WATERPROOFING FOR INTERNAL WET AREAS

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FOREWORD

The Building and Construction Authority's (BCA) Construction Quality Assessment System (CONQUAS 21) has been widely adopted as the de facto national yardstick for measuring the quality of building projects. Besides setting standards and assessing the level of workmanship through CONQUAS 21, BCA is developing a series of publications called CONQUAS 21 Good Industry Practices Guides to share with the industry good work practices adopted by practitioners and contractors who consistently deliver high quality work.

This "Good Industry Practices – Waterproofing for Internal Wet Areas" is part of the CONQUAS 21 Enhancement Series on Good Industry Practices. Waterproofing of internal wet areas is one of the more common and problematic areas in building work. This guide provides simple and practical tips to assist designers in designing internal wet areas waterproofing and contractors in achieving high quality workmanship.

In this second edition, the guide has been revised to include additional good practices. More photographs, graphical representations and tables are also added for easier reference and better understanding of the practices.

It must, however, be pointed out that this guide only serves to illustrate some of the good practices designers and contractors have adopted while designing and installing waterproofing for internal wet areas. This guide is not meant to be a text book on how waterproofing for internal wet areas must be designed and installed. We gratefully acknowledge the contributions of these practitioners and trust that the industry will find this publication useful in its pursuit of quality excellence.

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ACKNOWLEDGEMENT

"Good Industry Practices –Waterproofing for Internal Wet Areas" was first published in year 2001, with inputs from architects, main contractors, waterproofing suppliers/installers and members from the various construction industry professional associations, including the Real Estate Developers' Association of Singapore (REDAS), Singapore Institute of Architects (SIA), Institution of Engineers, Singapore (IES) and Singapore Contractors Association Ltd (SCAL).

A Technical Committee for Good Industry Practices – Waterproofing for Internal Wet Areas was then formed to endorse the good practices identified. We wish to again express our gratitude to the Members and Chin Leong Corporation Pte Ltd for their contributions.

Technical Committee for Good Industry Practices – Waterproofing for Internal Wet Areas

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1. INTRODUCTION

A survey conducted by BCA on private residential buildings that were less than 5 years old indicated that most incidents of water leakage occurred at the floors and internal walls of toilets and kitchens. In Singapore where high rise residential estates are common, the problem of leakage at ceilings and floors is further compounded when the leak comes from the unit above.

In enhancing the watertightness performance of the internal wet areas of buildings, it is important to look at how the structure and the waterproofing membrane are detailed. This publication is a good practice guide that includes among others, sections on design, selection of material and installation. It is intended to complement the current Singapore Code of Practice, CP 82: 1999 titled "Waterproofing of Reinforced Concrete Buildings".

2. DESIGN

2.1 GENERAL

The Designer should refer to applicable local and international codes, standards and specifications when designing wet areas to be watertight.

The drawings and specifications should be prepared in sufficient detail by the Designer to provide proper guidance to the Waterproofing Specialist and other trades involved in the execution of work in wet areas. It is also important to ensure the compatibility and bonding performance of the membrane to substrate.

The structural, architectural and M&E drawings affecting the wet areas should be reviewed together for reliability of the waterproofing system and to ensure consistency in dimensions (eg, final thickness of the floors, M&E configurations, etc). There should also be a good level of awareness and understanding of the structural system being used (eg, precast hollow core slab system, cast in-situ RC system, etc).

2.2 PREFABRICATED BATHROOM UNITS (PBUs)

In recent years, both HDB and private developers have increasingly used PBUs. The feedback from homeowners has been encouraging. Some of the advantages of the prefabricated system over the conventional toilet/ bathroom are:

- The various trades involved in the wet area (tiler, plumber, electrician and waterproofing applicator) are made the responsibility of one party, reducing chances of errors due to lack of coordination.
- Better control of the materials and prefabrication process in the factory, resulting in higher quality finishes and lower wastage of materials.
- Piping and electrical cables are run in the space between unit bath's shell and the building structure, eliminating the need to chase the walls/ slabs or embed the services.
- The entire toilet unit can be produced in the factory without affecting site operations, thereby shortening the construction cycle and construction period.

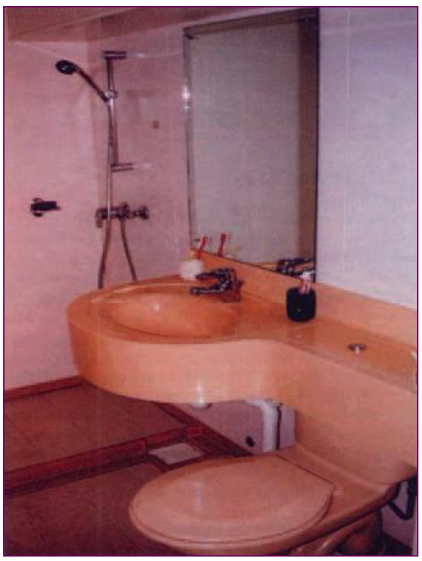

Figure 2.1: Interior of a prefabricated bathroom

1. INTRODUCTION

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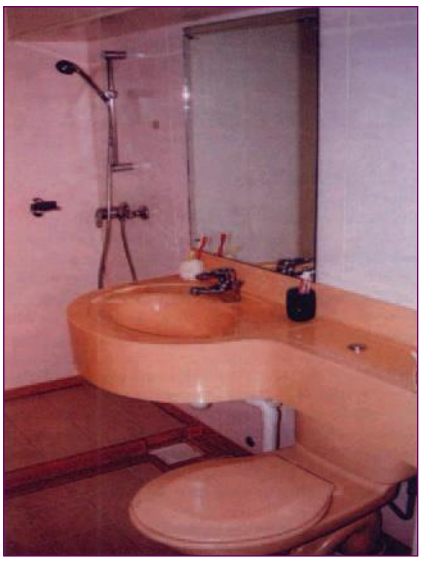


Figure 2.1: Interior of a prefabricated bathroom

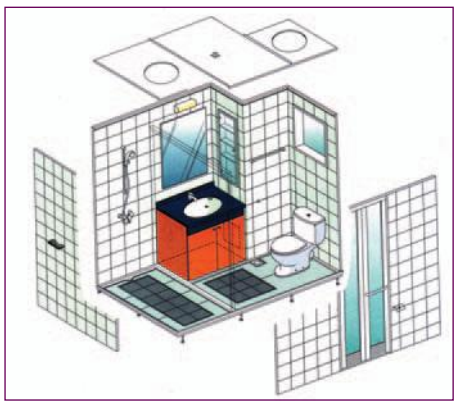


Figure 2.2: Different components of a prefabricated bathroom

These benefits translate into substantial cost savings, a consistently high quality product and simpler quality control process. To reap the full benefits of PBUs, its use should be considered at the early design stage. PBUs can be either precast concrete or prefabricated lightweight cells with finished walls and floor pre-assembled in the factory or assembled on site. More details on PBUs in Singapore can be found in BCA's publication titled "Reference Guide on Standard Prefabricated Building Components".

Figure 2.3: Pre-assembled PBUs

Figure 2.4: Prefabricated finished walls separately lifted and assembled on site

2.3 SUBSTRATE

2.3.1 Floor

In general, the use of high quality dense concrete and addition of admixtures in concrete help to enhance the watertightness performance of the substrate. The waterproofing system in a typical wet area consists of the following:

- Concrete slab
- Waterproofing membrane
- Screed
- Tile finish / others

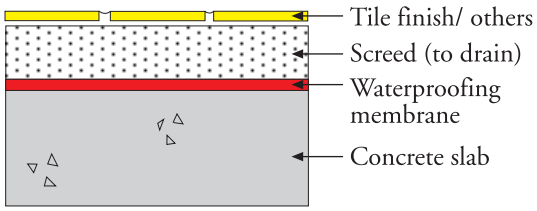


Figure 2.5: Typical floor slab with waterproofing membrane and finishes

An adequate drop during concrete casting is required to ensure that the finished level of the wet area is sufficiently lower than the level of adjacent concrete slab to prevent migration of water into the dry area. If pipes are encased in screed, the drop required should take into account the minimum screed thickness of 20mm required at the lowest level, i.e., at the floor water outlet. For wet area adjoining to dry area, the membrane should extend 150mm from the wet area into the concrete slab in adjoining dry area (see Fig 2.6).

Alternatively, concrete kerbs (see Fig 2.7) may be used to prevent migration of moisture into dry areas. It is a good practice to cast the kerb monolithically with the concrete slab to prevent debonding of the kerb.

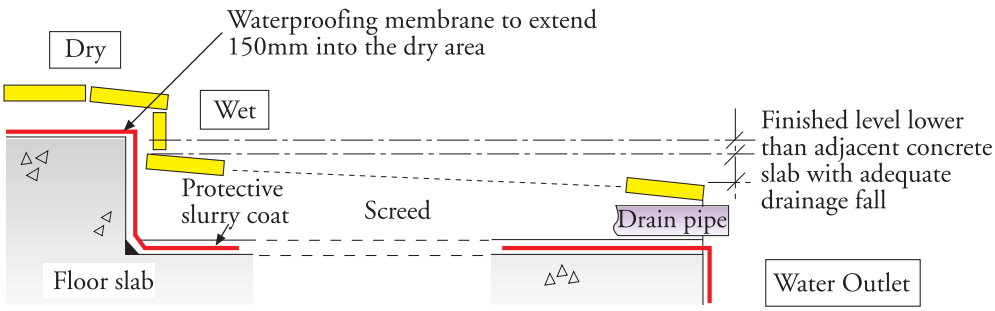


Figure 2.6: Adequate drop in floor slab

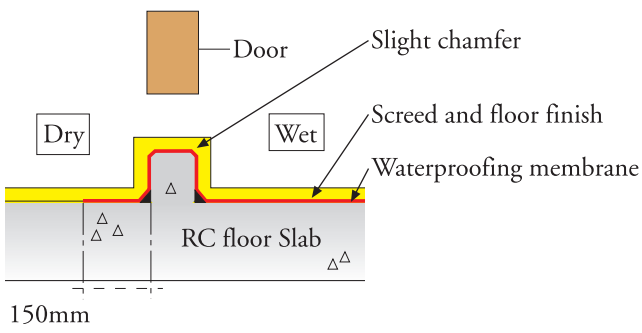


Figure 2.7: Kerb between wet and dry area

2.3.2 Wall

Joints at walls of wet areas, for example, brickwall to reinforced concrete columns should be minimized. Where joints are unavoidable, the designer should consider specifying reinforcement at these areas (refer to Fig 2.8).

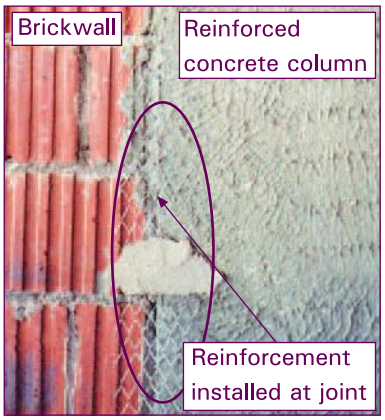


Figure 2.8: Reinforcement installed at brick-RC joint

The designer should also consider rendering walls to a minimum height of 300mm from floor level, for a smooth finish to receive the waterproofing membrane upturn (refer to Fig 2.9). Shower/ bath areas and other parts of the wall that require membrane application should also be rendered to the height and width specified. The designer may choose to add a waterproofing agent to the render to improve its waterproofing performance.

In accordance to CP 82, kerbs should be constructed at the base of walls to act as barriers to lateral movement of water (refer to Fig 2.9). A height of 100mm for the kerbs should be sufficient for this purpose.

For wet areas with a high amount of water splash, the waterproofing membrane should turn up to a minimum height of 300mm. This will create a minimum tanking protection against migration of water to spaces adjacent or below the wet area. Note that at the upturn areas, the membrane should extend minimum 100mm horizontally from the wall-floor joint to create sufficient lapping with the subsequent membrane application (see Fig 2.9). Depending on the designer's specifications, reinforcement such as fiberglass mat may be used at the wall-floor joint.

At bath and shower areas, ensure that the waterproofing membrane is applied to at least 1800mm height and 1500mm width of the wall (see Fig 2.10 and 2.11), or the entire width of the enclosure (see Fig 2.12). The wall or substrate immediately adjacent or behind a basin, sink or similar fixture must be applied with membrane to a height of not less than 300mm above the fixture if it is within 75mm of the wall (see Fig 2.11).

