

# **DEVELOPMENTS IN POLYMER AS WATERPROOFING MATERIAL**

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*Published in Civil Engineering & Construction Re view – Sept'2005*

### **ABSTRACT**

The conventional method of waterproofing have become obsolete over a period of time due to their short life & complexity of their application. On the other hand bitumen Asphalt & coal tar are the two types of bitumen found to be excellent waterproofing properties because of its versatile in nature.

Despite their great waterproofing property, conventional bitumen viz, asphalt and coal tar pitch being thermoplastic have undesirable temperature-dependent variations in their physical properties. At subfreezing temperatures, they become brittle and glasslike & too fluid at a higher temperature.

Attempts were made to modify the thermoplastic properties of bitumen by using fillers like wax & oxidation of blown bitumen led to small success. But progress made in Polymer technology with the development synthetic plastic & synthetic rubber waterproofing system got new lease of life, birth of polymer modified bitumen membrane. It was observed that Atactic Polypropylene (APP) & Styrene Butadine Styrene (SBS) are two polymers compatible with Bitumen & enhances almost all the main properties of bitumen. In addition few thermoset & thermoplastic polymers were also developed. With the discovery of synthetic plastic & synthetic rubber, asphalt & roofing

An attempt has been made to look into various aspect of polymer based modified bituminous membrane & other types of polymeric product which are already has the acceptance in the market.

### **INTRODUCTION**

Waterproofing of Concrete structures has always been a challenging job for the civil engineers. Quality of concrete application and its subsequent waterproofing plays an important role in the durability of the structure. It has often been found that the seepage and leakage through concrete is a very common phenomena. Oflate this problem has caused concern among the architects, consultants & government agencies. In fact good concrete practice solves around 80% of the waterproofing problem. As a part of waterproofing process, major technological changes continue to occur with respect to the material, design and construction practices. The shortfall associated with changing technologies is keeping practitioner informed about the attributes and benefits of applying the technological advances in their business.

The conventional methods of lime concrete, brick bat coba 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 asphalt as a waterproofing coating gained popularity because of its abundant availability as a byproduct from petroleum at a cheaper price.

Forty years back hessian reinforced bituminous felt was introduced in the construction industry and over a period of time tarfelt became generic name in the industry for all oxidised bituminous felts. However with the advancement of technology replacement of hessian as reinforcement material was imminent as it was biodegradable with very short life span. Also very importantly the base material, oxidized bitumen has been replaced with polymer modified bituminous membrane & thermoplastic membranes

The breakthrough came with the progress made in Polymer technology. With the discovery of synthetic plastic & synthetic rubber, asphalt & roofing waterproofing system got new lease of life, birth of polymer modified bitumen membrane.

The advent of polymer modified bitumen membranes saw one more noticeable change and that was system of laying. Torch on and self-adhesive application of these products has led to more faster execution and less labour intensive. (fig. 1)

In the present study, some methods of providing waterproofing treatment to structures using state of the art technology – polymeric membrane along with few thermoplastic membrane have been discussed.

### **HISTORICAL BACKGROUND**

Asphalt & coal tar are the two types of bitumen found to be excellent waterproofing properties because of its versatile in nature. Both these versions have some unique physical properties. The properties are

1. Excellent resistance to moisture
2. Resistance to weathering
3. Good cohesive and excellent adhesive characteristics
4. Thermoplastic in nature

Despite their great waterproofing property, conventional bitumen viz, asphalt and coal tar pitch, have undesirable temperature-dependent variations in their physical properties. At subfreezing temperatures, they become brittle and glasslike. (Around 25°F (-3°C), a chunk of coal tar pitch thrown against a hard surface will shatter into sharp-edged fragments). At elevated summer temperatures, conventional roofing bitumen becomes viscous fluids; in the intermediate, moderate temperature range, they are viscoelastic solids. Tensile strength, breaking strain, and elasticity all vary widely-even-wildly-through the normal cycle of temperatures experienced by roofs in most parts of the country. The same built-up membrane has radically different properties (e.g. breaking strain, tensile strength, thermal expansion coefficient) at 0°F (-18°C) and at 100°F (38°C).(fig. 2)

### **POLYMERIC MEMBRANES**

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.

Modified bitumen membranes can be applied by mopping with hot asphalt from a kettle, like built-up membranes, or they can be torched using a propane torch, with welded side and end lap seams. A limited number of self-adhesive systems are also available.

