without forcing sealant.

All movement joints need to be filled with a sealant. The sealant should be capable of accommodating the anticipated amount of movement without loss of adhesion to the sides of the joints and be able to withstand the normal service conditions affecting the installation, e.g. resistance to water and, where applicable, ultraviolet light. If in doubt or unsure of the performance of the sealant, it is a good practice to consult the manufacturers.

Due to tendency of staining, oil-based organic sealant should not be used in natural stone finishing works. The same goes to asphalt-coated materials sometimes used as joint backers.

Locations and details of the movement joints should be specified and shown in drawings in consultation with the supplier/manufacturer. For more details, refer to SS 68, Code of Practice for ceramic wall and floor tiling. Table 2.5 shows the locations of movement joints and their appropriate joint widths.

Table 2.5. Location of movement joints and their appropriate joint widths

Location of joints	Minimum joint width
1. Structural movement joints should be carried through screed/render, adhesives and stone layer. If the joints in the base structure are not straight and parallel, or if their layout does not coincide with that of the stone tiles, guidance should be sought from the designer.	- Not less than the existing structural joint widths
2. Where stone work abuts restraining surfaces, such as columns, beams, perimeter walls, curbs, pipes and ceiling.	- 5mm for interior - 12mm for exterior
3. At junctions where the substrate changes alignments, such as concave wall corners, or where the substrate changes materials, such as between conventional clay bricks and aerated precision blocks.	
4. To divide continuous stone finish on large floors and walls into bays of 50m ² for interior and 25m ² for exterior, with the bay lengths not more than twice as long as the corresponding widths.	- 3mm ~ 5mm for interior - 10mm ~ 12mm for exterior

2.6. ADJOINING LOCATIONS / TRADES

Design at adjoining locations or trades i.e. bedrooms and toilets, timber and natural stone floorings is a challenge. Planning for a smooth interface joint involves the understanding of use of the area, sequence of works, matching the finished level of the adjoining flooring or wall and selecting the appropriate interface material. Inadequate consideration may have an adverse impact on the quality of the finishing. Some designers may select joint grout to seal such joint whereas others may introduce metallic strip, capping or sealant as an alternative to achieve a neat joint and to prevent staining of the stone from adjacent material. Figure 2.6 shows examples of adjoining locations and trades.



Joint with metallic strip



Joint with laminate or timber capping



Threshold to reduce water ingress



Window frame flush with wall finish surface



Joint at door frame covered with sealant



Timber skirting – less joints and no wet work



Joint at floor trap covered with grout

Figure 2.6. Adjoining locations and trades

2.7. ANCHORAGE SYSTEM

When anchoring stones with mechanical anchors, the types of anchorage system are dependent on the following factors:

- shape, weight and dimensions of the stone
- height and location to be anchored
- substrate conditions including that of the structure to which the stone is anchored and on the design and material out of which the anchors are manufactured to any case, corruptions due to oxidation or bimetallic reaction shall be taken into consideration for all anchors dowels, pins and supporting angles

As a guide, at least 4 anchors shall be used to install a stone piece of up to 1m² of facial area, and 2 more shall be added for every additional 0.75m² on the same piece. For more specific details and designs, refer to BS 8298 Code of Practice for design and installation of natural stone cladding and lining.

2.8. WATERPROOFING

With regard to natural stone finishes, waterproofing refers to the normal protection of the stones from damages due to both rising dampness and direct contact with water, such as in a shower compartment.

2.8.1. Rising Dampness

Continuous rising dampness due to capillary action should be prevented by a proper vapour barrier in the form of polyethylene sheet below floor slab and/or of any damp-proof-course in wall.

2.8.2. Direct Contact with Water

A stone finish, even when its joints are filled with impervious grout, cannot stop water from passing through. In wet areas, a waterproofing membranes should always be installed to prevent water penetrating to the neighbouring areas and below. The water trapped between the waterproof membrane and the stone layer can only evaporate by passing through the stone layer. Depending on the stone type, the evaporation may sometimes lead to efflorescence and watermark on the stone face. To prevent watermarking and staining, a water-repelling impregnator may be applied to the visible face of porous stones.

For more details on waterproofing in wet areas, refer to Good Industry Practices Guide – Waterproofing for Internal Wet Area, CONQUAS® Enhancement Series.

2.8.3. Mixing-Water Transmissions

Mixing water used in construction may take time to evaporate especially in cast-in-situ concrete members. Stone installation should commence at least 28 days after curing of these members to prevent unnecessary moisture transmission through the stone finishes.

Part of the mixing water in cementitious adhesives will unavoidably evaporate through the stone finishes. This is a potential cause of failure for thin and moisture sensitive stones. In relation to this, resin-based or fast-setting cement-based adhesives should be used.

Some specifications call for sealing the back face of stones in order to prevent watermark and efflorescence. However, caution should be taken as the sealer might prevent the adhesives from adhering to the stones. It is a good practice to seek the recommendations of the sealer manufacturer to ensure that the performance of the stone finish is not compromised.