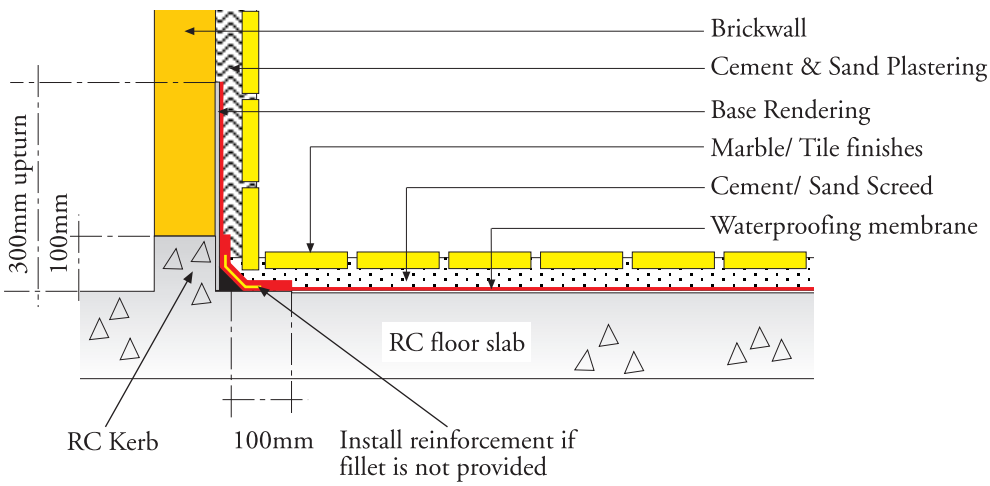


Figure 2.9: Typical details on waterproofing upturn at walls

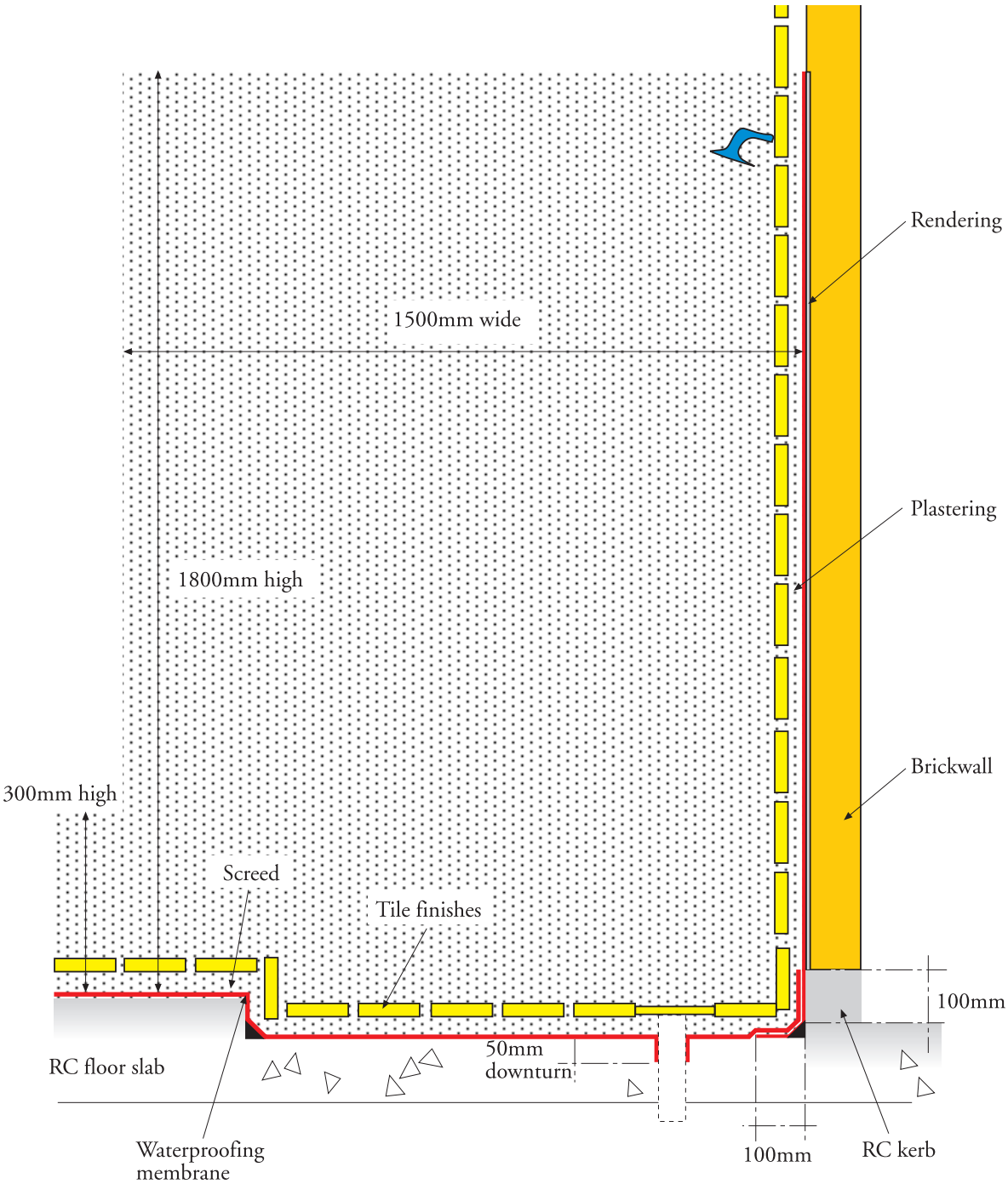


Figure 2.10: Typical waterproofing details at shower area

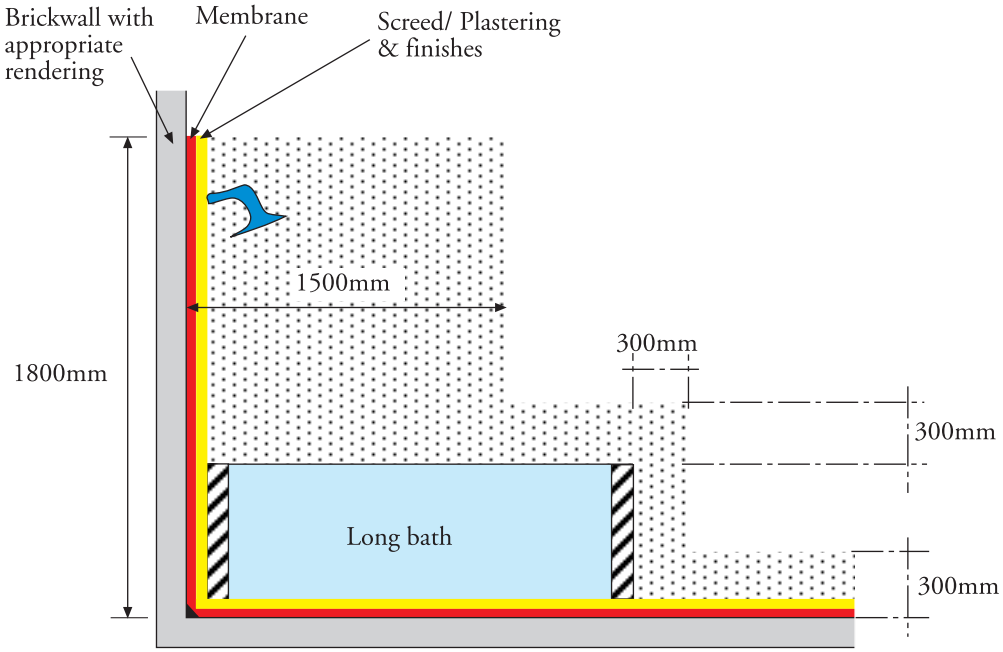


Figure 2.11a: Typical waterproofing details at long bath area

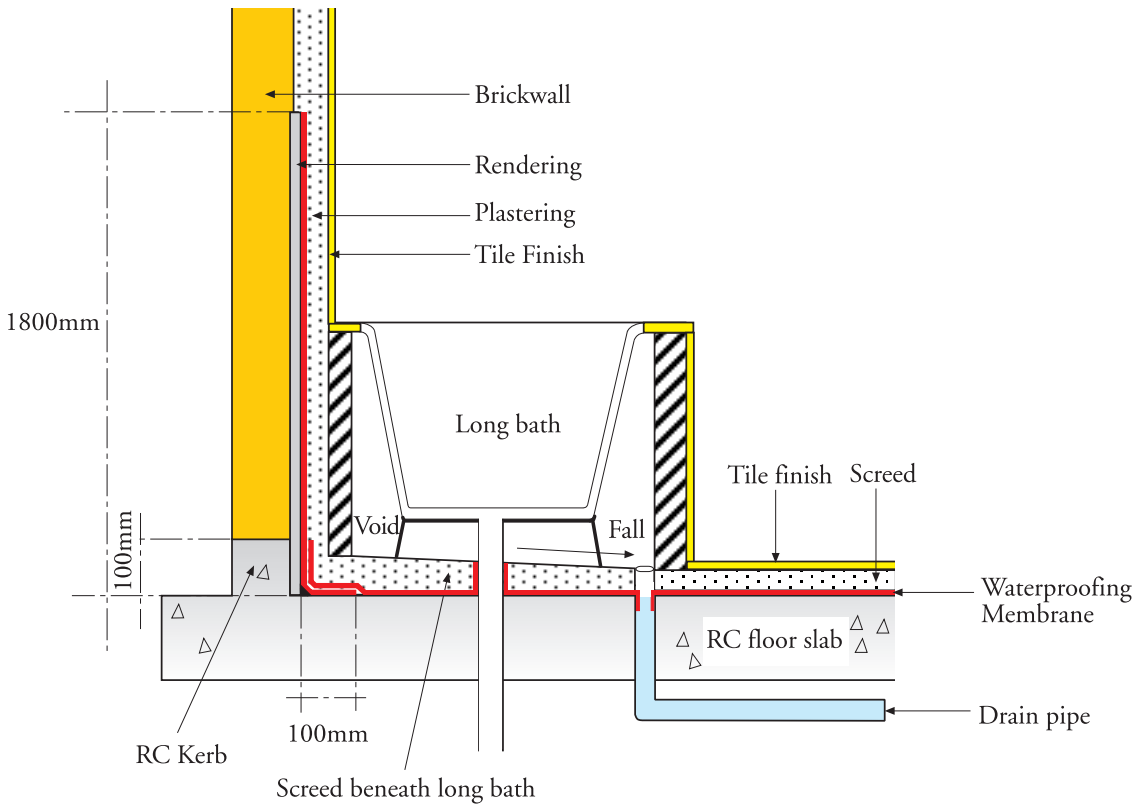


Figure 2.11b: Detailed cross-section at long bath area

At sunken bath area, the membrane should similarly be applied to a minimum height of 1800mm (see Fig 2.12).

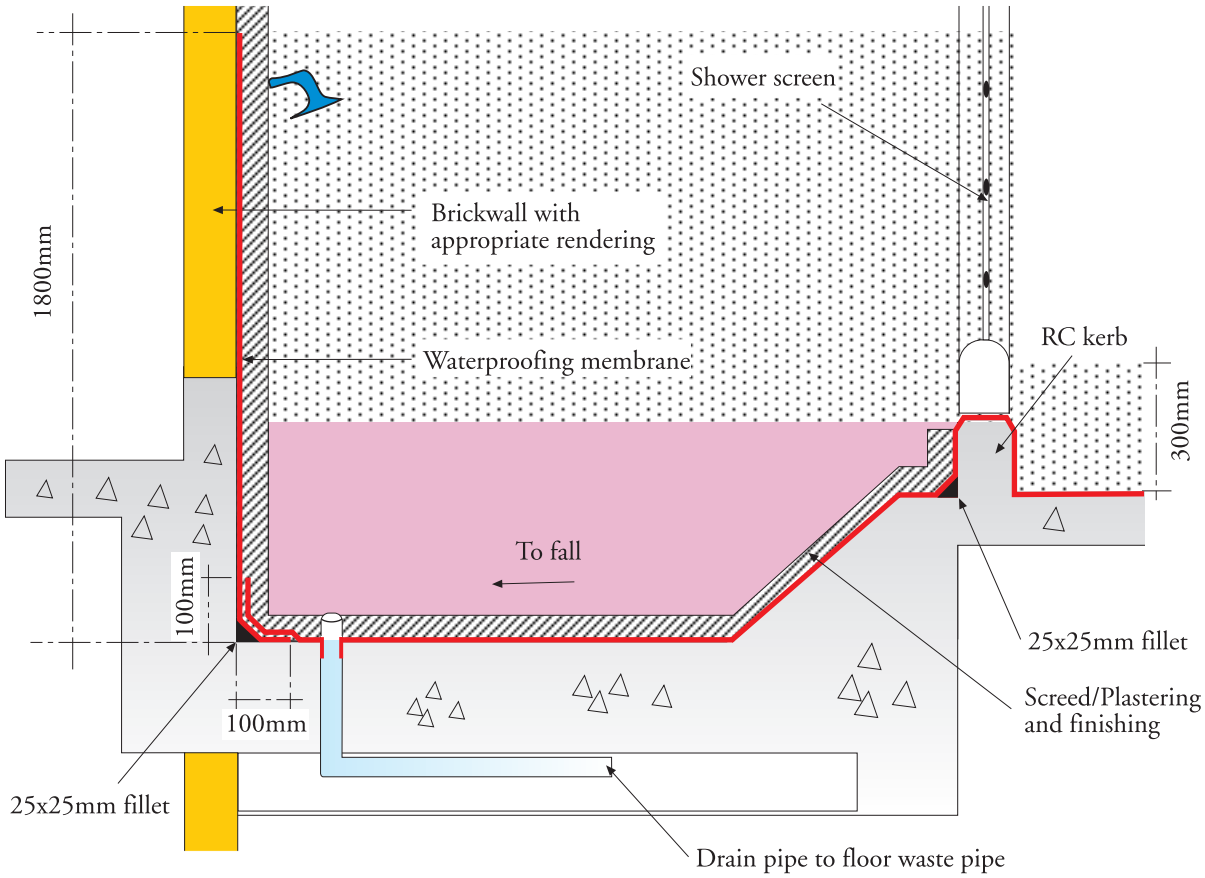


Figure 2.12: Typical waterproofing details at sunken bath

2.4 PIPES AND PENETRATIONS

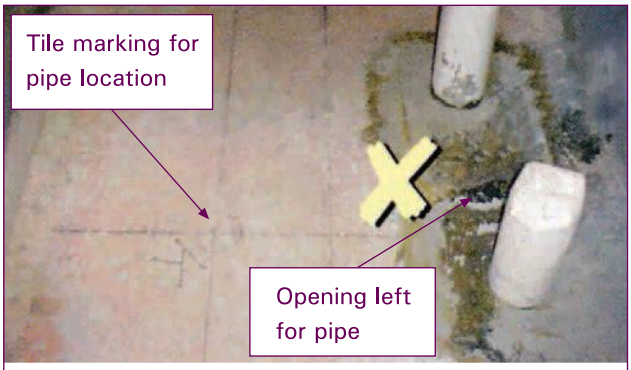
2.4.1 Arrangement of pipes and penetrations

Designer should:

- minimise number of penetrations through the slab/ wall which affects the continuity of the waterproofing membrane and increases the probability of leakage.
- group common discharge stacks and provide a raised platform at this area or alternatively provide a shaft/ service space to house them.
- avoid chasing of walls and floors.
- connect drain pipes directly to waste pipes as shown in Fig 2.13.
- avoid concealing drain pipes in the screed of dry areas eg, bedroom and hall.

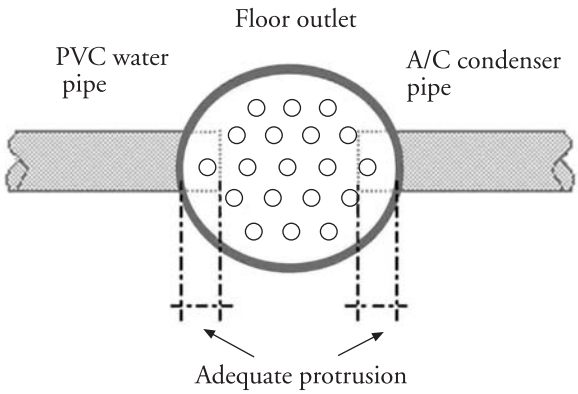
Pipes/ pipe sleeves should be cast with the floor slab rather than leaving an opening in the slab for the pipes. For instance, it is not good practice to leave an opening so that the pipe position can be adjusted to accommodate the tile layout. This is to avoid possible leakage due to improper grouting around the pipes.

Poor arrangement of pipes

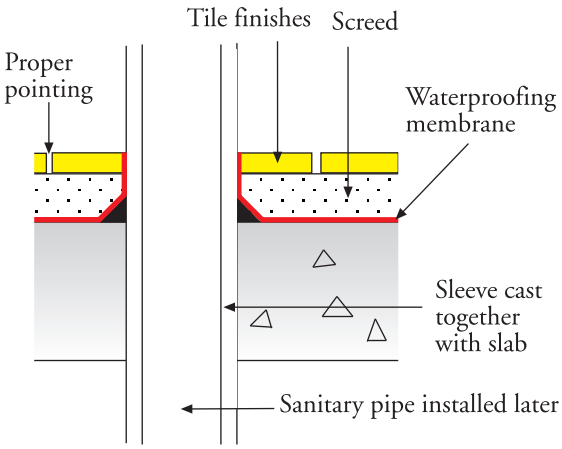


Avoid leaving opening for pipe

Recommended arrangement of pipe connections below the slab



Recommended arrangement of pipes at floor outlet (Plan view)



Pipe sleeve cast with floor slab

Figure 2.13: Pipes and Penetrations

2.4.2 Waterproofing Membrane around Pipes and Penetrations

Membrane should be dressed up at pipe penetrations to the finished floor level (see Fig. 2.14) and dressed down to at least 50mm into the floor outlet (see Fig 2.15). The membrane should be applied 100mm horizontally around the pipe. This coating should overlap with the subsequent membrane applied to the entire wet area.