With its thick, tough cap sheet, modified bitumen offers a membrane almost equal to an aggregate-surfaced built-up membrane (and superior to a smooth-surfaced or cap sheeted membrane) in puncture and impact resistance. Unlike the more puncture-prone elastomeric or thermoplastic single plies (PVC), these membranes enable the roof designer to give a durable waterproofing system without sacrificing the toughness of traditional built-up roofing.

Compared with traditional built-up roof assemblies, modified bitumen offers advantage in roofs with many penetrations and flashing. Modified bitumen is especially adaptable to reroofing projects. Unlike elastomeric and thermo plastic single plies, it is totally compatible with asphalt built-up construction. In instances where it is permissible i.e. in existing roof systems not plagued with wet insulation-a single ply modified bitumen sheet can sometimes be applied directly to an old smooth surfaced membrane. Such adaptability is a tremendous convenience on projects requiring only spot repair or partial reroofing where large portions of the roof have substantial remaining service life.

With modified-bitumen, polymer chemistry replaces the air blowing process that is used to produce the asphalt used in traditional built up membranes. Air blowing is a dehydrogenation process, removing lighter oils from the asphalt as water molecules are formed and evaporate from the heated, oxygenated asphalt. For modified bitumen, air blowing is reduced or totally eliminated. This preserves lighter oils, thereby improving the flexibility and weather resistance.

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 itself 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.

APP thermoplastic polymer forms a uniform matrix in the blended asphalt. It increases the asphalt's ultraviolet resistance, flexibility at high & low temperatures ( though not as much as SBS), resistance to flow at high temperatures, breaking strain, and even waterproofing quality.

SBS on the other hand works via more complex chemical process, and as a consequence, the chemical constitution of the blending asphalt is far more critical than for APP blends.

APP & SBS modified bitumen differ not only in softening point temperature, but in their response to this temperature. APP's crystalline structures gives it a definite melting point, with rapid conversion from solid to liquid at 300<sup>0</sup> F (149<sup>0</sup>C). In contrast, SBS modified bitumen gradually melts in a 220<sup>0</sup> to 250<sup>0</sup>F (approx. 100 to 120<sup>0</sup> C ) temperature range. This behavior is characteristic of a rubbery, crosslinked molecular material.

**SBS vs APP**

SBS modified membranes offer greater versatility, in application techniques than APP modified membranes. APP modified membranes 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 220°F.

<b>Distinctive Features:</b>		
•Increased stability of membrane with variation of temperature		
•Distilled Bitumen	0°C	50°C
•Blown Bitumen	-5°C	70°C
•UEAtc compliant APP	-15°C	150°C
•UEAtc compliant SBS	-30°C	100°C

Table 1 : SBS & APP bitumen characteristics

**REINFORCEMENT**

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.

