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Waterproofing Practices in Australia for the Building Construction

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Water damage in Concrete Structures

Efflorescence

Water leaking

Reinforcement Corrosion

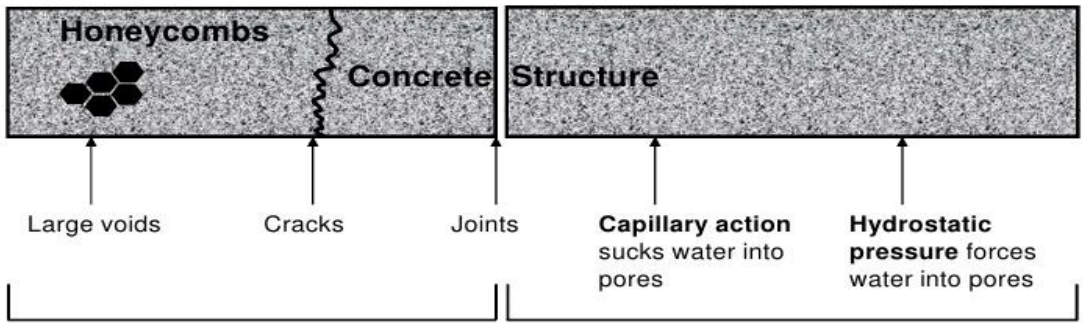
Cracking

Outline of the Presentation

1. Introduction
2. Standards and Building Codes in Australia
3. Classifications of Membrane Systems
4. Types of Waterproofing Membrane
5. Waterproof Defects and Risk Minimization
6. Waterproofing failures Case Studies
   - Testing and Quality Assurance
7. Concluding Remarks

Introduction – Water Permeability

How Water Can Penetrate Concrete Structures?



GRACE

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Waterproofing - Australian Standard Definition

- Waterproof is defined as "the property of a material that does not allow moisture to penetrate through it"
- Waterproofing membrane is defined as "a barrier that is impervious to moisture"

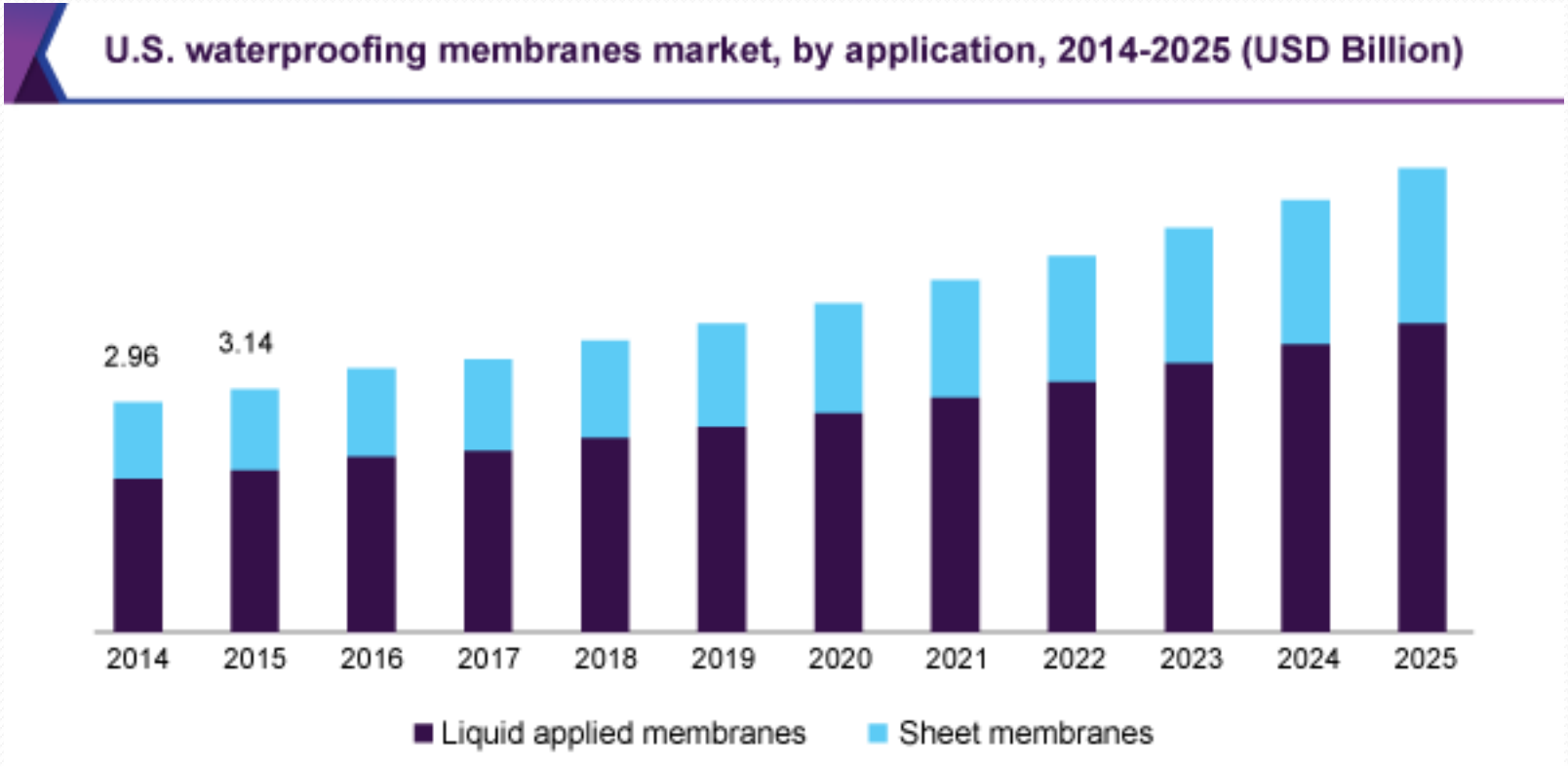
Hence, waterproofing can be defined as a system that creates an impermeable layer that prevents the infiltration and condensation of moisture into building components