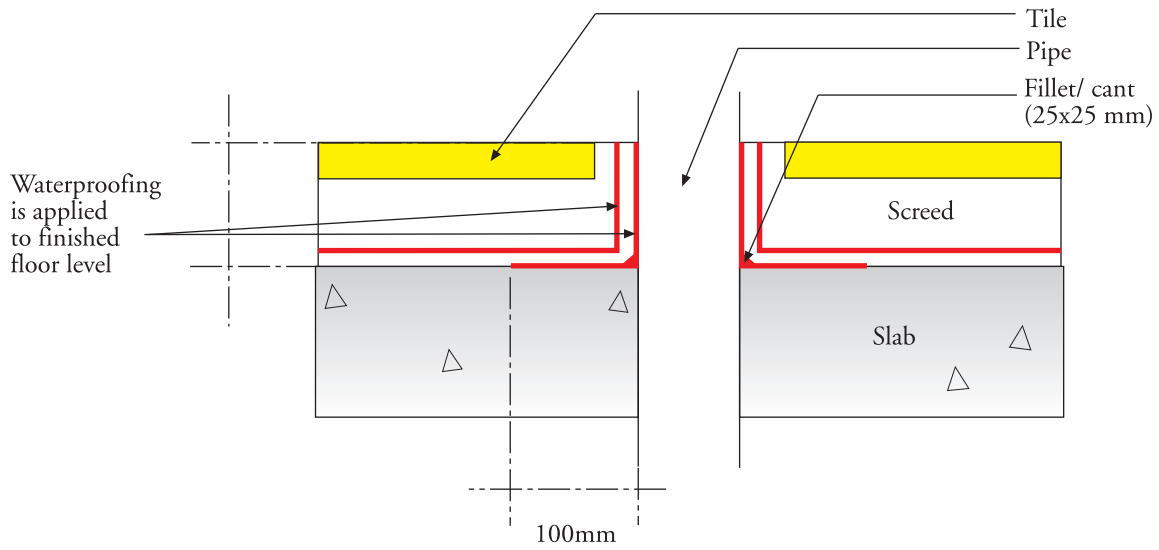


Figure 2.14: Typical waterproofing details at floor penetration

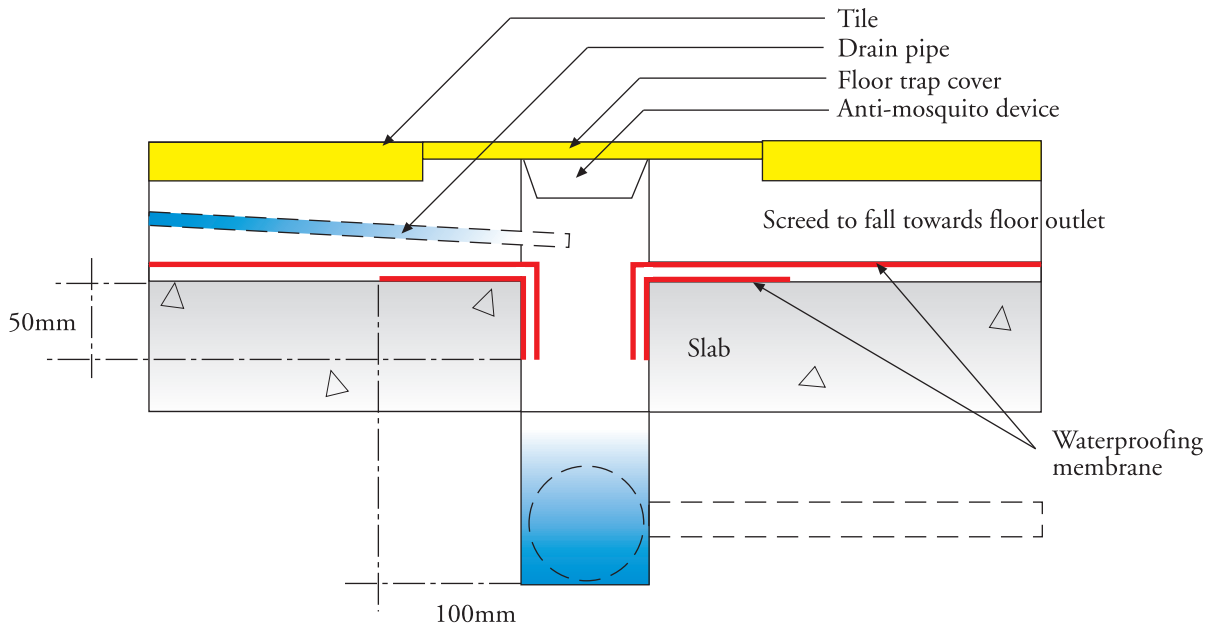


Figure 2.15: Typical waterproofing details at floor outlet

The cross section of pipes fully embedded in the screed is as shown in Fig 2.16.

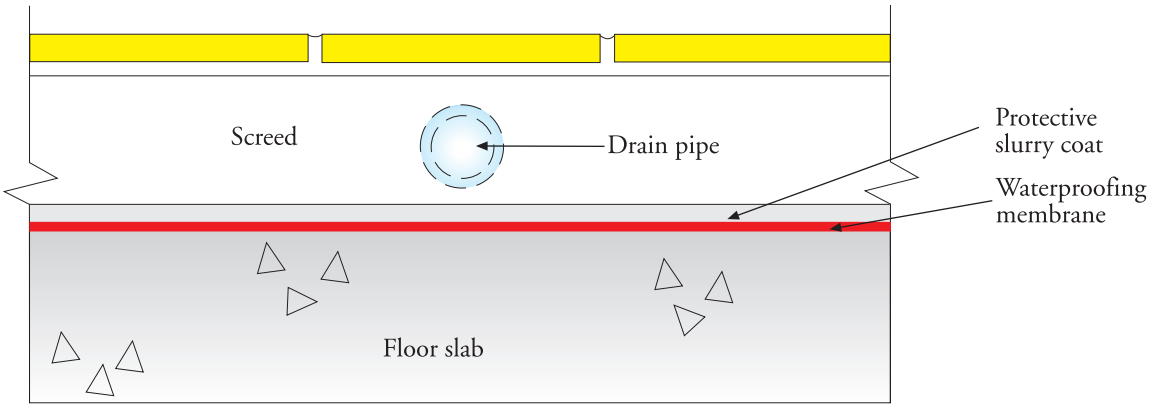


Figure 2.16: Pipes embedded in screed

2.5 SCREED

Screed should be laid to slope towards the floor outlet. The direction of the fall must be planned with pedestrian traffic flow in mind so that pedestrian traffic will move across rather than up and down the slope. The direction of slope should be indicated clearly in the drawing (see Fig 2.17). Tiles may then be laid onto the screed with an adhesive compatible to the waterproofing screed.

Note that it is not recommended to lay tiles directly bonded to the waterproofing membrane. As a protective measure against damaging the membrane during tiling, a layer of screed should be laid over the membrane after the curing of the membrane. Similarly, for waterproofing applications to wall upturns or shower areas, apply a layer of 20mm thick plaster to protect membrane before laying the tiles.

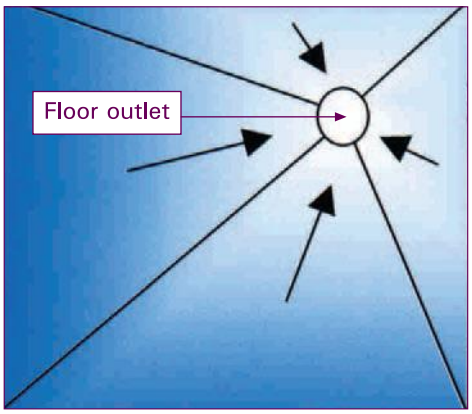


Figure 2.17: Saucer slope for internal wet areas

3. MATERIAL SELECTION

3.1 GENERAL

Following the design of the wet area by the Designer, the Contractor will propose a suitable waterproofing system. Selection should be based on life-time cost-performance. This should include not only the initial performance and cost of the waterproofing system, but also the cost of replacing a waterproofing system failing prematurely and other costs associated with failure.

An experienced and qualified person should review the qualities of a recommended product in meeting existing standard test or specifications. The selected system should be reviewed and agreed with the Designer. Test certificates of the product should be submitted to confirm their compliance with the stated specifications.

3.2 WATERPROOFING SYSTEMS FOR INTERNAL WET AREAS

Waterproofing systems can be generally classified into 3 main categories, namely preformed membrane, liquid applied membrane and integral systems. An overview of the general waterproofing systems is given in Appendix A.

3.2.1 Suitable Systems

Preformed membrane systems are suitable for large areas with minimum protrusions. In Singapore, they are not commonly used in the internal wet areas.

Integral systems, such as the concrete admixture system and the crystalline system, are waterproofing systems that become part of the reinforced concrete structure that they are protecting. However, these systems cannot withstand movement and the waterproofing capability will be severely undermined once concrete cracks develop after the waterproofing application.

Liquid applied systems are normally preferred over preformed systems and integral systems for internal wet areas because of the following advantages:

- Continuity of the membrane between horizontal and vertical planes, around projections and penetrations and it is self-flashing.
- Membrane adheres to every part of the substrate, which helps in isolating leaks and preventing lateral movement of water.
- Membrane is able to withstand minor cracks.

However, liquid applied systems require more supervision and quality control during substrate preparation, mixing (some coatings require mixing on-site) and application. Weather conditions such as ambient temperature, precipitation, and humidity can affect the quality of the application. Certain liquid applied products, such as the polyurethane and rubber systems, have two formulations (one for horizontal and one for vertical application) which must be ascertained before application. Curing requirements for acrylic based liquid applied waterproofing system must be followed strictly or it may not be suitable for usage under constant immersion or with an active hydrostatic head of water.

Liquid applied systems can be classified into water based or solvent based, depending on whether water or solvent is used to create a liquid form. Consult the manufacturer for the classification of the product used.

Table 3.1 shows the suitable materials for wet areas recommended in the Singapore Code of Practice (CP 82: 1999).

Table 3.1: Suitable systems and their characteristics

TYPICAL CHARACTERISTICS	RUBBER BASED SYSTEMS	ACRYLIC BASED SYSTEMS	POLYURETHANE SYSTEMS	CEMENTITIOUS SYSTEMS
Main characteristic	Highly flexible with excellent resilience to cyclic extension and contraction.	Good UV resistance, flexible and good tearing strength (due to fiberglass reinforcement).	Good flexibility, excellent adhesion to concrete and good tearing strength.	Easy application, excellent compatibility with concrete and good vapour permeability.
Dry film thickness	Generally between 0.8 to 1.5mm recommended.	Minimum 1.2mm due to fiberglass reinforcement.	Between 1 to 1.5mm.	Between 2 to 3mm.
Application method	Brush, roller or airless spray.	Application is normally by rollers, to work material into fiberglass reinforcement.	By brush, squeegee or broom. Vertical grade by brush or trowel.	Brush or spray followed by trowelling.
Method of curing & drying time	Air-drying. About 1 hour in exposed condition. 3-4 hours in enclosed areas. 72 hours before flood test.	Air-drying. Within 1 hour, but requires minimum 4 to 5 coats due to reinforcement. Total system therefore requires longer drying time. 48 hours before flood test.	Normally moisture-cured. Contains solvent therefore requires ventilation. Recommended 24 hours curing time. Most systems recommend 72 hours before flood test. For coal tar based systems, 7-10 days is required.	Normally 1-2 hours. Requires curing similar to concrete. Flood test within 24 hours to assist in curing.
Adhesion to concrete substrate and bedding mortar	Generally good adhesion. May be improved by appropriate priming.	Good adhesion to concrete. Vertical application to exclude fibreglass reinforcement for better bonding.	Solvent based is sensitive to moisture. Adhesion may be affected if applied onto damp substrate.	Excellent bonding to concrete for both slabs and vertical walls. Not affected by surface dampness.

3.2.2 Solvent based systems

Most solvent based systems will have slightly better adhesion especially if they are epoxy or urethane based. However, solvent based membrane demands stringent surface preparation before application. Normally, the surface has to be totally dry and free of dust to ensure good bonding. Certain solvent based systems may affect PVC, other plastics or some metal fittings. Check with manufacturers and obtain their confirmation if in doubt.

3.2.3 Water based systems

Water based systems generally adhere well to moist substrate but may blister if substrate contains excessive moisture. It is a good practice to ensure the substrate is relatively dry. Use a moisture meter to check the relative dampness before application. Some water based system may require special primer, especially for application on metallic finishes. For water based cementitious systems, the membrane could be adversely affected, under a process called hydrolysis, if water test is conducted before the membrane is fully cured and set (refer to Chapter 8: Table 8.2).

3.2.4 Waterproofing screed

Performance of screed is important especially for wet areas and depends on the mix proportions and method of mixing. If control of such factors is poor, the screed will have shrinkage cracks which may become potential paths of water seepage. This will result in faster deterioration of the waterproofing membrane beneath it and as a result, the life span of the total waterproofing system in wet areas will be shortened.

For wet areas, the waterproofing screed could be specified as a secondary layer of defense. The waterproofing screed may be prepared by gauging cement mortar with a waterproofing compound to reduce its permeability. For specifications on waterproofing screed, refer to CP 82:1999. Waterproofing screed can also be specified for internal areas where intermittent wetting is expected. A minimum 20mm screed thickness is normally adequate to provide the watertightness.

For better site control of the mix quality, pre-packed waterproofing screeds, which are dry mixed and packed with the waterproofing additive in the factory, are recommended. Workers need only to add the correct amount of water to the pre-packed mix on site using a mechanical mixer to produce the desired mix.

3.3 SELECTION CRITERIA

The waterproofing system for wet areas should:

- be able to bridge over cold joints
- be compatible and easy to apply, especially at pipe penetration areas
- be elastic to bridge over differing materials
- have good adhesion and cohesion strengths
- be able to receive screeding and plastering
- to a certain extent, be resistant to some mechanical damage prior to screed finish
- be fully bonded to the substrates to isolate any leaks in future

It is important to note that two products of the same generic type may vary extensively from each other depending on their chemical composition. For this reason the fundamental properties/characteristics of the different products (given by the manufacturer) must be checked against those specified by the designer. Table 3.2 gives the performance standard specifications that could be referred to as a guide for specifying liquid applied waterproofing systems in wet areas. A brief description of the various tests is given in Appendix B.

Table 3.2: Specifications for liquid applied membranes used in internal wet areas

	PROPERTIES/ CHARACTERISTICS	TYPE SPECIFIED	
		Flexible cementitious or other approved water-based waterproofing membrane	**Solvent-based elastomeric membrane**
1	**Tensile strength (N/mm^2)** Condition as cast Change in Strength (%) After ageing at 50°C for 14 days After 72 hrs chemical immersion at room temp: 1. 0.5% (v/v) NaOCl 2. 1.25% (v/v) NH_4OH 3. 3.7% (v/v) HCl	≥1.5 N/mm^2 ≥1.2 N/mm^2 }-ve change ≤ 40% }No limit for +ve change }	≥1.6 N/mm^2 ±25% max } ±20% max } }
	Test method specifications ref.	ASTM D 412	ASTM D 412
2	**Initial hardness (Shore A)** • 7 days curing (Determine indentation hardness of membrane)	≥ 40	≥ 25
	Test method specifications ref.	ASTM D 2240	ASTM D 2240
3	**Adhesion to substrate** • Condition as cast (To determine the strength and characteristics of the peel properties of a cured-in-place membrane)	0.3 N/mm^2	0.5 N/mm^2
	Test method specifications ref.	ASTM D 4541	ASTM D 4541
4	**Crack bridging**	Condition as cast: no cracking at 2 mm width. No crack after 10 cycles of stretching and closing to a width of 1 mm	Shall be able to bridge crack up to 2 mm in width 1. on original sample. After 72 hrs chemical immersion at room temp: 2. 0.5% (v/v) NaOCl 3. 1.25% (v/v) NH_4OH 4. 3.7% (v/v) HCl
	Test method specifications ref.	ASTM C 836	ASTM C 836
5	**Elongation at break (%)** a) Condition as cast **Change in Elongation (%)** b) After ageing at 50°C for 14 days c) After 72 hrs chemical immersion at room temp: 1. 0.5% (v/v) NaOCl 2. 1.25% (v/v) NH_4OH 3. 3.7% (v/v) HCl (Tension/ Tensile properties)	≥150% ≥120% }-ve change ≤ 40% }No limit for +ve change }	≥ 500% ±25% max } ±20% max } }
	Test method specifications ref.	ASTM D 412	ASTM D 412
6	**Chloride content**	≤ 0.1%	NA
	Test method specifications ref.	ISEA Method	-

Table 3.2 continues on next page ►

Table 3.2 *(continued)*

7	**Resistance to water penetration**	No water penetration allowed at 0.2 kgf/cm^2 for 6 hrs	NA
	Test method specifications ref.	Adopted DIN 1048: Pt 5	-
8	**Water vapour permeability** (at recommended dried film thickness)	NA	30 g/m^2/day max
	Test method specifications ref.	-	ASTM E 96 (Dry method)
9	**Set-to touch time** i.e. RH 65 ± 5 and 32 ± 2°C (Rates of film formation in the drying or curing of membrane)	Touch dry within 2 hrs	NA
	Test method specifications ref.	ASTM D 1640	-
10	**Elastomer content**	NA	25% min
	Test method specifications ref.	-	Solvent Extraction & Thermal Gravimetry Analysis
11	**Volatile content**	NA	25% max
	Test method specifications ref.	-	Oven: 105°C for 3 hrs
12	**Flash point**	NA	40°C min
	Test method specifications ref.	-	SS 5 (Part B 15)

Source : HDB's Specification (as at 1999)

An additional specification on polymer characteristics and polymer content is shown in Table 3.3 below.

