

## Waterproofing of New Roofs and Terraces

[Excerpts From Dr. Fixit Healthy Construction Booklet "Construct Your Ideas", 2012, pp.17-19, 24-27 & 46]

### 1.0 Introduction

A roof is a covering placed on any structure that protects from weather conditions. A roof can also be used as a terrace, where it is flat and has an entryway built into it. Terraces are flat, fully supported space on upper floors that allow room for people to walk, sit and various other activities. Roof is the most exposed surface of building. It is affected directly by the vagaries of sun, wind and rain.

The roof of a building should be designed and constructed in a way to effectively drain water by means of sufficient rainwater pipes of adequate size, wherever required, so arranged, jointed and fixed as to ensure that the rainwater is carried away from the building without causing dampness in any part of the walls, roof or foundations of the building or an adjacent building.

In India, terrace waterproofing has always been done with very traditional methods. Typically, systems like Brickbat Coba, China mosaic, Lime terracing or the "Mud Fuska" technique are still very much in vogue in different parts of the country. These systems have been offering waterproofing with some insulation against heat.

Some of the problems that these systems have are:

- Heavy loading on the slab
- Cracks on the surface, especially in case of Brickbat Coba
- Expertise levels of application required for lime terracing / mud fuska not as good as in the olden days
- Offer more insulation rather than a leak-proof or a watertight system
- As ageing takes place, breaking them and re-doing the same system is risky for the slab; cracks caused in the slab increase the problem of leakage

### 2.0 Types of Roofs

Various types of roofs used may be divided broadly into three types:

- Flat roofs
- Slope / Pitched roofs
- Shells and folded plates

Flat roofs are used in plains where rainfall is less and climate is moderate. Pitched roofs are preferred wherever rainfall is more. Shells and folded plate roofs are used to cover large column-free areas required for auditoriums, factories, etc. Brief description of these roofs is presented below:

#### 2.1 Flat Roof

These roofs are nearly flat. However, a slight slope (not

more than 10°) is given to drain out the rainwater. All types of upper storey floors can serve as flat roofs. Many times top of these roofs are treated with waterproofing materials like mixing waterproofing chemicals in concrete, providing membrane, etc. With an advent of reliable waterproofing techniques such flat roofs are constructed even in areas with heavy rainfall. There should be minimum variation in pitch over the entire roof. It is preferable to have a uniform fall over the entire roof. Providing steeper falls near the perimeter of the roof should be avoided in order to prevent the collection of water at the junction between the roof slab and the parapet wall, as this junction is prone to water leakage.

The advantages of flat roofs are:

- The roof can be used as a terrace for playing, and celebrating functions.
- In later stages, the roof can be converted as a floor by adding another storey.
- They can suit any shape of the building.
- Overhead water tanks and other services can be located easily.
- They can be made fireproof easily as compared to pitched roof.

The disadvantages of flat roofs are:

- They cannot cover large column-free areas.
- Leakage problem may occur at a later date also due to development of cracks. Once leakage problem starts, it needs proper treatments.
- The dead weight of flat roofs is more.
- In places of snowfall, flat roofs are to be avoided to reduce snow load.
- The initial cost of construction is more.
- Speed of construction of flat roofs is less.

#### 2.2 Slope / Pitched Roof

In the areas of heavy rainfall and snowfall, usually, sloping roofs are used. The slope of the roof should be more than 10°. They may have slopes as much as 45° to 60° also. The sloped roofs are known as pitched roofs. The sloping roofs are preferred in large spanned structures like workshops, factory buildings and warehouses. In all these roofs, covering sheets like A.C. sheet, G.I. sheets, tiles, slates, etc. are supported on suitable structures.

Advantages of slope roofs are :

- Water drains itself quickly, giving wind and gravity little opportunity to push or pull water through the roofing material.
- Steep roofs can be covered with roofing materials that are fabricated and applied in small, overlapping.

Disadvantages are:

- Top surface is in a slope and hence advantage of terrace is lost.

