Advances in Waterproofing Materials & Technology

Sonjoy Deb, B.Tech, Civil
Associate Editor

"Water leakage is a serious recurring problem and the traditional approach from the negative side is, at best, a short term solution. Performance of most waterproofing technologies today falls short of expectations, often resulting in continuing damage and economic loss. The key to perfect waterproofing is to solve these existing problems with the positive approach."

"Waterproofing is defined as a treatment of a surface or structure to prevent the passage of water under hydrostatic pressure as per ACI committee 515."

Waterproofing is one of the most important parameters considered in the construction of buildings and structures to prevent leakages, dampness etc and making the structures durable. For waterproofing latest advanced technologies are being used worldwide. Leaks and dampness in walls, ceilings, roofs, etc. can certainly be prevented. It is important to appreciate that in a country like India with its seasonal heavy rainfall, efficient waterproofing of structures should receive the utmost attention right at the time of construction itself. Many builders tend to neglect this primary precaution, notwithstanding the fact that the pre-monsoon repairs soon turn out to be more expensive than pre-planned preventive measures during construction.

Commonly used Waterproofing Systems till date

The old traditional systems of waterproofing have certain limitations and being replaced by modern waterproofing systems. These are different types of waterproofing such as admixtures, impregnation, film forming membrane, surfacing, joint seal and grouting.

- Admixtures - Admixtures are used in concrete during...
construction for different purposes. The various types of mineral admixtures such as lime, silica, fly-ash and chemical admixtures like plasticizers, super plasticizers, water reducers and high range water reducers, accelerators, retarders, viscosity modifying admixtures, air entraining admixtures and shrinkage reducing admixtures are widely used for specific purposes. But all these help to reduce the water content of the mix and make the concrete dense, compact, crack free and durable and thus able to make leakage free structure.

- Impregnation - For waterproofing of old and new structures, impregnation type being used. In this method the solution is penetrated into the pore structure considering three different actions such as hydrophobic, partial filling, and filling. For the hydrophobic phase silane, siloxane, diffused quartz carbide solution are being used. For the partial filling phase silicone, sodium silicate (densifier/hardener) solutions are being used. For filling low viscosity epoxy and methacrylate solutions are being used.

- Film Forming Membrane - This may be a liquid applied waterproofing coating or a preformed elastomeric membrane.

- Surfacing - For waterproofing, asphalt, concrete, epoxy mortar, polymer concrete, polymer modified mortar etc. are used as an overlayment or cover over concrete.

- Sealants- Joints are the necessary important part of the structures as it acts a link between various parts of structures such as column-beam joint, column-slab joint, slab-slab joint, beam-beam joint, floor-floor joint etc. all these joints should be sealed with proper sealants.

The conventional methods of lime concrete, brick bat cob a though are still in use as waterproofing system but these methods are slowly becoming obsolete due to their short life and complexity of their application. In between polymeric membrane as a waterproofing coating gained popularity because of its abundant availability as a by product from petroleum at a cheaper price.

**About Polymeric Membranes**

Polymeric materials - acrylics, epoxy resins, polysulphides, polyurethanes and silicones - have been employed in many forms for waterproofing applications in building and construction. Elastomeric sheeting materials - such as neoprene, butyl, hypaion, PVC, rubberized asphalt - have been used for waterproofing of roofs in several countries. Their high cost and unknown performance in tropical climates have, however, been reasons for non-acceptance of these materials so far in India.

Polymeric membranes represent a transformation to a superior, factory made component that reduces field work, where quality control is most difficult. Considered the next stage in the evolution of traditional built-up membrane, modified polymeric membranes reduce the 2 or 3-ply, field-fabricated membrane to a more flexible, ductile sheet of 1 or 2 plies. The slightly higher material cost is generally offset by its cost effectiveness in the long run.

Two types of polymers dominate the modified membrane with their outstanding performance.

1. Atactic polypropylene (APP)
2. Styrene Butadiene styrene (SBS)

The two major polymers APP &SBS, differ fundamentally in the chemical nature. APP is a plastomer whereas SBS is an elastomer. This chemical difference manifests it self physically in much greater elasticity for SBS- based modified bitumen, with more nearly uniform properties through wider temperature range e.g. greater flexibility at low temperature. APP modified bitumen are generally stronger and stiffer than SBS modifieds. They also greater resistance to high temperatures.

**SBS vs APP**

SBS modified membranes offer greater versatility, in application techniques than APP modified membranes. APP modifieds with their high polymer content can be melted only via propane torching. With their much lower polymer content, SBS modified bitumen can be hot mopped at application temperature around 2200F.