Table 3.3: Specifications for Characterisation of Polymer

	PROPERTIES/ CHARACTERISTICS	TESTING METHOD	SPECIFICATIONS
13	**Characterisation of Polymer**	• Fourier Transform Infrared spectroscopic technique (FTIR) • Differential Thermal Analysis (DTA) • Thermogravimetric Analysis (TGA)	FTIR, DTA and TGA graphs of the sample are to tally with the approved product in polymer characteristics and polymer content.

Source : HDB's Specifications (2003 Edition)

4. DELIVERY, STORAGE & HANDLING

4.1 DELIVERY

All waterproofing products delivered to site should include the following information:

- general description of specified waterproofing product
- name of manufacturer/ supplier/ agent
- areas of application
- technical values for the specified product and related reference to any standards like SS, BS, ASTM or DIN
- shelf life and batch reference

Products should be sealed and delivered in original packaging. Verify the stated shelf life to ensure that the product has not expired. Please refer to the Inspection and Test Plan (Appendix D) for verification of products delivered to site.

The products delivered for waterproofing should possess the properties as required by the specifications. It is important to conduct random sampling of the product and send for testing to ensure the material provided is as specified.

4.2 STORAGE AND HANDLING

The Waterproofing Specialist should provide the Material Safety Data Sheets (MSDS) that contain all the information on safe handling of chemicals and hazardous materials (see Appendix C). These data sheets must be readily available at every project, for review by employees to educate themselves on the dangers of using the materials and risks to health. Specific safety and handling requirements to ensure safe and proper material usage should also be included. The Contractor should maintain a list of the hazardous chemicals on site and ensure that all containers are properly labelled. The Applicators must be trained to recognize and safely handle the materials.

For storage of adhesive and solvents ensure that:

- label identifies the hazardous material
- lids are tightly closed immediately after usage
- fire extinguishers should be accessible at storage areas
- the different types are stored separately, away from other chemicals
- proper disposal of all empty containers

All materials should be protected from the weather, sun, and heat, and stored in a dry and secured area. Products that require protection against moisture should be stored on a slightly elevated level rather than directly on the ground (see Fig 4.1).

For handling of adhesive and solvents ensure that:

- work area is well ventilated and lighted. Use mechanical ventilation with exhaust fans if required
- appropriate personal protective equipment are used
- no smoking
- awareness of other trades in the area. Acetylene, electrical welders and other flame or spark producing equipment may ignite vapours

Secured storage area

Neat arrangement of products

Storage on elevated palettes

Figure 4.1: Storage of waterproofing products on site

5. PREPARATION WORKS

5.1 GENERAL

The Waterproofing Specialist must have his shop drawings approved for construction by the Designer. A meeting should be called in the early stages of construction by the Contractor to ensure that all involved parties understand the sequence of work. In planning the sequence of work, adequate time should be allowed for the waterproofing membrane to cure and dry.

The requirements that must be satisfied at each stage or phase of the process should be stated in an inspection and test plan (ITP) prepared by the Contractor. An example of an ITP is given in Appendix D. The checks required by the ITP can be specified in a checklist that should be used to record the results during the verification (see Appendix E).

The Contractor must ensure that all pipe, duct and any other works that penetrate the floor slabs and walls should be completed before the start of waterproofing work. M&E clearance for the plumbing and sanitary fittings at wet areas should be obtained prior to concealing them. The pipes should be pressure and flow tested and free of leakage. To ensure that all involved parties understand their requirements, the Waterproofing Specialist should complete a "mock-up" to demonstrate the substrate requirements and preparation, and all other works that must be completed by other trades before application of the waterproofing system. Safety requirements, method of installation, watertightness tests and protection of membrane must also be demonstrated.

5.2 SURFACE PREPARATION

Proper preparation of the concrete surface is an important factor in ensuring good performance of the waterproofing system. The area to be waterproofed should be prepared according to manufacturer's recommendations prior to the application of the waterproofing system. For instance, blistering will occur if certain non-breathing materials are applied to wet substrates.

Concrete surfaces shall be cleaned and free from all forms of scale, laitance, dust, mould, form oils, wax, curing agents as well as any other foreign materials that may cause debonding of the waterproofing membrane from the substrate.

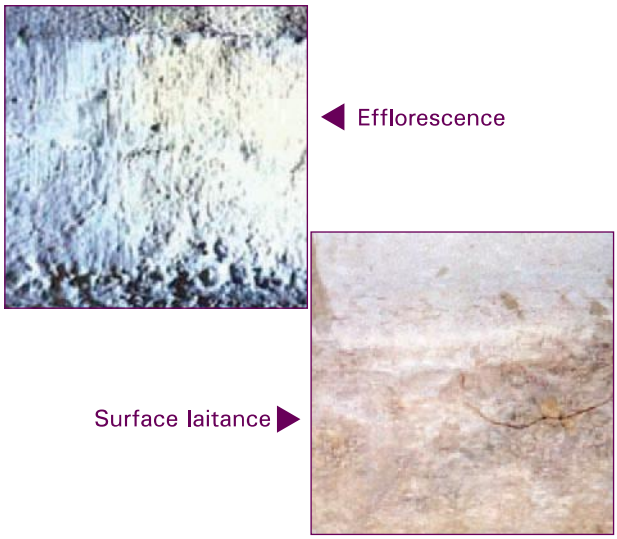


Figure 5.1: Examples of foreign materials on concrete surface

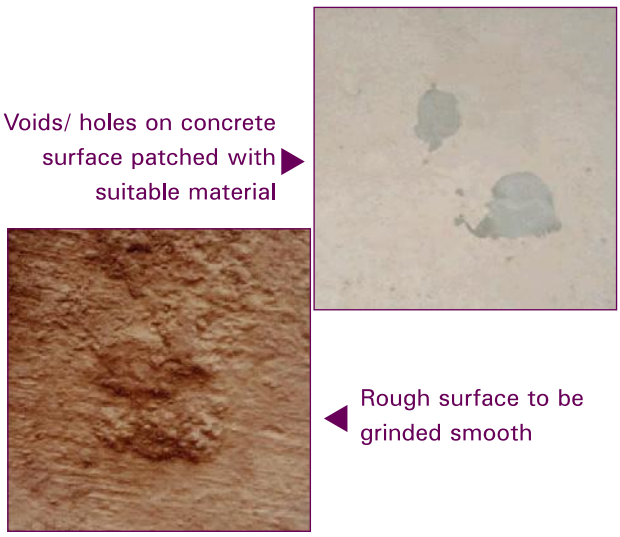


Figure 5.2: Examples of surface defects on concrete surface

Generally, two methods of cleaning may be employed: mechanical cleaning and chemical cleaning. Mechanical cleaning methods (i.e. compressed air, industrial vacuum cleaning, sweeping, abrasive cleaning, high-pressure water jetting and grinding) are effective in removing laitance, dust, efflorescence, loose plaster and weak surface materials. Chemical cleaning methods are effective in removing oil, grease and dirt. Efflorescence or leached salts should be removed from masonry surfaces with approved cleaning agents, according to the masonry surface type.

Figure 5.3: Examples of concrete surface cleaning methods

A summary of the common surface defects found on concrete surfaces and their treatments are specified in Table 5.1.

Table 5.1: Common surface defects

DEFECT	METHOD	TOOL
Holes/ voids	1. Clean out all dust, dirt and loose stones etc. 2. Plaster back to original profile using non-shrink grout or a sand/ cement/ polymer mix.	Clean using brush, broom or vacuum cleaner.
Cracks (non-structural)	1. "V" out to a minimum depth of 25 mm. 2. Remove all loose debris from affected area. 3. Plaster back to original profile using non-shrink grout or specified patch repair plaster.	"V" using a hammer and chisel or a mechanical hacker. Mixing of patching compounds using drill & mixing attachment and mixing bucket.
Honeycomb areas	1. Hack back to sound concrete. 2. Plaster back to original profile using non-shrink grout or recommended repair plaster.	Hack using a hammer and chisel or a mechanical hacker. Mixing of patching compounds using drill & mixing attachment and mixing bucket.
Rough surfaces	1. Grind to a smoother profile. 2. Apply sand/ cement screed over affected area. 3. Apply recommended layer of plaster topping over affected area.	Grind using electrical grinder or concrete grinder. Apply screed using a steel float and finish off with a wood float.
Sharp protrusions	1. Grind off.	Grind using electrical grinder.
Sharp external corners	1. Grind off to a smooth radius.	Grind using electrical grinder.
Dirt/ oil grease loose plaster etc	1. Remove with a high pressure water jet.	
Internal corners and around penetrations	1. Apply a sand/ cement fillet or as specified by manufacturer, to all internal corners and penetrations. 2. Alternatively, install reinforcement at these areas.	For mixing small quantities of sand/ cement plaster, patching compounds etc., use diamond point trowels. For constructing coves and fillets, use margin & coving trowels.
Brick surfaces	1. Proper pointing to the joints. 2. Apply cement sand render to the height of the upturn or to specified height of the waterproofing membrane.	

Note: Structural cracks must be repaired in accordance with Engineer's recommendations

A continuous angle fillet (25 x 25 mm) should be installed at all internal corners between horizontal and vertical surfaces. The fillet material is usually 1:3 cement sand with 1:4 bonding agent and water. The fillet serves to make the joints more gradual for the membrane to sit on. Alternatively, reinforcement (for eg, fiberglass mat) of 150mm width can be installed at the corners. Please see Chapter 6 for the actual application of the reinforcement.

For brickwalls, the mortar joints should be flush pointed and rendered with cement/ sand mix to receive membrane (see Fig 5.4). Ensure that rendering at shower areas, long baths and areas around wall hung basins, water cisterns, etc are applied to the required heights.

The following are pointers for repair of surface defects:

1. Defective concrete substrate surface should be removed with tools that will not further damage adjacent areas.

2. The repair material should be compatible with the concrete substrate being repaired. If dry pack portland cement mortar is used, the water/ cement ratio must be kept as low as possible to reduce shrinkage.

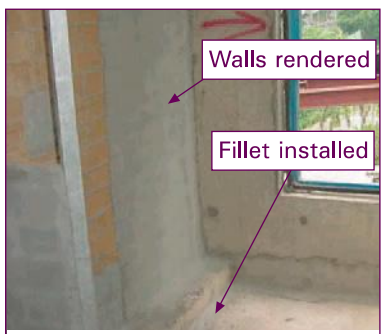
3. A bonding agent shall be applied on the concrete to have better adhesion to the repair material.

4. Wet curing during the first 24 hours is strongly recommended. (Due to the relatively small volume of dry pack repairs and the tendency of the existing concrete to absorb moisture from new material, water curing is a highly desirable procedure, at least during the first 24 hours). Spraying of curing compound is not recommended unless the curing compound is compatible with the waterproofing membrane.

Flush pointing of motar joints

Walls rendered to required height at shower area

Walls rendered to 300mm with fillet installed at corners



Surface preparation at sunken bath with fillet installed at corners

Figure 5.4: Surface preparation to brickwalls and internal corners

5.3 TESTS ON CLEANLINESS AND DRYNESS

For certain types of membrane where a dry surface is required, good ventilation should be provided to enable the substrate to dry sufficiently. A moisture meter test should be carried out by the applicator to check the dryness of the substrate before membrane application. The meter should be correctly calibrated to the substrate type before use.

On the other hand, cementitious membrane systems require a damp surface to improve the adhesion of the membrane to the concrete surface. For application of such systems, remove all lying water from the concrete surface, then pre-saturate or dampen the substrate with clean water prior to application of the first coat of the waterproofing membrane.

Use sponge to soak up excess lying water

Dampen wall surface with wet roller

Figure 5.5: Preparation of substrate to receive cementitious membrane systems

The tests in Table 5.2 are recommended for the different systems to ensure adequate surface preparation prior to system application. Tests may be carried out as described in Table 5.3.

Table 5.2: Applicable tests for various membrane systems

	TYPE OF TESTS TO USE		
Systems	**Cleanliness**	**Dryness**	**Laitance**
Rubber based	✓	✓	✓
Acrylic based	✓	✓	✓
Polyurethane	✓	✓	✓
Cementitious	✓	-	✓

Table 5.3: Test methods

CLEANLINESS OF SURFACE
(a) Dusty Condition: - wipe surface with dark cloth. - if there is excessive white powder on the cloth the surface is too dusty. (b) Oily Condition: - sprinkle water on surface. - if standing droplets appear, the surface is oily.
DRYNESS OF SURFACE
- use moisture meter. - check if surface is adequately dry for membrane application.
TEST FOR LAITANCE
- scrape surface with knife. - if loose powdery material is observed, excessive laitance is present.

5.4 PREPARATION OF PIPES AND PENETRATIONS

To reduce the risk of water leakage at floor penetrations:

- ensure that the portion of the pipe in the slab does not have joints.
- create a slight upward sloping profile surrounding pipe protrusions (fillet for membrane upturn)(see Fig 5.6). Alternatively, reinforcement could be installed.
- provide additional protection at these areas. The waterproofing membrane used to treat the pipes should adhere and be compatible with the pipe material and the subsequent membrane applied on to it. For water outlets, ensure pipes are cast to flush with floor level to facilitate membrane dress down.

Figure 5.6: Fillet installed around pipe penetrations

5.5 PRIMING

Primers are usually applied to the substrate before the application of the actual waterproofing material, to enhance adhesion properties of the waterproofing system, eg, polyurethane system. Ensure that the concrete substrate is sufficiently cured before applying a recommended vapour barrier as a primer to the substrate. Primer should always be brush applied. Check the procedures as some membranes must be laid onto wet primer. The primer should also be applied to the render coat on the brick wall, ensuring full coverage and allowed to dry, prior to application of membrane.

5.6 PRECAST PANELS

Insufficient surface preparation at the concrete surfaces receiving the membrane material can cause debonding of membrane near the joints. Prior to the application of the joint sealant, all loose materials, debris and weak concrete that may inhibit the sealant from adhering to the joints have to be removed. Backer rods of appropriate sizes should be inserted into the joint as backing for the sealant material. The sides of the joint are taped before gunning the sealant into the joint. The joint is then tooled to achieve a smooth even surface, and the masking tape removed to allow the sealant to cure.

6. INSTALLATION

6.1 PLANNING

The applicator should plan the application sequence before commencing works to avoid movement on freshly applied material and to ensure that the pot life of waterproofing material does not expire on site. Various factors influence the application:

1. Size of team
2. Tools
3. Size of mixes
4. Detailing
5. Location of construction joints
6. Curing time of material

6.2 TOOLS

Tools and equipment used for application must be cleaned before and immediately after use. Refer to Fig 6.1 for the common tools used on site.

The appropriate tools must be used for the different materials and areas, as specified by the manufacturer. For example, applying the protective slurry coat with a steel trowel may damage the membrane (see Fig 6.2 and 6.3).

1. Mortar bucket
2. Hopper gun
3. Broom
4. Mixing drill & attachment
5. Mixing container
6. Measuring containers
7. Roller
8. Cutting knife
9. Scissors
10. Steel float
11. Serrated trowel
12. Rubber gloves
13. Brushes

Figure 6.1: Common tools/ equipment used

Figure 6.2: Apply using steel trowel

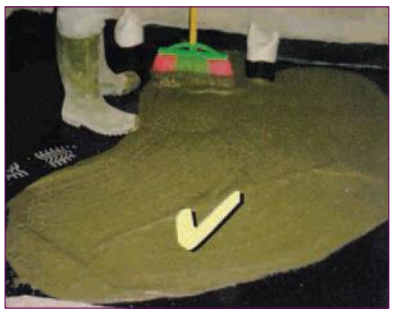


Figure 6.3: Apply using broom

6.3 MIXING

Any mixing of waterproofing products on site should be done in a controlled environment with the mixing equipment and container cleaned prior to mixing. All liquid applied waterproofing products must be machine mixed. Hand mixing should only be used for products that do not machine mix satisfactorily. The mixing must be administered by a trained personnel, taking into account the specified ratio and usable pot life etc.