- Cannot cover a building of any horizontal dimension because it becomes too tall on a broad building.

### 2.3 Shells and Folded Plates Roof

Shell roof may be defined as a curved surface, the thickness of which is small compared to the other dimensions. In these roofs a lot of load is transferred by membrane compression instead of by bending as in the case of conventional slab and beam constructions. The thin R.C.C. shell roofs are built to cover large column-free areas.

Advantages of shell roofs are:

- Good from aesthetic point of view.
- Material consumption is quite less.
- Formwork can be removed early.
- Large column-free areas can be covered.

Disadvantages are:

- Top surface is curved and hence advantage of terrace is lost.
- Formwork is costly.

### 3.0 Flat Roof Assembly

A low slope roof or flat roof has four parts such as roof deck, vapour retarder, insulation and roof membrane. The combination of these parts is known as roof assembly.

#### 3.1 Roof Deck

An entire roof system is held up by a roof deck. This is the base of roof assembly. Roof decks can be made of many different materials. Some of these materials include steel, wood, concrete, lightweight insulating concrete and cement wood fibre.

#### 3.2 Vapour Retarder

Moisture vapour is created inside buildings. A vapour retarder helps keep vapour from getting into insulation. It is usually installed between the deck and insulation.

Materials used for vapour retarders include felt plies, plastic sheets, aluminium foil and kraft paper sheets. Vapour retarders are not used with every roof system. It depends on the moisture in the building and climate of the area.

#### 3.3 Insulation

If there is no vapour retarder, insulation is usually the first component installed over a roof deck.

The purpose of insulation is to help keep heat in a building in cold weather. It also helps keep heat out of a building in hot weather. Insulation saves money because the air-conditioning and heating systems will not be used as much. Some buildings do not need insulation. It is not used with every roof system.

#### 3.4 Roof Membrane

A roof membrane makes a roof system watertight. It is installed over the insulation. In some systems, a roof membrane may be installed right over a deck

### 4.0 Design Consideration for Waterproofing System

The design of the waterproofing system should include its construction detailing, specification of materials and accessories, the fixing method, the joining of waterproofing membrane with other structures and drainage. For the efficient design and laying of the waterproofing treatment, the designer shall take into consideration the following salient factors as per IS 3067:

- Shape of the roof, such as flat, slope or curved
- Type of roof
- Type of finish required
- Type of thermal insulation treatment
- Projection through roofs
- Drainage arrangement
- Intensity of rainfall
- Total weight of waterproofing treatment on the roof

Apart from the above factors, a successful waterproofing application depends on a structurally sound slab. To ensure the construction of a structurally sound slab, provisions for the following items should be included in a building's structural design and in the design of a slab:

- Live loads
- Construction loads, such as moving installation equipment, workers and materials
- Dead loads, such as mechanical equipment, duct work, piping or conduit such as fire sprinkler and electrical lines
- Dead loads, such as a waterproofing system, soil overburden, concrete toppings
- Slab strength (gauge, density, type and thickness)
- Expected deflection
- Drainage
- Placement of expansion joints
- Placement and structural support of curb and penetration members and details
- Attachment provisions for a deck
- Suitability for adhesion / attachment of waterproofing membrane
- Suitability for water test loads

A structurally sound slab or deck should remain so as not to deflect excessively under live loads. It should be understood that a waterproofing contractor can only inspect the surface of a slab or deck to receive the waterproofing materials and cannot assume responsibility for the slab's slope, structural integrity, method of attachment, or any other conditions beyond his control or professional expertise.

The slope of the roof should be adequate to prevent ponding of water. A sufficient slope ensures a good and economic result. The recommended slopes for the flat roofs are as follows:

- With smooth finish would be 1 : 150 to 1 : 133,
- With rough stone / tiles 1 : 100 and
- For gravel set in cement or loosely packed concrete finish 1 : 75 to 1 : 66.

Terrace with water ponding leads to leakages and seepages. The faster the water is directed off the envelope, the less chance for leakage.