Waterproofing Cost in Australia
An Example: Bathroom

Bathroom waterproofing can cost as little as $40 per square metre, but that is the low end of the scale.

In general, expect to pay between $500 and $750 to completely waterproof an average sized bathroom

Waterproofing Industry in USA

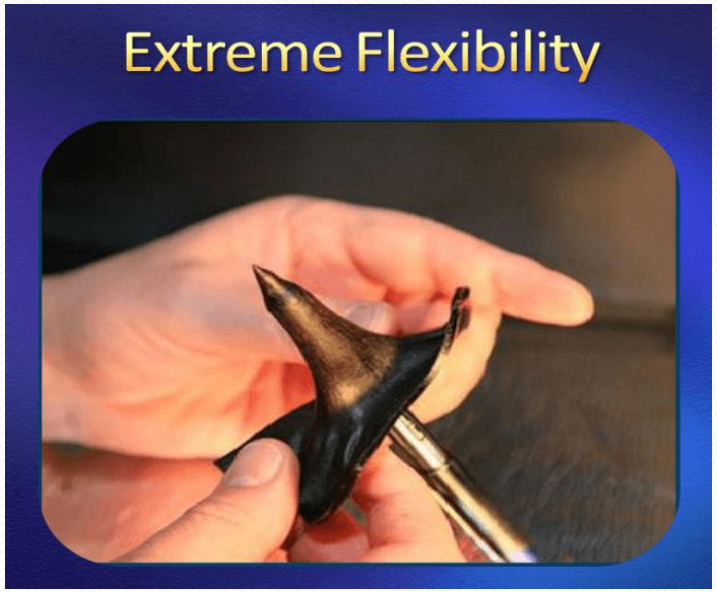


Waterproofing System

A comprehensive waterproofing system is an integrated combination of factors, includes

- **product selection**
- **membrane detail**
- **drainage design**
- **substrate preparation**
- **design**
- **installation**
- **quality assurance and testing**
- **maintenance**