**Reinforcement of Polymeric Membrane**

Most of the polymer modified bitumen membranes are available with reinforcement at the core in the form of Fibre glass mat, Non woven polyester mat & high molecular high density polyethylene with varied grammage. The Reinforcement at the core serves the following purposes.

- Increases tensile strength and puncture resistance.
- As a fire protection enhancement.
- As a structural element bridging substrate gaps.
- Enhances some elongation capabilities.

The particular properties imparted by reinforcement depend on following factors:


Figure 1: Cross section of polymer modified membrane with reinforcement
The predominant materials used as reinforcement are glass fibres and polyester. Glass fibres provide better dimensional stability, fire resistance and ultra violet resistance. Polyester mat provides greater strain energy. Polyester also has greater flexibility and fatigue and puncture resistance (Refer Figure 1). Figure 2 below demonstrates a typical application process of reinforced polymer membranes on RCC roof.

**Latest Addition to Water Proofing Technology**

Though all the polymeric membranes are widely used yet their performance today falls short of expectations, often resulting in continuing damage and economic loss. Figure 3 depicts the shortfalls of these technology and expectations from an ideal waterproofing material.

![Surface Preparation](a)  
![Primer application](b)  
![Rolling and aligning the membrane](c)  
![Torching of membrane and pressing](d)  

![Overlapping the membrane for minimum 100 mm](e)  
![Finishing at joints with slight torching](f)  

![Finishing at parapet](g)  
![Finishing with aluminium paint for non-foot traffic area and protective screed for foot traffic area](h)

Figure 2: Typical application process of Reinforced Polymer Membranes

Figure 3: Limitations of modern waterproofing technologies and requirement from an ideal waterproofing material.

- **Limitations of existing waterproofing technologies**
  - Lack of responsiveness to the shifting and vibration of structures
  - Low/poor bonding in wet conditions or underwater structures
  - Low/poor bonding between heterogeneous materials (metals, plastics, concrete, etc)

- **Truly effective waterproofing**
  - Tough, elastomeric, flexible and self-sealing accommodates movement and vibration
  - Workability in wet conditions, underwater and/or cold environment
  - Effective on multiple material surfaces and compatible with other waterproofing products
  - Easy maintenance
  - Non-Solvent material, Chemical resistance, durability, stability in a wide range of temperature
  - Environment-friendly composition

Some of the latest additions to the waterproofing technology are being discussed below which tries to overcome the above mentioned shortfalls.

(A) Thermoplastic & Thermo set Membranes-Single ply synthetic roofing membrane based on thermoplastic & thermo set technology are the latest addition to the waterproofing membrane family besides polymeric modified bituminous membrane.

Thermo set membranes are those whose principle polymers are chemically cross linked. This chemical cross-linkage is commonly referred as vulcanization. Main characteristic of thermo set polymers is once they are fully cured they can be...
bonded to like material with an adhesive. The four common sub-categories of thermo set roof membranes are:
- Neoprene (CR)
- Chlorosulfonated Polyethylene (CPSE)
- Epichlorohydrine (ECH)
- Ethylene Propylene Diene Monomer (EPDM)

Unlike thermo set membranes, thermoplastic membrane are different because there is no chemical cross linking. Thermoplastic membranes are single ply flexible sheet material that are divided into seven general sub categories.
- Polyvinyl Chloride (PVC)
- Copolymer Alloy (CPA)
- Ethylene Interpolymer (EIP)
- Nitrile Alloys (TPA)
- Tripolymer Alloy (TPA)
- Chlorinated Polyethylene (CPE)
- Thermoplastic Olefin (TPO)

Flexible PVC membrane in the thermoplastic category & EPDM in the thermo set category are becoming quite popular though Neoprene, thermoplastic Olefins are also being used for specific requirements.

(B) Active Polymer Technology

The predominante problem with conventional thermoplastic waterproofing membranes is that since they are installed loose laid they require an expensive grid anchoring system to isolate water infiltration due to an installation defect or puncture. But some advanced technology has evolved where if the thermoplastic membrane is punctured, its Active Polymer Core (APC) activates with the water to seal the breach thus preventing water infiltration in to the structure. Active Polymer Core Technology activates and seals water breach through the thermoplastic membrane — automatically and reliably. Unlike conventional thermoplastic waterproofing membranes, expensive grid containment systems are not required to maintain or control water infiltration. Additionally, the APC geo textile layer provides a protective cushion to decrease the potential of the thermoplastic membrane to be punctured from irregular substrate surface texture. Figure 4 shows advantage of APC technology over the conventional technology.

