DEPARTMENT OF CIVIL ENGINEERING
IIT Madras

# Selection Criteria for Waterproofing Chemicals

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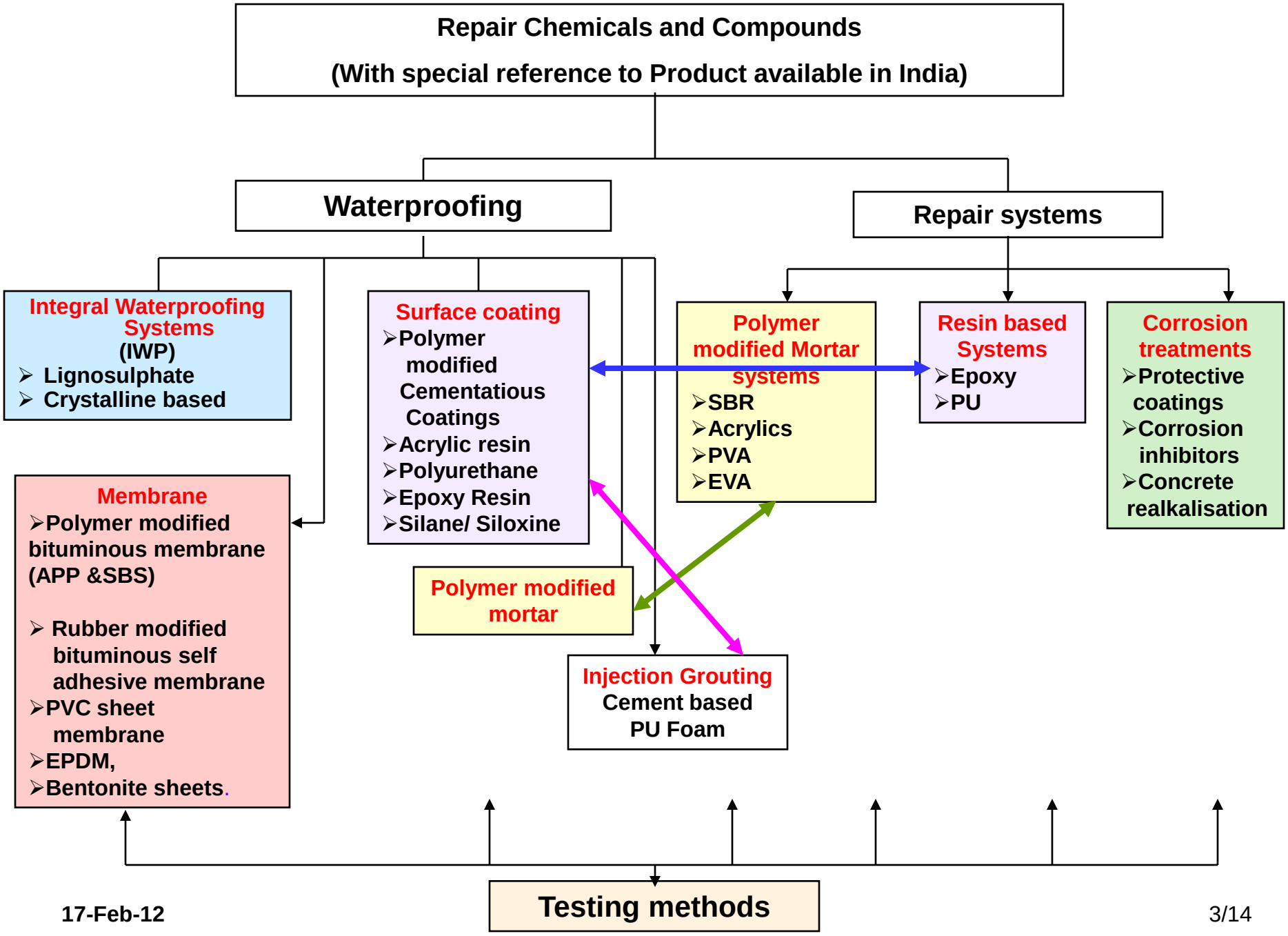
# Introduction

Aggressive environment leads to durability related problems in concrete structures, e.g. **Deterioration, Corrosion**

Some Desirable Properties for Waterproofing Materials are:

- Impermeability to water and chemical pollutants
- Compatibility with the repaired surface
- Bonding with base concrete
- Resistance to weathering action
- Ease of application and maintenance
- Cost effectiveness