Desirable Properties of Waterproofing Membranes



Elongation (Stretchability)
150% means 1.5 times original strength

Australian Standards (AS 4654.1) Testing of Membranes for Durability

TABLE A4

DURABILITY OF MEMBRANES

Exposure	Conditions	Requirements	Pass/fail criteria
Control samples	7 days at 23 ±2°C and 65 ±15% relative humidity	Record the tensile strength and elongation at break	N/A
Water immersion	7 days at 23 ±2°C and 65 ±15% relative humidity plus 7, 28 and 56 days immersed in 1 L of deionized water at 23 ±2°C, surface dry and test	Record the tensile strength and elongation at break. Note any significant change in appearance, e.g., blistering	Elongation at break shall be not less than 25% retention of elongation at break of the controls
Chemical resistance testing			
Detergent	7 days at 23 ±2°C and 65 ±15% relative humidity plus 7, 28 and 56 days immersion in 1 L 2% solution of N8* at 23 ±2°C, surface dry and test	Record the tensile strength and elongation at break. Note any significant change in appearance, e.g., blistering	Elongation at break shall be not less than 25% retention of elongation at break of the controls
Heat ageing	Condition where necessary for 7 days at 23 ±2°C and 65 ±15% relative humidity then plus 14 days heat ageing at 80 ±2°C plus 2 days at 23 ±2°C and 65 ±15% relative humidity	Record the tensile strength and elongation at break. Note any significant change in appearance, e.g., blistering, etc.	Elongation at break shall not be less than 50% of the result recorded for the controls
UV	Condition where necessary for 7 days at 23 ±2°C and 65 ±15% relative humidity then plus 1000 hours of exposure in a Q-Panel Ultraviolet (QUV) weatherometer	Record tensile strength and elongation. Note any significant change in appearance, e.g., blistering	Elongation at break shall not be less than 40% of the result recorded for the controls
Bioresistance	Due to the diversity of testing for different materials, it is recommended that the manufacturing guidelines for bioresistance should be followed		

* Or equivalent. N8 is a generic type of detergent.

NOTE: Passing the 'heat ageing' requirement listed in Table A4 will automatically meet the requirement of the 'heat ageing' requirement of AS/NZS 4858.

Tensile strength and Elongation at varied exposures (elongation loss is compared with control sample results)

- Water immersion
- Detergents
- Heat Ageing
- UV Exposure
- Bio-resistance

Australian Standards (AS 4858)– *Wet Area Membranes*

Standard Testing Procedure for the

Evaluation of moisture penetration of waterproofing membrane

No current Australian Standards for

Waterproofing systems for below-ground use

Waterproofing to retaining walls, lift pits and basement under-slabs must be installed, according to the manufacturer's specifications by the licensed and approved applicators.

Building Code of Australia (BCA) sets the minimum health, safety and sustainability requirements in the building industry.

Technical Data Sheets (TDS)

Composition of membrane, application, application procedure, material properties, and coverage rate and safety advice

Selection and Forms of Membrane Systems

Selection of waterproofing membrane systems

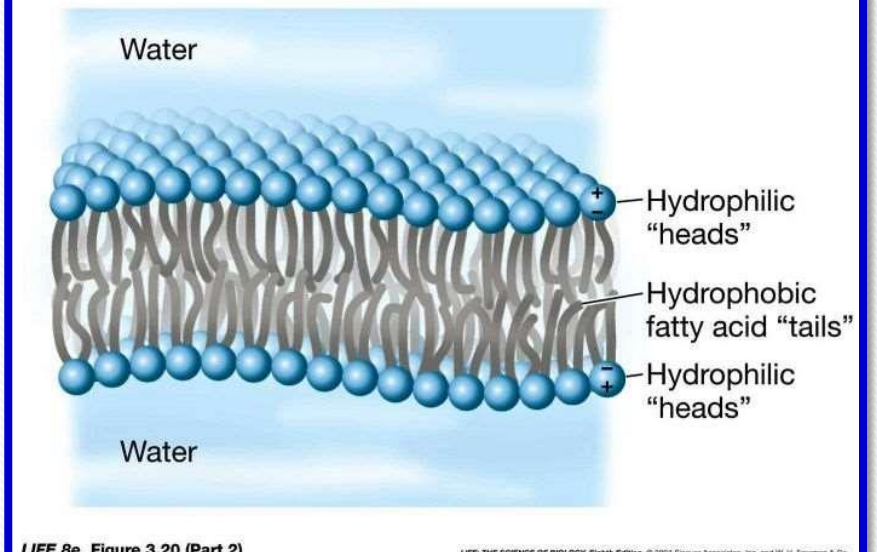
- : Membrane Type
- : Primer Type (affecting binding with substrate)
- : Volatile Organic Compound (VOC) content

Two forms of waterproofing membranes

- : Hydrophilic

  (Particles crystalline with water to prevent water ingress)
- : Hydrophobic

  (Blocking pores by fatty acid particles)



Classifications of Membrane Systems

Liquid Membranes

: Applied by Brush or Rollers

: Cold-applied or Hot-applied

: Volatile Organic Compound (VOC) content

: Acrylic membranes – inexpensive

- Three Forms:
  - Solid beads;
  - Polymer solution;
  - Emulsion (Commonly used)
    - Low cost;
    - Less hazard;
    - Altered chemically to suit applications
- Applications: Internal wet areas and Balconies
- Durability: High and UV Resistant

Liquid Membrane - Polyurethane

Known for its

- Robustness;
- Chemical properties;
- Ease of installation; and
- High performance.