For the two component (two-part) system, ensure the materials are accurately measured out using appropriate measuring containers. Measure the correct amount of the liquid component and transfer the measured contents into a clean container. The powder component is then slowly added to the container and mixed for the specified time using a mechanical mixer. Care should to taken to ensure that the mix is homogeneous and lump-free and a workable liquid for application is achieved. Random tests or visual checks on the consistency of sample materials taken during the application can be conducted to ensure that there is no improper dilution.

Materials should be mixed only as fast as it can be laid. Mixed materials are to be discarded after the pot life has been exceeded even though mixture may still be in liquid form. It is also a good practice to manually re-stir the waterproofing material before use.

When using liquid applied waterproofing material from sealed containers, always remove the skin on the surface of the liquid before use.

Two component (Part A and B) waterproofing system

Measure Part A (liquid) and pour into a clean container

Measure Part B (powder) and pour into container to mix with Part A

Mix Part A and B thoroughly with a mechanical mixer

Homogeneous and lump free mix is achieved. Re-stir the mix before use

Figure 6.4: Mixing of 2-component waterproofing products

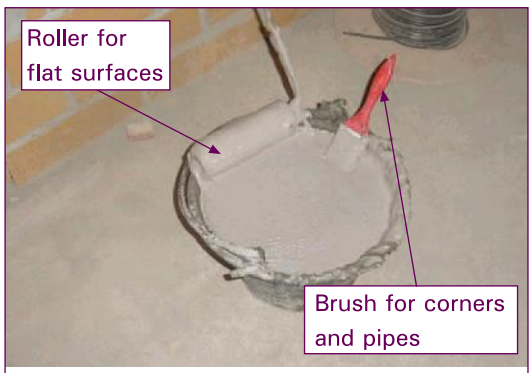
6.4 APPLICATION

Apply material on prepared surface by brush, roller, serrated trowel, spray or a combination of these methods, as specified by the manufacturer. Please refer to Table 6.1 and Figure 6.5 for more details.

Whatever method of application is chosen, a continual check must be made on the amount of material that has been used and the area covered to ensure that the recommended coverage rate is being achieved. It is also important to ensure that the extent of waterproofing does not deviate from what has been specified.

Table 6.1: Methods of application and suitable tools

DESCRIPTION OF AREAS	APPLICATION
Corners and confined areas	Brush application
Large vertical and horizontal areas	Roller application
High vertical walls	Spray application
Large horizontal surfaces	Self-leveling waterproofing material and evenly spread out with a serrated trowel



Roller and brush for different application areas


Spray method for high vertical walls


Equipment used in spray application


Spray nozzle

Figure 6.5: Tools for applying waterproofing membrane

6.4.1 Wall-Floor Junctions

Application normally begins with the upturns at wall floor junctions, and starts at the corner of the wet area, diagonal to the entrance to avoid stepping on applied area. The use of a roller with the same width as the upturn provides an even and uniform application. The use of a brush at these junctions will help to ensure good coverage. Depending on manufacturer's requirements for certain membrane systems, the designer may choose to install reinforcement such as fiberglass mat at corners rather than installing a continuous fillet. For such cases, the reinforcement is to be cut into specified width and length with shears or a sharp knife. A coat of material is to be applied at the position to be reinforced and the reinforcement material is then covered with a wet coat of waterproofing membrane.

Brush application at corners

Apply upturn with roller

Apply membrane with roller

Lay reinforcement at corners

Cover reinforcement with a wet coat of membrane

Completed 1st coat of membrane at corners

Figure 6.6: Application of waterproofing membrane around wall-floor junctions

6.4.2 Pipe Penetrations

Pipe penetrations are dressed up and floor outlets dressed down. As double protection, either fillet or reinforcement should be applied around pipe penetrations.

Figure 6.7: Application of membrane at pipe penetrations

Dress down to 50mm	Apply membrane outside pipe	Completing application

Figure 6.8: Application of membrane at floor outlet

Dress down and apply around floor outlet	Lay reinforcement into wet coat	Completing application

Figure 6.9: Application of membrane at floor outlet (with reinforcement)

6.4.4 Walls and Floors

After the first coat of application to corners and pipe protrusions has sufficiently dried, proceed with using a roller to apply a coat of membrane to the walls and entire floor. The applicator should bear in mind that once the application of waterproofing to the floor and walls has commenced, the waterproofing works should be completed without any breaks in between. This is to achieve a seamless and continuous membrane throughout.

Roller application to wall

Completed wall application

Roller application to floor

Completed floor application

Figure 6.10: Application of waterproofing membrane to walls and floors

6.4.5 Special Considerations for Liquid Applied Membrane

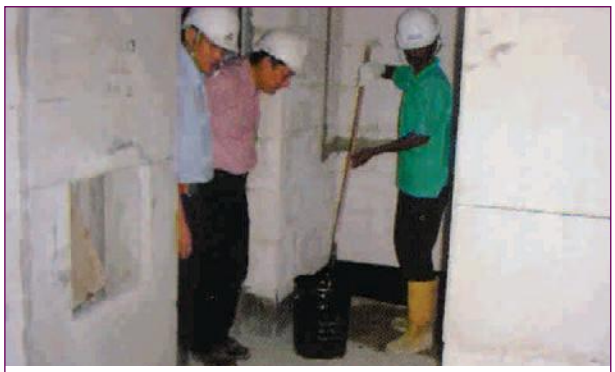
For liquid applied membrane, it is a good practice to apply several thin coats to achieve the required wet film thickness (WFT), rather than applying one thick layer. The applicator should bear in mind that overcoating can only be carried out after the previous coat remains firm under hand pressure with a twisting thumb, or until the membrane no longer feels tacky. Coverage of liquid applied membrane must be monitored to ensure that the membrane is applied sufficiently to achieve desired thickness. A wet film thickness gauge can be used to check and confirm thickness compliance (see Fig 6.11).

The curing period for each coat prior to subsequent coats should be monitored to follow manufacturer's specifications. Generally, adequate provision of ventilation at wet areas is necessary for the proper curing of all liquid applied waterproofing membranes, especially when they are applied in confined spaces such as bathrooms and toilets. Proper ventilation is also required for the safety of workers while handling chemicals within confined spaces.

At appropriate points during the process, joint inspections should be conducted (see Fig 6.11). Random checks on number of coats, mixing, method of application, spread rate and curing should be conducted. Visually ensure that air is not trapped in the membrane as this may result in the development of pinholes, which could become potential paths of leakage.

Particular attention shall be given to the following:

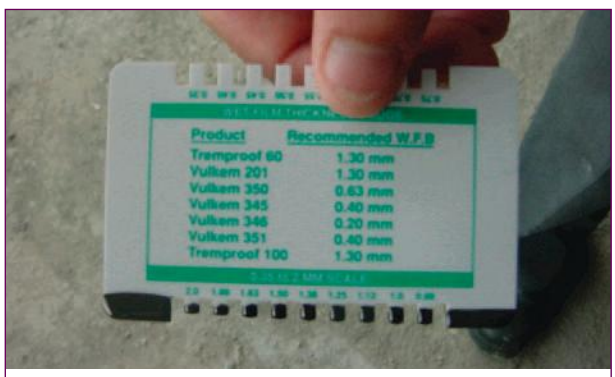
- minimum number of coats required
- wet film thickness (WFT) and coverage
- curing time between and after coats
- the right viscosity for vertical or horizontal application
- use of primers where necessary
- consistent application
- termination at upturn
- minimum total dry film thickness (DFT) – eg, pull-out tests on completed membrane, especially for upturn areas. This is a destructive test and requires rectification of the area tested.



Joint inspection during application

Example of a wet film thickness gauge

Conducting check on the WFT



Verifying reading on WFT gauge

Figure 6.11: Inspections of WFT and joints

Any damaged materials or work should be rejected and immediately removed and replaced with new materials. If damage is not confined to a localised area, the membrane should be reapplied for the entire area. If damage is localised, cut out localised area and reapply waterproofing to the localised area with proper lapping of minimum 100mm all round the localised area.

The membrane should be left to cure after application of the final coat with proper protection (Please refer to Chapter 7).

7. PROTECTION AND COMPLETION OF WORKS

7.1 PROTECTION

The Contractor must ensure that after completion, the area is cordoned off until a protective covering or screed has been laid. He must be notified of any damage and given time to carry out necessary repairs before protective covering is applied. The Contractor should ensure that work is carried out under controlled conditions and membrane protection is provided during and after application. Certain products require a layer of slurry coat as a protective layer against subsequent damage to horizontal membrane surfaces. All subsequent works should be carried out carefully to avoid any damage to the membrane.

All pipe/ floor openings in wet areas should be fitted with temporary caps so that debris or rubble cannot enter and cause chokage.

Figure 7.1: Entrance barricaded

NO ENTRY
WATERPROOFING IN PROCESS
FINE: S$500.00

UNIT NO: _____ BLOCK NO: _____

DESCRIPTION OF WORKS	DATE OF APPLICATION
1ST COAT	
2ND COAT	
M&E CONDENSATE PIPES	
WATERPROOFING TEST	

Figure 7.2: Example of a "No Entry" sign

Figure 7.3: Slurry coat

Figure 7.4: Opening protected from debris

7.2 SCREEDING AND FINAL FINISHES

A layer of protective screed should be laid over the membrane immediately after the completion of the watertightness test (refer to section 7.3) to prevent any damage to the waterproofed area. Construct level pegs as points of inspection to ensure correct falls to floor outlets. The waterproofing screed as defined in Chapter 2 is then prepared and laid.

As stated in CP 82, waterproofing screed should be mixed according to the specified mix proportion by a mechanical mixer. The adding of the mix constituents to the mechanical mixer according to the right procedure is important to ensure a workable and consistent mix for ease of trowelling to the required fall. Cement mortar mix of 1 part cement to 3 or 4 parts washed sand by volume with a water/ cement ratio not exceeding 0.40 is recommended by CP 82.

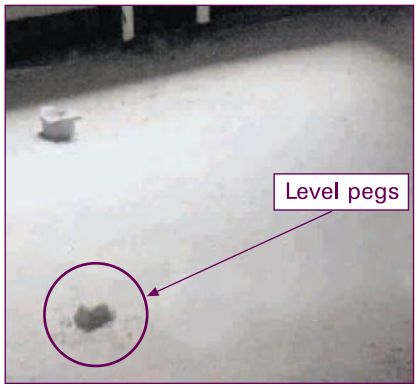


Figure 7.5: Level pegs

Figure 7.6: Screeding in progress

Supervision would be required to ensure compliance of correct proportions of the mix:

(a) correct dosage of waterproofing additive
(b) correct water to cement ratio
(c) correct cement to sand ratio
(d) uniformity of mixing

Alternatively, pre-packed waterproofing screed can be used, which will require less supervision.

Care should be taken not to damage the membrane during screeding. Proper supervision should be provided. Remedial works done after membrane application should be avoided. If this is unavoidable, the Waterproofing Specialist should be consulted on the proper action for the remedial works.

Complete with tile finishes in accordance to Architect's detail (refer to Good Industry Practices - Ceramic Tiling, BCA). Ensure that the finished floor level of the wet area is lower than the concrete slabs of adjacent areas to prevent migration of water into dry areas.

7.3 WATERTIGHTNESS TEST

Watertightness test should be conducted at the following stages during the application of waterproofing membrane:

1. During surface preparation, before laying the waterproofing membrane (structure watertightness test).

2. After application of waterproofing membrane, before laying of screed or final floor finishes.

3. After laying of screed or final floor finishes, depending on whether the final floor finishes are susceptible to staining, such as in the case of natural stones.

The watertightness test should be carried out as follows:

1. Temporarily seal all outlets.

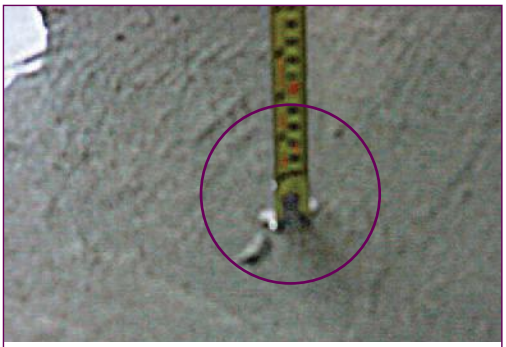
2. Flood the whole area to a minimum of 25mm of water (as measured from the highest point of the area). Ensure the water level is not above the finished level of the membrane upturn at walls.

3. Flooding time should be 24 hours, or as specified. Inspect bottom of the concrete slab for signs of leakage.

Structure watertightness test

Watertightness test after membrane application

Watertightness test at sunken bath



Flood to minimum 25mm for 24 hours

Figure 7.7: Conducting watertightness test

If leakage is observed during the structure watertightness test, repair all honey-combed and defective concrete areas by removing any unsound concrete and patch with suitable mortar such as shrinkage compensated grout, polyurethane grout, polymer modified mortar, epoxy mortar, etc. Special attention should be paid to all corners and wall-floor joints. Conduct watertightness test on the concrete slab again after the repair to ensure that the leakage has been rectified before proceeding with the subsequent waterproofing works.

If leakage is found after application of membrane, the preferred method is to re-apply membrane to the entire wet area. Otherwise, if leakage is localised, re-apply the waterproofing membrane at the localised area. Conduct watertightness test until water leakage is arrested.

If the final floor finishes (eg, natural stone) are susceptible to staining, one last watertightness test can be conducted after screeding has completed instead of after the final floor finishes.This will allow any dampness to escape without causing staining to the final floor finishes. There should also be a visual check to ensure that there is no stagnation of water.

Small areas on the walls should also be randomly selected and to subjected to shower spray for a duration of 15 minutes. Check for signs of dampness on walls from the other side of the wall. Alternatively, use a moisture meter to check the moisture content of the walls before and after water spray for any significant increase in moisture content which may be an indication of ineffective waterproofing.

8. DEFECTS AND RECTIFICATION

8.1 DEFECTS DURING SERVICE LIFE

The possible leak paths in wet areas are as shown in Figure 8.1.

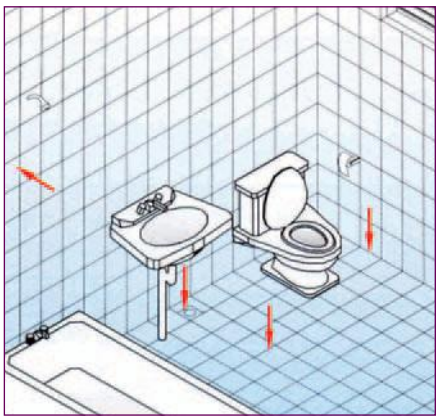
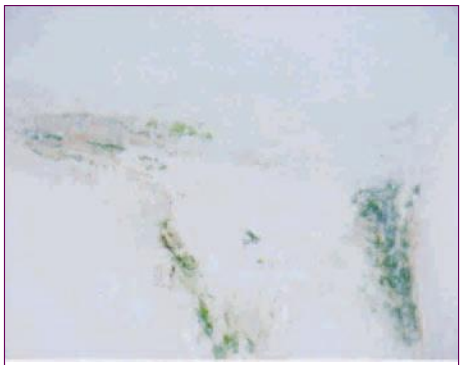


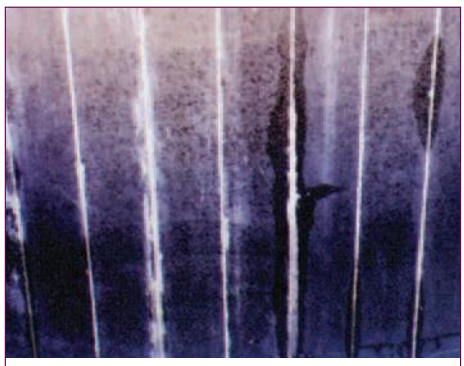
Figure 8.1: Possible leak paths in bathroom

Leakage through walls and slabs can lead to either architectural or structural defects, depending on the extent of leak. Some of the common defects arising from such leaks are as given in Fig 8.2. Detailed investigation will help in ascertaining the cause or causes of the problem. The repairs of such problems vary based on the causes determined. In general, the substrate is thoroughly cleaned and repaired/ restored prior to reapplying with suitable waterproofing materials. As leakage repairs are often expensive and disruptive, the principle of "do it right the first time" is certainly relevant for waterproofing.