Repair Chemicals and Compounds
(With special reference to Product available in India)
Waterproofing
Repair systems
Integral Waterproofing Systems
(IWP)
Lignosulphate
Crystalline based
Surface coating
Polymer modified Cementatious Coatings
Acrylic resin
Polyurethane
Epoxy Resin
Silane/ Siloxine
Polymer modified Mortar systems
SBR
Acrylics
PVA
EVA
Resin based Systems
Epoxy
PU
Corrosion treatments
Protective coatings
Corrosion inhibitors
Concrete realkalisation
Membrane
Polymer modified bituminous membrane (APP &SBS)
Rubber modified bituminous self adhesive membrane
PVC sheet membrane
EPDM,
Bentonite sheets.
Polymer modified mortar
Injection Grouting
Cement based
PU Foam
Testing methods

# Ambiguity in selection of waterproofing material

- Manufacturers specify (only) test results favorable to them. Most of these results are not relevant for WPM applications.
- Even chemically similar products are sold in the market with different concentrations and different price.
- Manufacturers often specify that water can be added to give required consistency, which leads to uncontrolled addition of water and variations in the properties.
- Chemical nature and expected reaction of WPM with substrata / concrete are not revealed by manufacturer.

# Testing techniques

In order to assess the material response, the following properties and evaulation procedures are useful:

- ✓ Water Permeability - EN-ISO 7031
- ✓ Water absorption - RILEM CPC11.2
- ✓ Pull off or Bond strength - C1583/C1583M-04e1
- ✓ Shrinkage and swelling - C1148 – 92a
- ✓ Water vapour permeability - ASTM E96/M-05
- ✓ Compressive strength - ASTM C109/C109M – 08
- ✓ Flexural strength - ASTM C348-08.
- ✓ Resistance to chemical attack - ASTM C267: 2001
- ✓ UV/ Accelerated weathering - ASTM G154

# Germann Water Permeability test (GWT)

**Testing procedure**

GWT is mounted on cube of 150mm size

Water pressure is maintained by tuning gauge in clock wise direction (0.50 to 1.00 bar)

After 2 min gauge is adjusted to keep the initial water pressure. Change in gauge reading is noted for every 2 minutes and up to 15 minutes,

$$q = \frac{B.(g_1 - g_2)}{At} = \frac{78.6(g_1 - g_2)}{3018.t} = \frac{0.026.(g_1 - g_2)}{t} mm/\text{sec}$$

$$c_{cp} = \frac{qL}{p.10^4}$$

**Ccp** - coefficient of the surface permeability concrete (Unit mm/ sec)

**q** - flux (mm/ sec )

*0 e 1,0 x $10^{-3}$ mm/sec ( high permeability concrete )*

*1,0 x $10^{-3}$ e 1,0 x $10^{-4}$ mm/sec ( average permeability concrete )*

*1,0 x $10^{-5}$ e 1,0 x $10^{-6}$ mm/sec ( low permeability concrete)*

*1,0 x $10^{-6}$ e 1,0 x $10^{-7}$ mm/sec ( high impermeability concrete)*

*1,0 x $10^{-7}$ e 1,0 x $10^{-9}$ mm/sec (higher impermeability concrete)*

# Accelerated UV Testing

**Procedure Adopted – ASTM G-154**

- Lamp used – UV 340 nm @ 1.55 W/m$^2$/nm
- Weathering cycle adopted – 8 hour UV exposure – 4 hour condensation
- Mechanical properties – test conducted on samples for Flexural strength, Bond strength, Compressive strength, Water permeability after 28 days of UV exposure and results were compared with samples kept to in lab condition.

# Why cement based products?

## Advantages of cement based repair materials

- Cost effectiveness
- Ease of application.
- Physical and chemical properties of cement based materials are almost similar to concrete.
- They are generally non-toxic
- Can be applied in wet condition
- Breathing ability

## Limitations of cement based waterproofing material

- Shrinkage, often resulting in cracking
- Poor resistance to aggressive chemicals

# IIT Madras Study on cement based waterproofing materials (WPM)

- To evolve a selection criteria, widely used WPM were procured from the market.
- WPMs used in this study
  - **SBR (Styrene butadiene rubber)**
  - **AR (Styrene acrylic)**
  - **IWP (Lignosulphonate based)**
- Dosage adopted as per the manufacturer specification.
- Tests related to mechanical and durability properties were conducted on WPM modified cement mortar

# Mix proportions adopted

Two different mixing procedures were adopted to assess the performance of the WPM