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

**Protective covering-** Polyethylene, Mineral finish or Aluminium foil faced

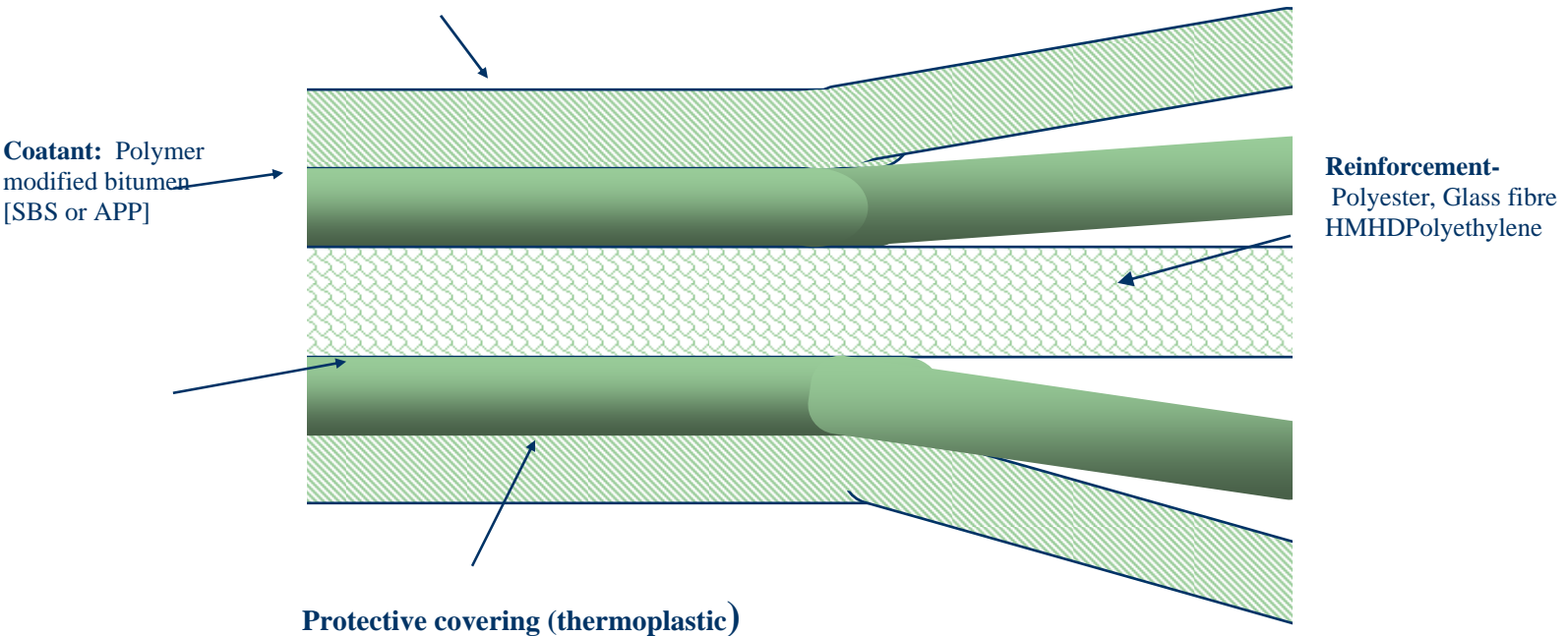


Fig 3 : Cross section of polymer modified membrane with reinforcement

The particular properties imparted by reinforcement depend on following factors:

- a. The type of fabric
- b. & material.

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.

(Fig. 3)

### **SURFACING**

Surfacing for modified bitumen membranes provides heat resistance vis solar reflectance ultraviolet resistance and fire resistance. SBS modified sheets require surfacing because of their slight ozone and ultra violet resistance. APP modified sheets may be left unsurfaced because of their greater weatherability. However all modified membrane should have some kind of surfacing.

Three basic types are

1. Mineral granules
2. Metallic foil
3. Field applied protective coatings

### **THERMOPLASTIC & THERMOSET MEMBRANES**

Single ply synthetic roofing membrane based on thermoplastic & thermoset technology are the latest addition to the waterproofing membrane family Besides polymeric modified bituminous membrane.

Thermoset membranes are those whose principle polymers are chemically cross linked. This chemical cross-linkage is commonly referred as vulcanization.

Main characteristic of thermoset polymers is once they are fully cured they can be bonded to like material with an adhesive.

The four common sub-categories of thermoset roof membranes are

1. Neoprene (CR)
2. Chlorosulfonated Polyethylene (CPSE)
3. Epichlorohydrine (ECH)
4. Ethylene Propylene Diene Monomer (EPDM)

Unlike thermoset membranes, thermoplastic membrane are different because there is no chemical cross linking.

Thermoplastic membranes are single ply flexible sheet material that are divided into five general sub categories.

1. Polyvinyl Chloride (PVC)

2. Copolymer Alloy (CPA)
3. Ethylene Interpolymer (EIP)
4. Nitrile Alloys (TPA)
5. Tripolymer Alloy (TPA)
6. Chlorinated Polyethylene (CPE)
7. Thermoplastic Olefin (TPO)

Flexible PVC membrane in the thermoplastic category & EPDM in the thermoset category are becoming quite popular though Neoprene, thermoplastic Olefins are also being used for specific requirements. These single ply roofing membranes are fixed primarily by me

### **SPECIFICATION & TESTING**

In fact the polymer modified bitumen was developed in seventies but the testing procedure & standard spec. came very late. ASTM constituted first committee to look into the spec & its testing in 1982. In 1999 annual book of ASTM standards , published two standards ASTM D6222, D6223 - STANDARD SPEC FOR ATACTIC POLYPROPYLENE (APP)

### **SYSTEM SPECIFICATION**

The ultimate selection of a waterproofing system for a particular projects depends on various factors such as the design of the roof deck, life expectancy, type of deck and its use, type of insulation , cost etc. Some of the specification designed for the benefit of architects, consultants are enclosed along with this write up.

### **CONCLUSIONS**

In the last twenty years, the use of polymer modified roofing system has grown substantially. According to a recent market analysis, 80 per cent of the waterproofing in the developed countries are being executed with polymeric material. In India these material have been introduced recently and have been accepted as one of the durable solution for waterproofing .

Roofing professionals and building owners now have a large portfolio of products to choose from. NRCA '97 roofing guide has incorporated around 360 types of different variation of polymeric material. There is no doubt that these material can do wonder if applied with right technique. Unlike other countries in India, tar felt has been the most sought after waterproofing material. Accordingly it has been laid

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