Leakage on the ceiling and walls below and adjacent to wet areas

Paint flaking/ peeling on the ceiling below wet areas



Efflorescence build up on wall due to water seepage

Corrosion to steel reinforcement bars/ concrete spalling in the slab below wet areas

Figure 8.2: Common defects arising from leaks

8.2 DEFECTS DURING STORAGE AND APPLICATION

To achieve watertightness, applicators and site supervisors should know the common defects during storage and application of the waterproofing material. They should also be familiar with the remedy methods of such defects as given in Table 8.1 and 8.2.

Table 8.1: Defects during storage

DEFECTS	CAUSES	PREVENTIVE MEASURES	RECOMMENDED REMEDIAL METHODS
ACRYLIC SYSTEM			
Gellation 	Material thickens up in pail and forms a gel-like consistency. Caused by improper storage (usually under heat where the solvents in the pail evaporate off) or due to expired shelf-life.	Always check expiry dates when receiving materials on site. Store materials away from heat and direct sun. Protect from extreme temperatures. Note: Stored material must be mixed prior to application.	Contact manufacturer for advice. If due to improper storage, certain acrylics may be re-constituted on site by adding the correct solvent.
POLYURETHANE SYSTEM			
Hardening of material	Material sets in the can, lumpy appearance and hardens. Caused by improper storage or due to expired shelf-life.	Check expiry date. Observe proper storage on site. Some imported materials may not be 'tropicalised' - shelf-life is considerably shortened in different weather conditions. Make sure that original seal is not broken until prior to usage.	Reject material.
CEMENTITIOUS (INTEGRAL OR CRYSTALISATION TYPE AND LIQUID-APPLIED TYPE)			
Hardening of material 	Powder component sets in container, lumpy appearance and hardens.	Check expiry dates. Store materials in a dry place, under cover and raise above ground.	Reject material.
RUBBER BASED SYSTEM			
Hardening of material	See above under polyurethane system.	See above under polyurethane system.	See above under polyurethane system.

Table 8.2: Defects during application, curing and drying

DEFECTS	CAUSES	PREVENTIVE MEASURES	RECOMMENDED REMEDIAL METHODS
ACRYLIC SYSTEM			
Skinning 	Surface skins/ dries off too quickly trapping uncured material beneath. Usually caused by applying material too thickly or over-coating before previous coat has set sufficiently.	Ensure the correct coverage per coat and sufficient drying time between coats is followed, as per manufacturer's instructions.	Membrane needs to be removed and all uncured material scraped off and re-applied.
Pin-holing 	Tiny pin-holes appear on surface of membrane when set. Some pin-holes may breach through entire membrane. Caused by introduction of excessive air bubbles in material by over-stirring or over-working such as brushing or rolling over the same spot many times thus trapping air bubbles into the material.	Allow material to stand for 5-10 minutes after stirring. Apply to recommended coverage but do not work excessively over same area. Use correct application techniques as recommended by manufacturer.	Re-apply another coat over the affected area. If pin-holing is prevalent over the entire area, it may be advisable to re-apply the full system over the affected membrane.
Blistering 	Trapped moisture beneath membrane, evaporation rate higher than vapour permeability rate of membrane.	Ensure substrate is kept dry before application of membrane. Check with moisture meter.	Usually done by cutting out blister to allow moisture to escape. Allow substrate to dry out before re-application.

Table 8.2 continues on next page ▶

Table 8.2 *(continued)*

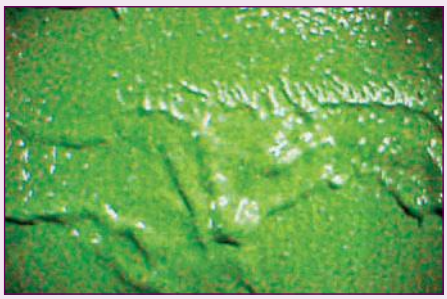
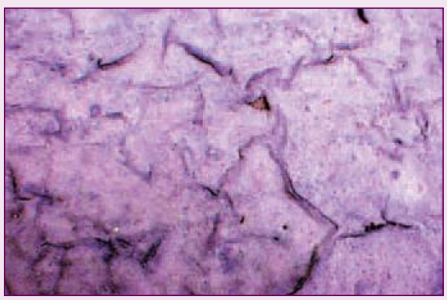
DEFECTS	CAUSES	PREVENTIVE MEASURES	RECOMMENDED REMEDIAL METHODS
POLYURETHANE SYSTEM			
Fail to set	Membrane remains wet and sticky. Due to expired material or could also be caused by inadequate mixing. Sometimes may also be caused by contamination/ adulteration of materials.	Check expiry dates of material before usage. Ensure mixing instructions are followed strictly i.e., do not hand mix if mechanical mixing is required. Check substrate for suitability before application.	Remove material. Check whether substrate is contaminated by chemicals etc. Clean substrate and re-apply with fresh material.
Solvent entrapment	Material sets on surface but remains soft below. Caused by applying too thickly or too quickly before previous coat sets sufficiently.	Observe recommended coverage rates strictly and allow sufficient inter-coat drying time.	Remove entire system, clean substrate and re-apply the entire membrane again.
Sagging or running of material on walls 	Material sags and creeps when applied to vertical surfaces. Caused by applying too thickly or using the wrong grade of materials.	Most PU would have 2 formulations – vertical and horizontal. Vertical formulations have thixotropic properties so that materials can be applied to vertical surfaces and will not sag or run. Observe coverage rates.	Cut out sagging area and clean substrate. Lightly sand edges to roughen it before applying further coats over the cut out area.
Blistering and pin-holing	See above under acrylic.	See above under acrylic.	
RUBBER BASED SYSTEM			
Fail to set	Remains soft and unset. Caused by expired materials, application too thick or insufficient ventilation for air-curing systems	Check expiry dates prior to usage. Ensure proper storage on site. Observe coverage rates. Ensure sufficient ventilation.	Remove material and discard, clean substrate and re-apply entire system.
Surface cracks 	Alligator cracking on surface. Caused mainly by prolonged UV exposure.	Protect membrane against direct sunlight or other forms of UV exposure. Most rubber-based or bitumen/ rubber are sensitive to UV. Store material under shade and cover.	Grind surface and re-apply additional coat. If cracks right through, remove membrane and re-apply.
Blistering and pin-holing	See above under acrylic.	See above under acrylic.	
Sagging or running of material on walls	See above under polyurethane system.	See above under polyurethane system.	See above under polyurethane system.

Table 8.2 continues on next page ▶

Table 8.2 *(continued)*

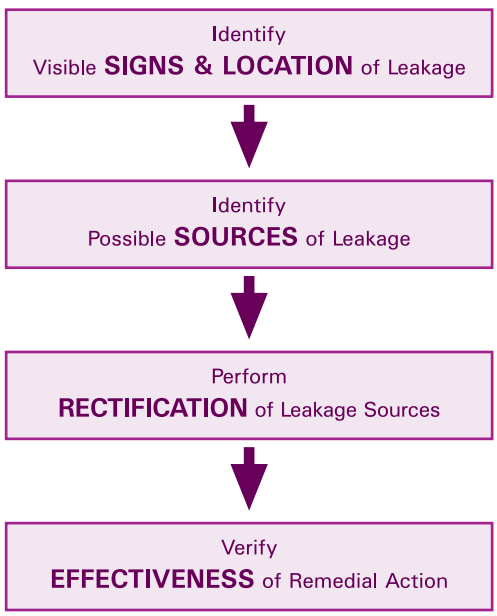
DEFECTS	CAUSES	PREVENTIVE MEASURES	RECOMMENDED REMEDIAL METHODS
CEMENTITIOUS (INTERGRAL OR CRYSTALISATION TYPE AND LIQUID-APPLIED TYPE)			
Staining (ochre - for integral system only) 	Applied substrate turned "rust" colour. Caused by chemical reaction between waterproofing compound and impurities in aggregates used for concreting.	Ensure that concrete aggregates do not contain excess silt or other impurities such as ferrous compounds.	Stains are not harmful to system. However if objectionable, surface may be grinded to remove stains.
Hydrolysis (for liquid-applied system only) 	Appearance of whitish stains on surface caused by migration of free lime. Usually the result of flooding with water before system sets sufficiently.	Ensure sufficient setting and curing time for membrane before subject to prolong contact with water.	Drain ponding water and allow to dry. Stains are efflorescence and may be removed by light scrubbing. Cure system properly first before subjecting to flood test.
Surface cracking	Tiny cracks appear on surface of set membrane. Usually caused by insufficient polymer mixing, over dilution with water or improper curing.	Check mixing ratio between dry component and liquid component.	Grind affected areas and allow to set/ cure properly. Re-apply additional coat to affected area if necessary. Normally cracks affect only just the surface. However, if cracks perpetrates throughout the membrane, then scrap off entire membrane and re-apply.
Sagging or running of material on walls	Material sags and creeps when applied to vertical surfaces. Caused by wrong water ratio during mixing or material applied too thickly.	See above under polyurethane system.	See above under polyurethane system.

8.3 RECTIFICATION WORKS FOR LEAKAGE

The application of a waterproofing system requires extreme care, supervision, and strict adherence to the manufacturer's recommended procedures. Poor workmanship would result in leaks that are difficult and costly to repair. Apart from workmanship, wear and tear over time and improper renovation works may also lead to leakage. The main causes of leakage include natural deterioration of materials, poor workmanship at time of construction and improper subsequent renovation works.

Ceiling leakage is likely to occur over time due to deterioration of the integrity of the waterproofing membrane or floor screed, degradation of pointing between tiles and wall/ floor joints and also deterioration of concrete infill/ grout around pipes. Faulty pipes/ sanitary fittings/ fixtures such as leakage at joints of concealed pipes and misalignment at sanitary discharge pipes may also lead to leakage.

A simplified ceiling leakage rectification procedure can be shown as below:



The following sections give a brief description of the materials that are commonly used in rectification works and the different types of repair methods for arresting ceiling leakage.

8.3.1 Materials for Repair

The pre-packed waterproofing screed, as explained in Chapter 2, is able to produce good bond strength with low shrinkage. The use of pre-packed waterproofing screed allows better site control of quality and housekeeping.

Flexible cementitious membrane (or other approved water-based membrane) is recommended because it requires much less stringent surface preparation compared to solvent-based polyurethane membrane. It is able to achieve adequate bonding to the substrate even if the surface is wet and not totally free of dust.

Chemical grouts are materials which mix readily with water at the time of application. As such, chemical grouts provide good penetration of wet joints and cracks. Chemical grouts react with the water to form a waterproofed solid, stopping the water that is infiltrating the structure. A common chemical grout used to seal off leaks in concrete is the polyurethane injection grout, which upon contact with water, expands and forms a tough, flexible foam seal that cannot be penetrated by water.

8.3.2 Rescreeding Method for Rectification of Ceiling Leakage

In general, this provides a more effective rectification to ceiling leakage. All the floor tiles, screed, squat or pedestal pan and any other fixtures are first removed. Areas around pipes should be hacked slightly deeper (about 25mm more). Hacked surfaces should be cleaned free of loose particles. Ensure proper preparation of floor surface (eg, existing floor tiles/ screed to be completely removed, hacking around pipes/ gully trap). The hacked

areas around pipes are then filled with a suitable material such as non-shrink grout. Ensure that the application of non-shrink grout is according to manufacturer's instructions.

A good quality waterproofing membrane is applied and left to cure to the manufacturer's requirements. A new layer of waterproofing screed is subsequently laid on the membrane after the membrane is sufficiently cured. Please refer to Chapter 5 – 7 for more details on the preparation of the surfaces, membrane application and laying of screed.

New floor tiles are subsequently laid and the pedestal pan (if applicable) and any other fixtures are re-installed. If squat pan is to be re-installed, this should be done after the membrane had cured and before screeding work is carried out.

8.3.3 Injection of Chemical Grout

This method of rectification results in lesser inconvenience to the homeowners as the repair work does not require hacking of floor tiles and removing of existing fixtures.

In cases where leakage is observed, the specialist should first locate the crack which is causing the leak. Before any rectification work can proceed, the crack and surrounding concrete should be thoroughly cleaned (by mechanical means) to remove all loose, unsound, friable and deleterious materials. A 45-60 degree angle hole should then be drilled so as to intersect the center of the crack at a depth of approximately 1/3 thickness of the concrete. The center to center distance between the drill holes will depend on the characteristic of the proprietary product used and site conditions. To remove debris and improve penetration, the crack should be flushed with water prior to resin injection. A plastic injection packer is then inserted into the hole.

If the proprietary product is made up of 2 components, care should be taken to ensure correct mix ratio of the components. It is a good practice to test out a small amount as sample first. The chemical grout is then injected through the nozzle into the crack line using a suitable pump, at the specified pressure. Injection is considered complete once excess amount of unreacted grout is observed to appear from the crack.

Upon completion, the plastic packers can be removed. The face of the joint and the excess materials should be cleaned on the following day and all holes are to be filled using an approved material eg, non-shrink grout.

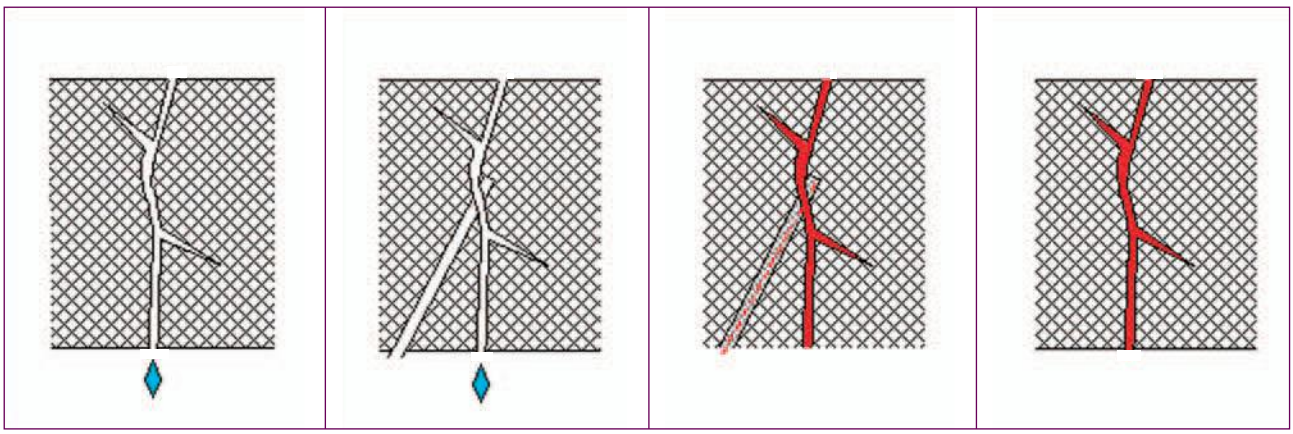
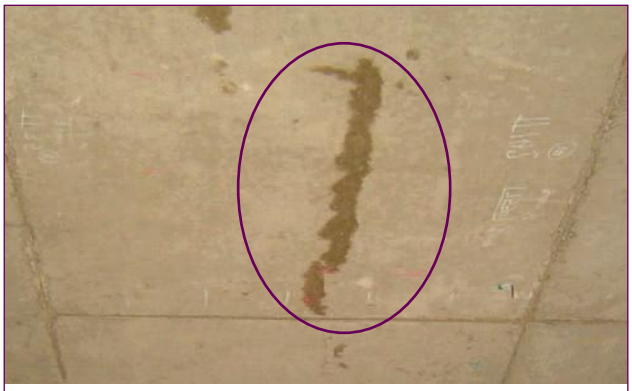
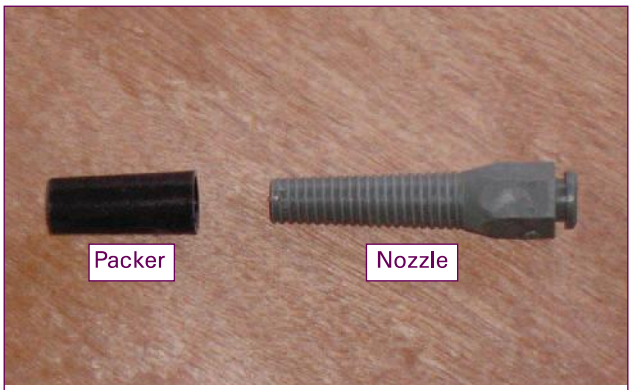


Figure 8.3: Sealing of a crack in concrete structure using injection method



a) Detection of seepage

b) Pressure grout machine and proprietary product

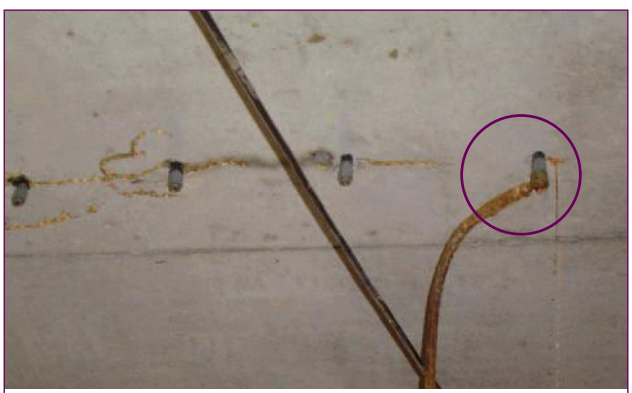


c) Tools for chemical grouting

d) Drilling hole

e) Nozzles inserted along crack line

f) Mixing of products



g) Grouting in progress

h) Fully grouted crack line

Figure 8.4: Injection of chemical grout

Appendix

Appendix A : Waterproofing Systems

Appendix B : Tests for Liquid Applied Waterproofing Membranes

Appendix C : Sample Material Safety Data Sheet

Appendix D : Sample Inspection & Test Plan

Appendix E : Sample Checklist for In-Process Inspection

Appendix A

WATERPROOFING SYSTEMS

The available waterproofing systems can be generally classified under three main groups as given in Figure A.1. Each group has their advantages and disadvantages when used in different parts of the building. The designer should carefully study the general characteristics of each group and propose the most suitable material for use. Table A.1 provides a general classification of the systems.