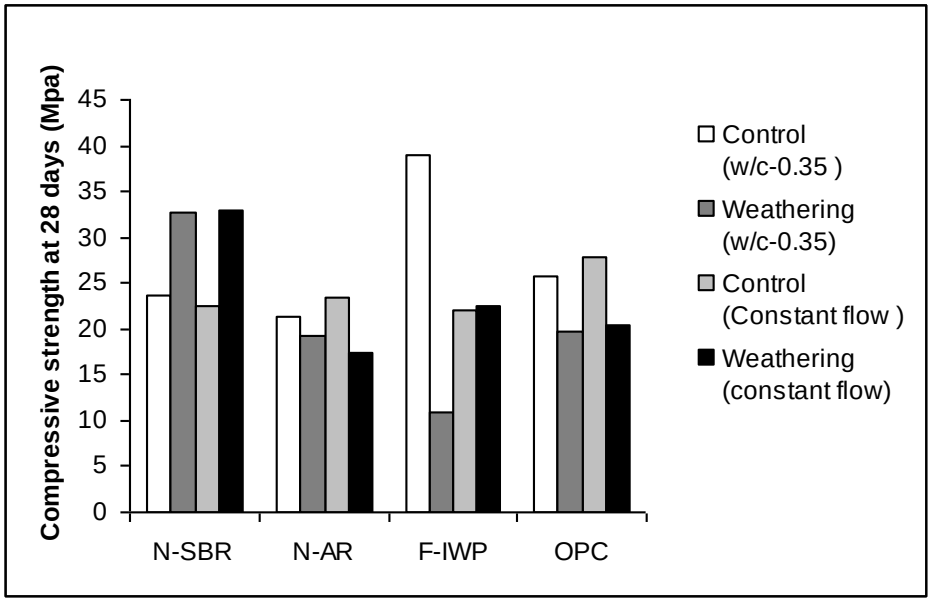
- Maintaining the same workability by varying the water to cement ratio (constant flow)
- Constant water to cement ratio (w/c) of 0.35*

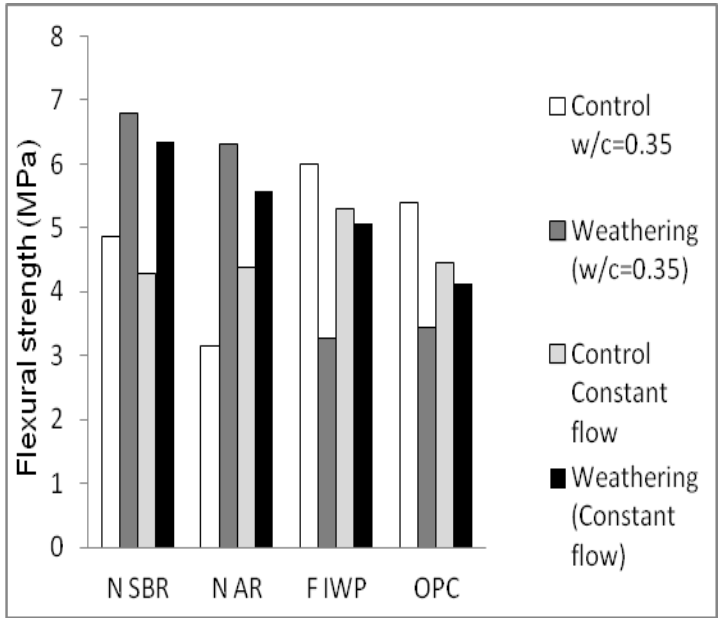
*Since the WPM employed for the work were either latexes or water emulsions the water present in the WPM were also included in the calculation of w/c ratio.

| Samples | Solid content in % | Dosage as per manufacturers specs. | Method 1. Constant water content | Method 2. Constant flow |
|---|---|---|---|---|
| | | | Ref w/c 0.35 | Ref w/c 0.50 |
| N-SBR | 58 | 9 Lit for 50 kg of cement | 0.27 | 0.29 |
| N-AR | 78 | 10 Lit per 50 kg cement | 0.31 | 0.325 |
| F-IWP | 59 | 200 ml for 50 kg of cement PPC | 0.35 | 0.48 |
| OPC | | | 0.35 | 0.50 |

# Mechanical Properties

- Higher the w/c, lower the mechanical strength
- Significant reduction in strength for OPC and IWP samples may be due to leaching and/or cracking due to alternate wetting and drying
- For OPC and IWP samples, significant colour changes observed after the exposure.
- Polymer modified samples exhibit significant increase in mechanical properties after accelerated weathering, which may be due to cross linking of polymer due to low irradiation & coalescence of polymer due to alternate heating and wetting.