(C) A new concept in waterproofing material has come up which forms a gel that expands and adheres to any leaking area upon contact with water. This gel is formed by combining a polymer resin of rubberized asphalt with special adhesives. It seeks out leaks and expands to repair damaged layers. It absorbs movement and vibration to minimize damage and separation. This material can be applied as a membrane sheet or a repair material in any environment (Refer Figure 5).

The benefit attained with such materials are as mentioned below:-
- Responsive to substrate movement and absorbs vibration due to the gel’s flexibility and dampening capabilities
- Materials are non-degradable and thus maintain a continuous waterproofing layer
- Not affected by foreign substance, maintaining consistent adhesive, stable waterproof coating
- Self-sealing and expands upon contact with water
- Workability in wet conditions or underwater structures
- Superior tensile strength and tear resistance
- Superior repetitive fatigue resistance
- Soft sheet facilitates work on bent parts
- Excellent viscosity

(D) Nano technology in waterproofing building materials-

The new development in science & technology has allowed using the latest nano technology to produce eco-friendly Organo-Silicon products to waterproof practically all the different kinds of building materials. Nano technology has ensured that service life of this approach will lead to life cycles beyond 20 to 30 years at very economical cost. There are two classes of waterproofing products:

a) Film Formers - The economics and the ease of application have led to widespread use of film forming water repellents.
The products like acrylic paint, silicon polymers are commonly used in the world for waterproofing application. These film formers have particle size greater than 100 nm, which will not allow them to penetrate inside the pores of the building materials but form a film covering and preventing the surface from water absorption.

b) Penetrants - Most penetrants are solvent based, soluble monomeric material with less than 6nm size. They easily penetrate inside the pores and sub-branches of the pores. There are two types of penetrants i.e. non reactive and reactive.

Experimentally it has been seen that Silane based waterproofing products are desirable for long-term performance. Silanes and Silane/Siloxanes are known as new class of waterproofing products. These products are used in USA and Europe for last 30 years. However only last few years they became available in India. The solvent based silane waterproofing compounds are proven to provide long lasting performance and are used very widely in USA and Europe. The various alkyl silanes that are used for waterproofing are (i) isobutyltrialkoxysilane (ii) n-octyltrialkoxysilane. Therefore, these types of products impart water repellency by modifying surface characteristics from hydrophilic to hydrophobic.

Standards for Performance Tests for Waterproof Concrete:

The various standards for performance tests for waterproof concrete are:
- BS 1881 : Part 122 : 1983 – water absorption
- ASTM C 642 – permeable voids and water absorption
- AASHTO – T 277/ASTM C-1202 – Rapid chloride permeability

In addition the structural designer and architect has to specify the requirements depending on the exposure conditions. DIN 1048 recognizes that a water penetration of 50 mm or less represents a concrete that is waterproof and water penetration of 30 mm or less is usually specified for severe exposure conditions.

Additional Performance Tests for Durable Concrete- For a durable concrete structure the concrete should have following specifications such as:
- The design of concrete mix should be considered for a design life of 120 years.
- As per ASTM C642 specifications – the absorption of concrete should not exceed 4 % and the permeable voids should not exceed 10%.
- As per AASHTO T 277 and ASTM C1202, the chloride permeability of concrete should not exceed 1000 coulombs.

Quality Assurance and Quality Control

The waterproofing system should become a part of designing and detailing for ensuring the proper installation of each component. Quality control to be taken such as to check prepour preparations for slab castings, to supervise at the batch plant, to supervise at the concrete placement, to check prepour installation for seals and hoses prior to casting of wall elements, to ensure proper compaction and placement of concrete during casting, to ensure proper and sufficient curing of concrete after casting, to inspect construction joints for defects prior to installation of membranes, to ensure proper records were kept for all activities etc.

Conclusion

The construction industry must make every effort to solve the problems that are inherent in the use of current materials and technologies. In recent times the increasing cost of new construction as well as of repairs and restoration of constructed buildings, led essentially by escalating raw materials and labour costs, is making project developers and owners opt for effective and advanced waterproofing products and solutions. There is also an increasing perception amongst the project developers and owners that the long-lasting concrete structures alone should not suffice. The requirement of waterproofing should be coupled with “aesthetics” and also with the “environmental demands”.

Reference

- www.CETCO.com
- www.re-systemsingapore.com
- M.C.Roco, R.S. Williams, and P. Alivisatos. Nanotechnology Research Directions: IWGN Research Report.