Figure A.1: Waterproofing System Classification

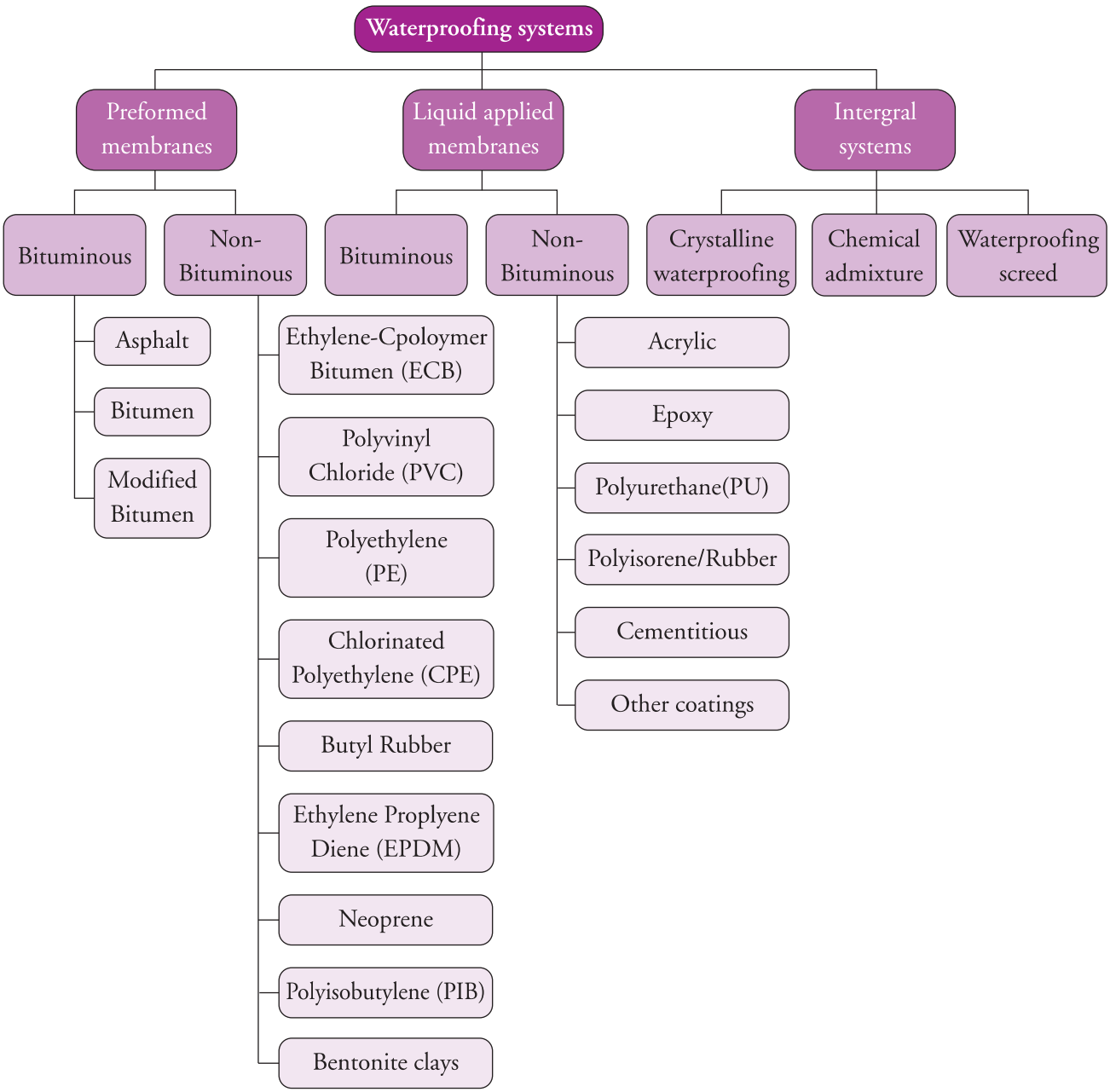


Table A.1: Comparison of System

DESCRIPTION	PREFORMED MEMBRANES		LIQUID APPLIED MEMBRANES		INTEGRAL SYSTEMS		
	Bituminous	Non-bituminous	Bituminous	Non-bituminous	Crystallisation waterproofing	Chemical admixtures	Waterproofing screeds
Surface preparation	Clean and dry (less affected by damp concrete)	Clean and dry (less affected by damp concrete)	Clean and dry (roughness affect thickness)	Clean and dry (roughness affect thickness)	Clean and damp (to promote better penetration into concrete pores)	Not applicable as it is mixed into concrete during batching	Reasonably rough to provide good mechanical key for adhesion of screed
Priming (concrete)	Required	Required	Not required	Not required	Not required	Not required	Old concrete may require a coat of bonding agent
Application	Skill required	Higher skill level required	Simple multi-coat application	Simple coating application	Slurry application by brush/ spray or dry sprinkling	Mixed into host concrete during batching	Masonry skills in application of cement screeding
Re-application	Skill required	Higher skill level required	Simple re-application (may need to cut-out)	Simple re-application (may need to cut-out)	Simple re-application by coating	Not possible to re-apply	Re-screed over area — may require bonding agent
Homogeneity of system	Joints are potential weakness	Joints are potential weakness	Seamless (note over-coating time)	Seamless (note over-coating time)	Not applicable	Not applicable	Cold joints are potential weakness
Inspection	Can be visually inspected	Can be visually inspected	Multi-layers require more inspection	Can be inspected visually	Can be inspected after application	Cannot be inspected	Can be inspected after application
Drying time	Not applicable	Not applicable	Require drying before proceeding	Require drying Before proceeding	Require drying before proceeding	Drying time same as host concrete	Require drying and proper set before proceeding
Curing	Not applicable	Not applicable	Curing required	Curing required	Curing similar to host concrete	Curing similar to host concrete	Curing required
Bridging over concrete defects	Can bridge over concrete defects	Can bridge over concrete defects	Can bridge over concrete defects	Can bridge over concrete defects	Limited to hair-line cracks only	Cannot bridge cracks in concrete	Limited crack bridging abilities
Protection against damage	Required	Required	Required	Required	Not required	Not required	Required against high impact and abrasion
Ponding test	Can be done immediately	Can be done immediately	Require curing before testing	Require curing before testing	Ponding after initial set (2 hours)	Immediate ponding when concrete sets and cures	Require curing before testing

Appendix A

Table A.2: Characteristics of various waterproofing systems

BITUMINOUS PREFORMED MEMBRANE	
Asphalt	- Raw minerals mined from the ground. - Provides excellent waterproofing and adhesive properties. - Normally used as a fully adhered system.
Bitumen	- Residue (or by-product) derived from the process of refining crude petroleum. - Quality of bitumen can be quite different from one location to another. - Normally used as a fully adhered system.
Modified Bitumen	- Called "Straight-run" bitumen. - Normally, organic polymers are added to make the straight-run bitumen soft and flexible. - Not resistant against prolonged exposure to sunlight (ultraviolet radiation) and often get oxidised and crack up. - Oxidised bitumen (which are more resistant against UV radiation) are produced through an oxidation process by passing forced air through the straight-run bitumen. - Normally used as a fully adhered system.
NON-BITUMINOUS PREFORMED MEMBRANE	
Ethylene-Copolymer Bitumen (ECB)	- ECB sheets formed by extrusion of a complex chemical combination of bitumen and coal tar (residue of coat after distillation). - Capable of considerable resistance to ageing and effects of weather. - Normally can be loosely laid, mechanically fastened or fully adhered.
Polyvinyl Chloride (PVC)	- As a basic raw material, PVC is hard and brittle. - Through proper formulation with plasticisers and stabilisers, PVC membranes are made resistant to weather exposure and ageing. - Synthetic or fabric reinforcement mesh may be added to improve its tear resistance. - Normally can be loose laid, mechanically fastened or fully adhered.
Polyethylene (PE)	- When protected from UV radiation, it is very stable and last many years. - A non-breathing membrane and normally used as a low cost vapour barrier. - By itself, it is not used as a waterproofing membrane.
Chlorinated Polyethylene (CPE)	- A non-breathing membrane and may be loosely laid or fully adhered with a water-based synthetic resin adhesive.
Butyl Rubber	- A non-breathing membrane and a solvent based adhesive is used to seal the lap joints. - As a sheet membrane, it is difficult to adhere to concrete surfaces. - Normally laid loosely to surface.
Ethylene Proplyene Diene Monomer (EPDM)	- Similar to Butyl rubber, but with better weather resistance. - Has good resistance to corrosive chemicals, ozone, weathering and has extremely low water permeability. - Normally loosely laid.
Neoprene	- Produced from acetylene and hydrochloric acid. - A synthetic rubber and is quite resistant to chemical attacks. - Bends & molds to surfaces better than other synthetic rubbers and easier splice sheets. - Seldom used underground as waterproofing membrane, but superior to any of the other synthetic rubbers when used as flashing materials.
Polyisobutylene (PIB)	- Usually reinforced with a non-woven synthetic felt and has good ozone, UV resistance and extremely low vapour permeability. - Good resistance against dilute mineral acids and solutions of alkalis, but low resistance against oils and solvents. - Can be loosely laid, partially adhered or mechanically fastened.
Bentonite clays	- Bentonite clays used in waterproofing are primarily made up of silica, alumina, ferric oxide, magnesia, lime and soda. - Expand anywhere from 10 to 20 times its original volume when allowed to free swell in standing water. If exposed to external pressure, its swell will be less. - Bentonite clays (in board form) are placed against the structures. Joints between boards are normally coated with liquid bentonite to assure a tight seal. - Due to the pressure of the backfilled soil and water, it will swell and the restriction of swelling prevents further water penetration.

Table A.2 continues on next page ►

Appendix A

Table A.2 *(continued)*

BITUMINOUS LIQUID-APPLIED MEMBRANE	
Bitumen Compounds (Bituminous)	- Bitumen compounds are basically asphalt or bitumens in liquid form. - Similar properties to their sheet membrane counterparts. - Usually applied in one or more coats to provide watertightness to the structure.
NON-BITUMINOUS LIQUID-APPLIED MEMBRANE	
Acrylic	- Acrylic latex emulsions have been successfully used for above-grade waterproofing. - Not recommended for use in below-grade applications. - Most formulations consist of a combination of emulsified acrylic resin, fillers (calcium carbonate), wetting agents (surfactants), bacteria killers and plasticisers.
Epoxy	- Excellent adhesion to materials such as concrete, steel, wood and glass. - Should be applied on the interior (or negative-side) of the structure. When applying the epoxy film to a concrete surface, ensure a uniform bond to the surface. In most epoxy systems, the cured film usually has a higher tensile strength and greater bond strength than the tensile strength of concrete. - When applying, cleanliness and dryness of the substrate, temperatures and relative humidity are important factors to ensure proper adhesion and curing of an epoxy film. - Major disadvantage of epoxies is that they have no re-sealing qualities or elasticity. If the concrete surface cracks, the epoxy film will crack too.
Polyurethane (PU)	- Generally denotes a common range of liquid-applied membranes using polyurethane as its base. - Also includes the coal-tar or pitch modified polyurethane systems. - Generally self-levelling and used more often as roof coatings as they have good resistance against UV and colour selection. - Coal-tar behaves well as waterproofing component. Unlike bitumen, it is compatible and accepts modification with a higher polymer such as epoxy and urethane to improve it physical properties. - Coal tar urethanes are used more commonly in Singapore for wet areas as they are available as a single-pot, air-curing material, applied by brush or squeegee and is normally black in colour. - It is solvent based, requires ventilation and generally takes a longer time to dry and set.
Polyisoprene/ rubber	- Also known as rubberised bitumen or asphalt, they are available as a single-component liquid emulsion system for application by brush or rollers onto the concrete substrate. - Generally water-based and usually available as black colour. - Rubber-based coatings are recognised by their inherently high recovery rate upon elongation, giving it a spring-back effect similar to those of a rubber band.
OTHERS	
High strength, dense surface coating	- Can be applied as negative or positive-side barriers. - Bond strength between coating and concrete surface should exceed the tensile strength of concrete to insure against internal water pressure rupture. - Common applications for these surface coatings to provide waterproofing are parking decks where wheel traffic is not excessive (where wear resistant surfaces are necessary, natural aggregates are added), swimming pools, water tanks, elevator pits and tunnels.
Crystalline Waterproofing	- Similar to the high strength, dense surface coatings, except that a chemical reaction takes place at the coating/ concrete interaction surface.
Admixtures	- Chemicals that can be added to concrete to improve its waterproofing abilities. - Waterproofed Portland cement is achievable by inter-grinding a small amount of calcium, aluminium or other stearate with the cement clinker. - Cement additives are generally blended at the manufacturing plant. Admixtures are usually added to concrete as it is being mixed. - Admixtures generally are used to effect workability, strength and setting time more than watertightness.
Waterproofing screeds	- Similar to high strength, dense surface coatings except that they usually combine with a latex such as acrylics, polyvinyl alcohol and/ or styrene-butadiene to make the systems flexible.