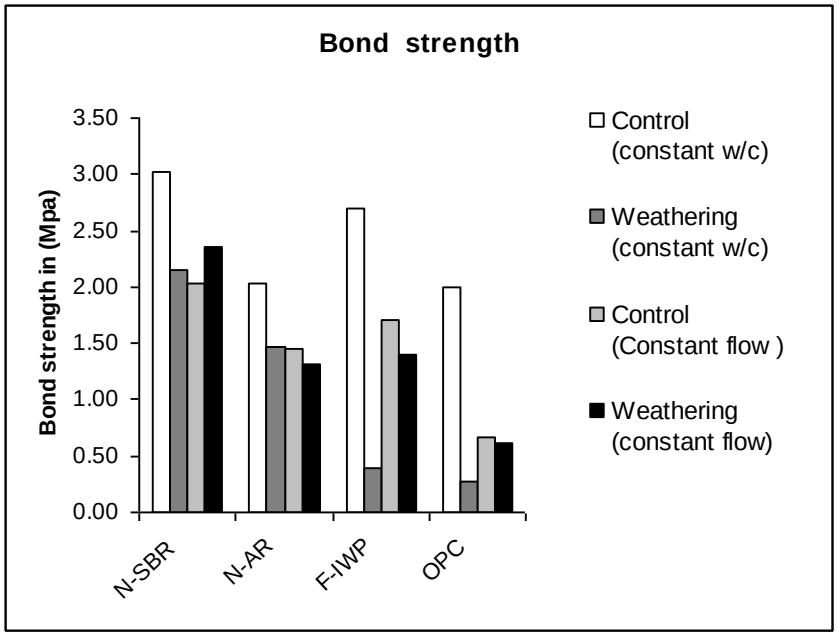


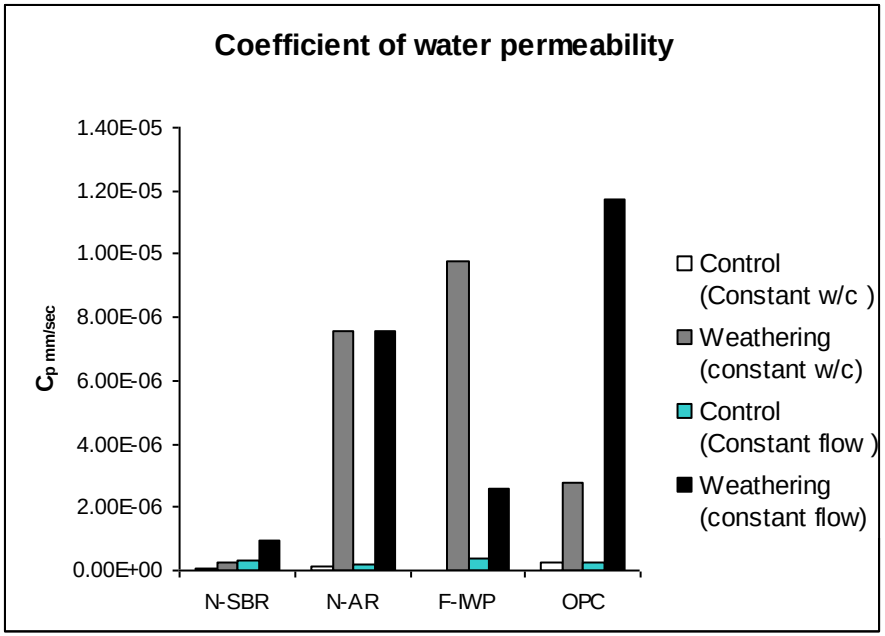



# Durability Assessment

- Except SBR, all the samples exhibit significant increase in permeability.

- In FIWP modified samples, minute pore holes are visible on the surface after 30 days of exposure, which may be due to degradation of lignosulphanate and leaching of cement hydration products due to alternate wetting and drying.



# Conclusions

Recommendation of tests to be conducted for mortars with WPM:

- ✓ Water permeability test & Water absorption test
- ✓ Bonding test / Pull off test
- ✓ Shrinkage strain
- ✓ Crack bridging
- ✓ Water vapor permeability

When mortars with WPM are exposed to natural environment in the application, all the above tests should be repeated on samples after exposing them to accelerated weathering (in order to check the degradation).

- ✓ SBR based products were found to be suitable for exposed environment
- ✓ Lignosulphonate based (IWP) products are cost effective, and suitable in areas where the mortar with WPM are not exposed to UV/weathering (e.g., sunken slabs in toilets)

Thank you