Forms of

- Single or two components
- Aliphatic or Aromatic
- Hardened by air moisture and/or hardener
- UV Resistant formulation possible

Liquid Membrane – Applied by Rollers

Liquid Membrane – Applied on a podium by Rollers

Liquid Membrane - Modified bitumen systems

- Hot-Applied Bitumen
  - Risk of handling hot bitumen
  - Roof areas applications
- Polymer modified bitumen
  - Poor UV resistant
  - Unable to withstand pedestrians traffic

Hot-applied rubberized bitumen

Methyl-methacrylates (MMA) flooring systems (Advanced Acrylic Technology based on MMA Resin)

- Two-parts system
  - Rapid cure to create tough, flexible and seamless flooring and decking system
  - Suitable for most environmental conditions
  - Constant traffic or flooring systems
    - Commercial kitchen
    - Plant rooms
    - Hospital flooring
    - Bridges and
    - Roofs

Methyl Methacrylate (MMA) flooring system

[100% non-porous and monolithic coating; Rapid cure 1 -2 hours; Low temperature installation: - 27 to 29 C]

Offers excellent wear and slips resistance for high traffic applications; high durability and low maintenance

Sheet Membrane Waterproofing

Known for its

- Consistent thickness
- High Durability
- Labour intensive
  - Handling; Cutting; Installing; and Detailing
- Poor detailing and overlapping – Water seepage
- Installed by experienced and licensed applicator

Self-adhesive waterproofing Sheet membrane

Sheet waterproofing membranes

Sheets are overlapped (100mm) to avoid water penetration

Heat applied sheet membrane

These membranes are in the form of rolls which when unfurled are stuck to the substrate with hot tar based adhesives using blow torches

Bentonite clay (moisture-driven expanding) membrane waterproofing

When exposed to water, bentonite expands to several times (30 times) and creates a barrier to the passage of water.

Below-ground applications (basement retaining walls, under-slabs and lift pits) which are installed before the concrete is poured

Spray-on Membrane

Liquid Membrane cures to form a seamless and joint free membrane (Superior to sheet membrane)