Appendix B

Tests for liquid applied waterproofing membranes

TENSILE STRENGTH AND ELONGATION AT BREAK TEST STANDARD (ASTM D412: 98A OR ITS LATEST YEAR OF EDITION)	
Condition as Cast	Test specimens in the shape of dumbbells and straight pieces of uniform cross-sectional area. ASTM D 412: 1998a is recommended for elastomeric and flexible cementitious membranes.
After Heat Ageing	Ageing of the waterproofing system can be accelerated by heating in a circulating-air oven as outlined in ASTM C836 at 50°C or 70°C for 14 days.
After Chemical Immersion	The proposed waterproofing system must be able to withstand attack by chemicals commonly found in toilets and bathrooms. These shall include at least: a) Sodium Hypochloride (NaOCl) - with a concentration of 0.5% (v/v) to simulate household detergents. b) Ammonium Hydroxide (NH_4OH) - with a concentration of 1.25% (v/v) to simulate urine. c) Hydrochloric acid (HCl) - with a concentration of 3.70% (v/v) to stimulate bleaching agents. The test specimens will be immersed in the above chemicals for 72 hours at room temperature prior to determining the effect (if any) on their tensile properties.
HARDNESS (ASTM D 2240: 1995 OR ITS LATEST YEAR EDITION)	
Based on the penetration of a specific type of indentor when forced into the material under specified condition. The indentation hardness is inversely related to the penetration and is dependent on the elastic modulus and viscoelastic behaviour of the material. The method permits hardness measurements based on either initial indentation or indentation after a specified period of time.	
ADHESION STRENGTH TO SUBSTRATE (ADOPTED FROM ASTM D 4541: 1993 OR ITS LATEST YEAR OF EDITION)	
The adhesion bond strength of the membrane to G40 concrete will be determined in accordance with the above adopted test procedure. The liquid applied membrane is applied on a clean, flat and pre-damped with water (i.e. only for water-based system) cast surface. The liquid membrane will be left to cure for normally 7 and 28 days for elastomeric and flexible cementitious membranes, or as recommended by manufacturer/ supplier.	
Condition as Cast	The adhesion strength will be determined after the membrane has been fully cured. Early age strength can also be determined, say at 3 days for elastomeric and 7 days for flexible cementitious membranes.
After Hot Water Immersion	It may be necessary to immerse the test specimen in hot water (i.e. 50°C or 70°C) for 72 hours prior to the testing for adhesion strength for both elastomeric and flexible cementitious waterproofing membranes.
After Chemical Immersion	No need to conduct the adhesion bond strength after the chemical immersion, as discussed in the tensile strength and elongation break test.
CRACK BRIDGING (ASTM C836: 1995 OR ITS LATEST YEAR OF EDITION)	
Condition as Cast	The crack bridging ability of the membrane should be assessed based on the test procedures outlined in ASTM C 836: 1995. Basically it will involves prior application of the membrane over 2 pieces of concrete blocks held together tightly with a masking tape. The blocks will then be subjected to pulling (stretching) and closing at specified speed over a certain distance (say 2mm) to simulate crack movement. After the required number of cycles, the membrane should be inspected for crack. The test procedures in accordance with ASTM C 836: 1995 shall be followed except the following: i) The test is carried at room temperature, i.e. 23 ± 2°C and 50 ± 5% RH. ii) The test specimen is subjected to ten cycles of movement, each cycle consisting of pulling the blocks apart, at the rate of 3.2 mm/hr, until the space between is 2mm, then closing the space at the same rate.
After Heat Ageing and Chemical Immersion	It may not be necessary to repeat the crack bridging test after the ageing and chemical immersion treatment. The effects after heat ageing and chemical immersion can be more directly assessed through properties like tensile strength as well as the elongation at break.

Tests for liquid applied waterproofing membrane continues on next page ►

Appendix B

Tests for liquid applied waterproofing membranes *(continued)*

CHLORIDE CONTENT BY ION SELECTIVE ELECTRODE ANALYSER (ISEA)

The amount of chloride in a cementitious product should be kept as low as possible to prevent corrosion of steel bars which may cause expansion and subsequent spalling of building structure. It may also react adversely with the cement binder thus weakens the strength of the system.

The chloride content can easily and accurately measured by using a chloride ISE. Chloride is extracted directly from the cementitious slurry or ready mixed cement powder. The chloride standard solutions are prepared and measured to construct a calibration graph. After the calibration, the concentration of chloride in the extracted solution of test sample is then measured.

RESISTANCE TO WATER PENETRATION (ADOPTED FROM DIN 1048: PART 5: 1991 OR ITS LATEST YEAR OF EDITION)

This method describes a laboratory procedure for determining the ability of a waterproofing membrane to resist penetration of water when the membrane is under a constant water pressure. The test is conducted by applying water pressure of 0.2 bar (kgf/cm^2) on concrete discs coated with the test membrane for 6 hours. After the test is completed, the concrete disc is split into halves, and observation is made for any sign of water penetration into the discs.

WATER VAPOUR PERMEABILITY/ TRANSMISSION (ASTM E 96: 1995 OR ITS LATEST YEAR OF EDITION)

The aim of water vapour transmission test (WVT) as describes in ASTM E 96 is to obtain reliable values of water vapour transfer through permeable and semi-permeable materials in specific test dish. There are two (2) basic methods in this ASTM test procedure, i.e. Desiccant or the dry method and the water method. In the dry method, one side of the membrane will be subjected to low humidity (eg, expose to desiccant) and the other high humidity. Water method will involve the use of distilled water in the test dish and the low humidity on the outside. Both methods provide a measurement of WVT expressed in terms of $g/hour.m^2$ under specific conditions of temperature and humidity at each surface.

SET-TO TOUCH TIME/ TOUCH DRY (ASTM D1640: 1983 (1989) OR ITS LATEST YEAR OF EDITION)

This test method is used to determine the various stages and rates of drying of organic coating normally used under conditions of ambient room temperature. For waterproofing membranes, it is important to know the initial drying time of the liquid membrane before second coating can be applied (i.e. for 2 or more coats system) or other activities can be proceeded. The coating is set-to-touch when it still shows a tacky condition, but none of it should adhere to the finger when the test coating is lightly touched with the tip of a clean finger.

CHARACTERISATION OF POLYMER (BY FTIR, DTA & TGA)

Fourier Transform Infrared (FTIR) spectroscopic technique is capable of scanning vibration modes of a polymer in a certain frequency range. The vibration modes (i.e. absorption peaks) of a specific functional group at a fixed frequency will provide qualitative analysis of a polymer used for both elastomeric and flexible cementitious membrane. Differential Thermal Analysis (DTA) provides transition temperature of polymer, such as melting and glass transition temperatures, and it is a complementary technique to TGA. Thermogravimetric Analysis (TGA) technique produces a quantitative break down of individual component in the waterproofing membrane system if the difference in the thermal degradation temperature is at least $10^{\circ}C$ between each component.

These analytical techniques (i.e. FTIR, DTA/ DSC and TGA) will provide fingerprint information/ data on the polymer and content of individual component in the waterproofing system, as well as its thermal property. These combined fingerprint data will serve as references for future comparison for checking any changes of the polymer or alteration of the polymer/ solid content (i.e. dilution or adulteration).

To prevent adulteration or unauthorised modification to product formulation and composition after approval is given, it may be necessary to conduct spot checks (say every 6 months) by taking random samples directly from job-sites for checking on some specific qualities such as:

i) Characterisation of polymer by FTIR, TGA and DTA/ DSC; &
i) Tensile strength and elongation at break (condition as cast only)

VOLATILE CONTENT BY THERMOGRAVOMETRIC ANALYSIS (TGA)

Volatile content of elastomeric membrane can be accurately determined by a thermal analyser (TGA). The liquid membrane is weighed and placed in an alumina crucible, and heated in a furnace at a rate of $5^{\circ}C$/min from ambient to $105^{\circ}C$ under nitrogen condition. After reaching $105^{\circ}C$, the sample is held isothermally for 3 hours. Finally, the sample is cooled down to ambient temperature under nitrogen flow. The volatile content can then be computed accurately.

FLASH POINT (SS 5: PART B15: 1987 OR ITS LATEST YEAR OF EDITION)

The aim of determining flash point property is to check the flammability of the product. Flash point refers to the lowest temperature at which application of the test flame causes the vapour at the surface of the liquid to flash or ignite. One of the test methods is described in SS 5: Part 15: 1987, using a closed-cup flash point tester.

Appendix C

Sample Material Safety Data Sheet

Product Name : _____

1. IDENTIFICATION OF SUBSTANCES/ PREPARATION AND COMPANY

Chemical description : _____

Supplier : _____

Emergency Telephone : _____

2. COMPOSITION/ INFORMATION ON INGREDIENTS

Concentration	Composition	CAS No.

3. FIRST AID MEASURES

General
Inhalation
Eye Contact
Ingestion

4. HAZARDS IDENTIFICATION OF THE PRODUCT

5. FIRE-FIGHTING MEASURES

Extinguishing Media
Personal Protective Equipment

6. SPILL OR LEAK PROCEDURES

7. HANDLING AND STORAGE

Handling
Storage

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Exposure controls
Personal/ Respiratory Protection
Eye Protection
Hand Protection
Other Protective Equipment

Sample Material Safety Data Sheet continues on next page ►

Appendix C

Sample Material Safety Data Sheet *(continued)*

9. ECOLOGICAL AND CHEMICAL PROPERTIES

Appearance
Odour
pH @25°C
Specific Gravity
Volatile Content (%)
Solubility in water
Flash Point
Flammability

10. STABILITY AND REACTIVITY

Stability

Hazardous polymerization

11. TOXICOLOGICAL INFORMATION

Inhalation and Overexposure
Skin Contact
Eye Contact

12. ECOLOGICAL INFORMATION

13. DISPOSAL CONSIDERATIONS

14. TRANSPORT INFORMATION

15. REGULATORY INFORMATION

16. OTHER INFORMATION

Project: _____

Scope of work : **Waterproofing to Wet Areas**

S/NO	ACTIVITY	RESPONSIBILITY (TO BE ASSIGNED)	INSPECTION METHOD	REQUIREMENT REFERENCE	ACCEPTANCE CRITERIA	STAGE/ FREQUENCY	RECORDS
1	**SUBMISSION**						
1.1	System type	MC/ADO	Review	-	Approved	Initially	Approved submissions
1.2	Technical data	MC/ADO	Review	-	Approved	Initially	Ditto
1.3	Test report	MC/ADO	Review	-	Approved	Initially	Ditto
1.4	Method Statement	MC/ADO	Review	-	Approved	Initially	Ditto
1.5	Shop drawing	MC/ADO	Review	-	Approved	Initially	Ditto
1.6	Working Programme	MC/ADO	Review	-	Approved	Initially	Ditto
1.7	Warranty	MC/ADO	Review	-	Approved	Initially	Ditto
2	**INCOMING MATERIALS INSPECTION**						
2.1	System type	MC/ADO	Visual	Visual	As per approved samples	Each delivery	Delivery dockets
2.2	Manufacturer/ supplier/ agent	MC/ADO	Visual	Visual	As per approved samples	Each delivery	Delivery dockets
2.3	Area of application	MC/ADO	Visual	Visual	As per approved samples	Each delivery	Delivery dockets
2.4	Shelf life	MC/ADO	Visual	Visual	Conform to manufacturer's data sheet	Each delivery	Delivery dockets

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND: **MC** – Main contractor/ Contractor/ Waterproofing Specialist/ Applicator **ADO** – Architect/ Designer/ Owner

Sample Inspection and Test Plan continues on next page ►

Appendix D

Sample Inspection and Test Plan *(continued)*

S/NO	ACTIVITY	RESPONSIBILITY (TO BE ASSIGNED)	INSPECTION METHOD	REQUIREMENT REFERENCE	ACCEPTANCE CRITERIA	STAGE/ FREQUENCY	RECORDS
3	**SUBSTRATE PREPARATION**						
3.1	Carry out structure watertightness test	MC/ADO	Visual	Section 7	No leakage	Before surface repairs. 100% wet areas	Appendix E
3.2	Concrete repairs if required (repeat watertightness test)	MC/ADO	Visual	Section 5	Approved	Before surface preparation	Appendix E
3.3	Preparing and testing surface	MC/ADO	Visual/ measure	Section 5	Conform to manufacturer's data sheet	Before application	Appendix E
3.4	Rendering for membrane upturn, bath/ shower etc	MC/ADO	Visual	Section 5	Conform to shop drawings	Before application	Appendix E
3.5	Angle fillet/ cant	MC/ADO	Visual	Section 5	Conform to shop drawings	Before application	Appendix E
3.6	Protection to wet area	MC/ADO	Visual	Section 7	Approved	Before application	Appendix E
4	**MEMBRANE APPLICATION**						
4.1	Application procedure	MC/ADO	Visual	Section 6	As per approved samples	Before application	Appendix E
4.2	Tools and equipment	MC/ADO	Visual	Section 6	As per approved samples	Before application	Appendix E

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND: **MC** – Main contractor/ Contractor/ Waterproofing Specialist/ Applicator **ADO** – Architect/ Designer/ Owner

Sample Inspection and Test Plan continues on next page ►

Sample Inspection and Test Plan *(continued)*

S/NO	ACTIVITY	RESPONSIBILITY	INSPECTION METHOD	REQUIREMENT REFERENCE	ACCEPTANCE CRITERIA	STAGE/ FREQUENCY	RECORDS
4.3	Primer application (if required)	MC/ADO	Visual	Method statement	Conform to manufacturer's data sheet	Before application	Appendix E
4.4	Treatment to pipes, floor traps etc.	MC/ADO	Visual	Section 6	Conform to shop drawings	Before application	Appendix E
4.5	M&E clearance	MC/ADO	Visual/ measure	M&E requirement	No pipe leaks, no joints concealed	Before concealing	Test results
4.6	Membrane application	MC/ADO	Visual	Method statement	Conform to manufacturer's data sheet	Before/ during application	Appendix E
4.7	Check membrane thickness, number of coats & curing	MC/ADO	Visual/ measure	Section 6	Conform to manufacturer's data sheet	During application	Appendix E
4.8	Carry out watertightness test	MC/ADO	Visual	Section 7	No leakage	100% wet areas	Appendix E
4.9	Protective screed/ slurry coat	MC/ADO	Visual	Section 7	Conform to manufacturer's data sheet	After application	Appendix E
5	**FINAL INSPECTION**						
5.1	Screed mix and laid to fall	MC/ADO	Visual/ measure	Section 7	Conform to shop drawings	During screeding	Appendix E
5.2	Floor finishes	MC/ADO	Visual	Tiling Guide	Conform to shop drawings	At completion	Appendix E

Prepared by _____ Verified by _____ Approved by _____

Date _____ Date _____ Date _____

LEGEND: **MC** – Main contractor/ Contractor/ Waterproofing Specialist/ Applicator **ADO** – Architect/ Designer/ Owner

Sample Checklist For In-Process Inspection

Appendix E

Project: _____

Location: _____

CHECKLIST	REQUIREMENT	DATE OF INSPECTION	REMARKS
SURFACE PREPARATION			
1. Carry out watertightness test	No leakage		Recify till leakage is arrested
2. Rectify surface defects	Surface defects repaired; other foreign materials removed		
3. Rendering for membrane upturn shower/ bath etc.	Refer to extent of membrane specified in drawings, or as described in Section 5.2		
4. Angle fillet	All internal corners		
5. Surface cleanliness & dryness	In accordance to product requirements		
6. Primer application	In accordance to product requirements		
7. Preparation & clearance for M&E services	As specified in drawings		
MEMBRANE APPLICATION			
8. Tools and equipment	Use clean tools as specified in product specifications		
9. Mixing	Homogeneous, lump free & workable liquid achieved		
10. Treatment to pipes, floor traps, corners, groove lines, etc	Apply membrane to correct upturn & lapping		
11. Membrane application	- Correct membrane type - Membrane thickness - Coverage - Uniform & even application - Sufficient membrane overlap		
12. Check membrane thickness	As per manufacturer's requirement		
13. Number of coats and curing period	As per manufacturer's requirement		
PROTECTION & COMPLETION			
14. Carry out watertightness test	No leakage		
15. Cordon area	Proper barricade set up		
16. Level pegs	Gradient as per drawings		
17. Screeding	To fall towards drainage outlet		
18. Final finishes	As per drawings		

Inspected by _____

Date _____

REFERENCES

1. Structural Waterproofing, John C. Maxwell- Cook, London, Butterworth, 1967

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7. Standards Australia, Waterproofing of wet areas within residential buildings, AS 3740, 1994

8. Screeds, floorings and finishes – selection, construction and maintenance, M J Gatfield, CIRIA, Report 184, London, 1998