Single operation needed to avoid cold joints

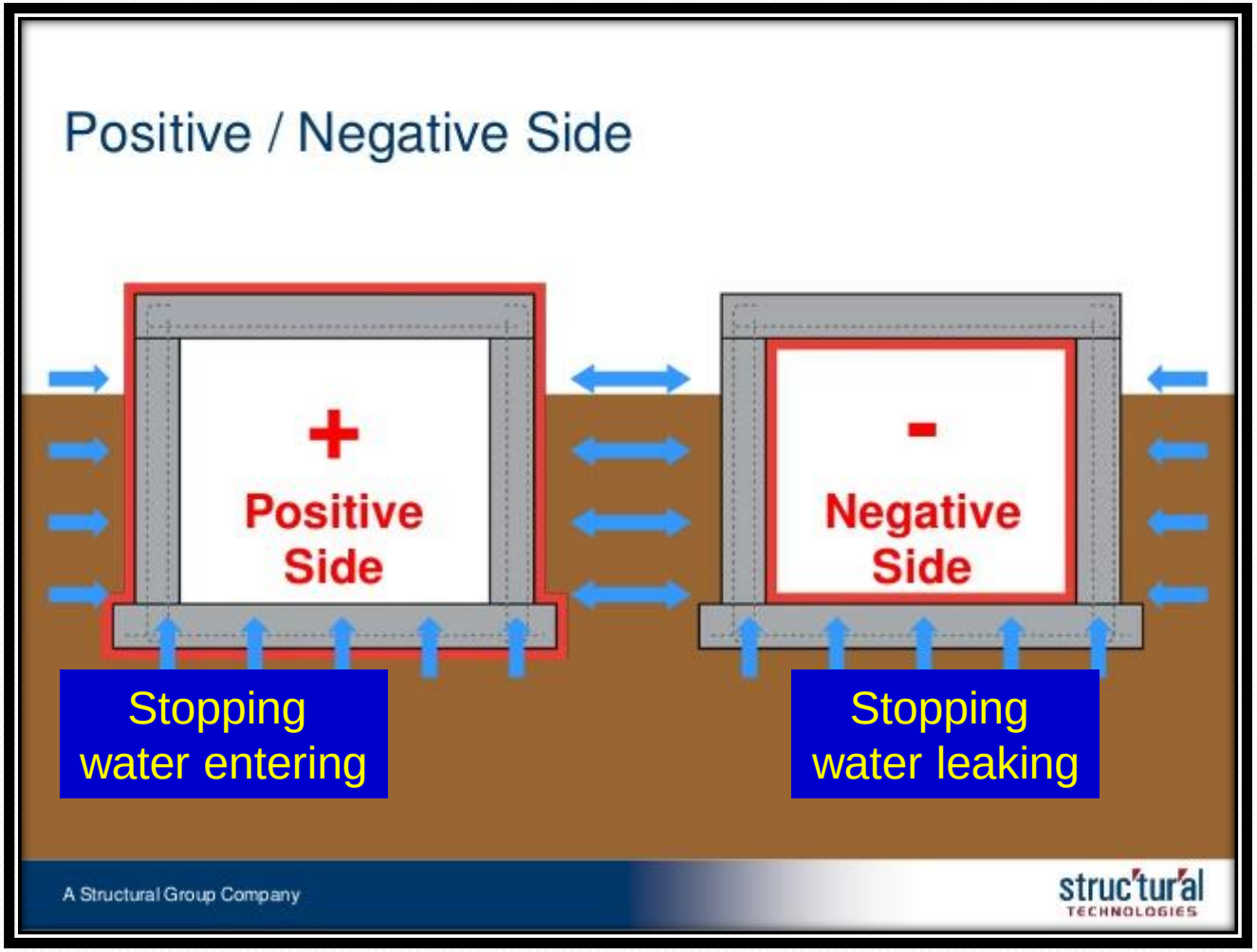
Roof Waterproofing

Liquid Membrane inhibits rust for metal roofs and slow down the deterioration of the roof surface

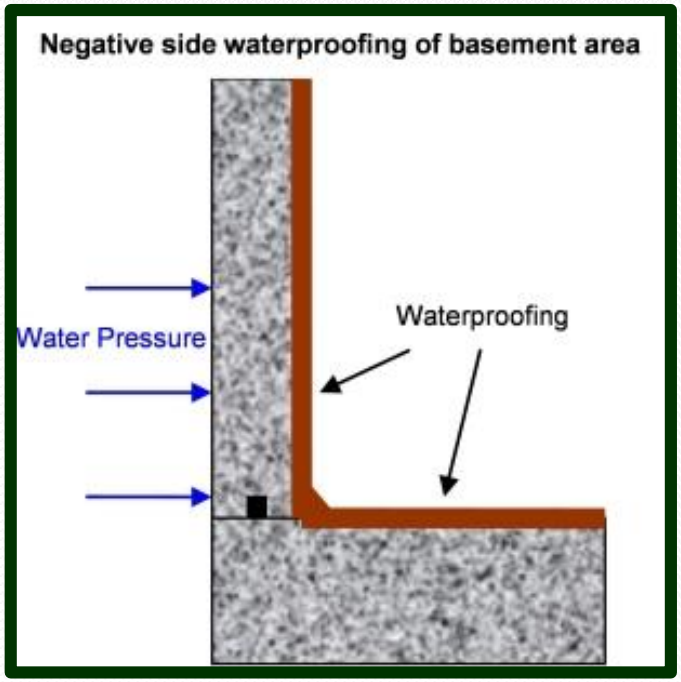
Liquid Rubber (Salt, UV and pollution resistant) used on roofs from coastal locations to CBD of large cities

Water Leaking Basement
Could be avoided by the application of proper waterproofing systems

Negative and Positive Side Membranes (High risk areas both negative and positive membrane applied)



Waterproofing – Negative sides



Waterproofing – Positive side
Wet areas – stopping water seepage

Design of waterproofing systems

: Drainage system

(Slope and drainage holes)

: Compatibility of membranes with other materials (Physical and Chemical)

: Exposure condition

(Durability of membrane)

: Expected movements

(Flexibility of membrane)

: Load in the membrane

(Membrane strength)


WATERPROOFING FAILURES
ERRORS IN ARCHITECTURAL DESIGNS
CONTRACTOR'S LAXITY
UNKNOWN TO STANDARDS

Waterproofing Failure

Leaching of efflorescence and signs of rust

Dampness of wall, rust and efflorescence

Waterproofing Failure (AS 4654.1: 2009)

Signs of Failure:

- : Bubbling of membrane
- : Wet walls and floor
- : Water ponding
- : Mould growth

Key Factors

- : Poor workmanship
- : Incorrect installation techniques
- : Poor understanding of the products used
- : Professional attitude

Waterproofing Failure

Condensation to the underside of a roof

Case Study 1: Membrane Failure (Deck area) (> 1000 sq. m. Trafficable membrane system)

Failure:
Signs of blistering and bubbling

Methyl-methacrylate resin (MMA)
(Durable, Flexible, Seamless)

- Primer
- Two coats of membrane
- Tack coat

Mechanically grinding the substrate surface

MMA system installed as per manufacturer recommendation

No sign of membrane failure in two weeks

Signs of failure (blistering and bubbling) in random areas that varied in size throughout the deck

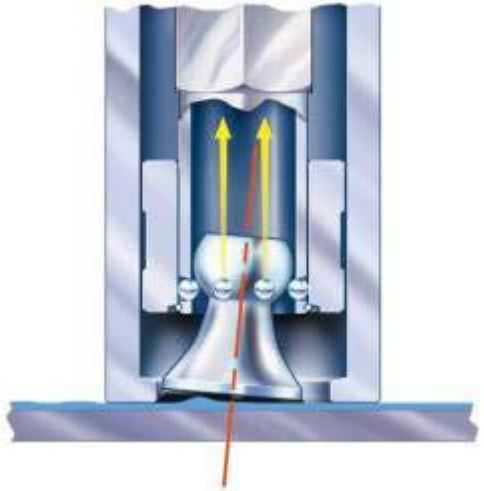
Case Study 1: Membrane Failure (Deck area)

Adhesion strength of 0.4 mPa

Types of failures - Adhesion Test

1. Membrane Failure (Dolly and Membrane adhesive failure)
2. Concrete Failure (Membrane and Concrete Failure)

Adhesion Test using Portable Adhesion Tester
(pulling out 20mm dia. aluminium dolly attached membrane surface) at failed areas and random areas



Test	Adhesion (mPa)	Film Thickness (mm)
1	0.40	2.0
2	0.50	2.1
3	0.50	2.0
4	0.40	2.0
5	0.50	2.2
6	0.50	2.1
7	0.60	2.0
8	0.40	2.1
9	0.60	2.0
10	1.0	2.2
11	0.6	2.1
12	0.4	2.1
13	0.5	2.0
14	0.4	2.0
15	0.7	2.1
16	0.6	2.0
17	0.4	2.1

QUALITY ASSURANCE TEST RESULTS
(Membrane and Concrete Failure at 17 out of 23 Tests – Poor Adhesion strength)
[Adequate adhesion strength = 0.70 mPa]

Dry Film thickness is above the required thickness

QUALITY ASSURANCE (Membrane Failure) at 5 locations

No sign of delamination between membrane layers showing proper membrane application

Stripping of failed surface indicated friable and unconsolidated substrate surface

Case Study 1: Solution to the problem (Tedious and expensive process)

- Stripping the failed area
- Adequate surface preparation
- Reapplication of the membrane
- Carry out quality assurance test

Quality Assurance Tests Results - after re-application of the membrane

- Adhesion strength (1.0 to 1.7 mPa with a mean of 1.3 mPa (> 0.7 mPa)
- Dry Film Thickness = 2.0 to 2.2 mm

Recommendation 1

For large areas to be waterproofed it is recommended to perform a test patch and to schedule a manufacturer's inspection on the area before the entire area is waterproofed.

Substrate preparation is essential in the proper installation of waterproofing membrane

Recommendation 2

Constantly monitor the conditions before, during and after installation of the membrane system.

This includes the air temperature, relative humidity, substrate temperature and dew point temperature.

The application of membrane should be performed at the recommended temperature thresholds as nominated by the manufacturer.

Dew Point Temperature (DPT)

- Dew Point Meter measures the humidity of the surface which affects Curing and Adhesion
- Dew Point Temperature (DPT) below 20 C recommended for some membrane applications
- Selection of primer type depends on the DPT
- Adhesion strength must be greater than 1 mPa

Case Study 2: Hospital Project

Waterproofing of 150,000 sq. m. floor space

90,000 sq. m. external and sub-base area

Specified Torch-on membrane system

- Changed to Spray-applied membrane system due to seamless waterproofing
- DFT (Dry Film Thickness) more than normal

Concluding Remarks

- Waterproofing is a vital building component in structures that should be taken with more care by the construction industry
- Proper waterproofing system requires adequate drainage, design details, installation techniques and maintenance procedures
- Membrane system proposed and waterproofing applicator's capability should be the major factors of decision-making
- The correct waterproofing system maintains the integrity of the building's intended design life.

Thank you
for your
attention