The waterproofing membrane should be protected from mechanical stresses, traffic, solar radiation, air pollution and other stresses. Depending on the stress and moisture conditions of the roof structure, a suitable insulation system is selected to withstand the long-term and construction time loads.

The design should also be carried out considering climatic conditions of regions such as hot climates, cold climates.

In hot dry climates, monolithic concrete structural roof can provide satisfactory roofing with no membrane except at the joints. More often, the concrete is covered with a membrane or insulation and membrane system. In hot humid climates water vapour is kept from entering the underlying insulation. Insulation above the roofing is sometimes used to protect membrane from high temperature and UV exposure in hot climates. In hot and moderate climates, a light coloured surface will reduce temperatures experienced by the roof membrane. This will reduce energy required to cool the building. For this purpose, the coating should prevent UV degradation of the underlying material.

In cold climates, roof eaves require special design to prevent or accommodate build-up of ice formations. Moisture within a building will move towards a cold roof. A vapour retarder may be needed to prevent condensation. An effective way to prevent condensation is to use a protected membrane roof where the insulation is placed above the membrane. This helps to isolate the membrane from temperature extremes and from freeze-thaw damage. When temperatures are lower 4°C then require special precautions such as insulated hoses and kettles. Hot bitumen and adhesives should not be applied at temperatures below the dew point. Some manufacturers provide loose-laid single ply or heat applied modified bitumen membrane systems which can be applied at low temperatures.

Apart from design considerations, there are many fixtures and parts that need to be installed properly while doing waterproofing of roof terraces.

#### 4.1 Pipe Penetrations

There are always different types of pipe penetrations in a roof. Their correct and watertight joining to the roofing is vital for the functioning of the entire roof. The penetration materials and systems must withstand mechanical stresses caused by changes in the roof structure resulting from

ageing, temperature changes and climatic conditions. When a pipe passes through RCC slab a cement concrete fillet shall be built around the pipe and waterproofing taken over the fillet. Penetrations should be kept to a minimum as far as possible. It is preferable to have a clear and uninterrupted roof deck for continuous waterproofing. Service fixtures, planters, etc may be designed to stand over the waterproofed deck on concrete pads. A typical figure of pipe penetration through roof slab is given in Figure 1.

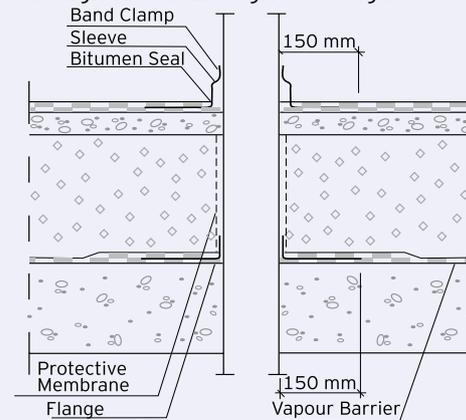


Fig. 1: Service pipe arrangement

#### 4.2 Roof Drains

All water that enters the roof should be channelled into roof drains with falls and into rainwater sewers via a system of downpipes. Rainwater pipes shall be constructed of cast iron, PVC, asbestos cement, galvanised sheet or other equally suitable material and shall be securely fixed. The rainwater pipes should be fixed to the outside of the external walls of the building or in recesses or chases cut or formed in such external wall or in such other manner as may be approved by the authority.

All the bends of rainwater pipes should be brought at terrace level beyond the inside face of the parapet and keep them clean.

When a rainwater pipe is taken through the slab, tight fit funnel of anti-corrosive material should be provided so that water does not seep into the structure through the slab.

The required number of rainwater pipes should be provided and their diameter should be selected as per average rate of rainfall as given in National Building Code.

The drain mouth with bell mouth entry shall be fixed and properly set to allow the water to flow into it. Felt shall generally be laid as on the other portion on the roof and the treatment shall be carried inside the drain pipes overlapping at least 100 mm. If possible grating

cap should be provided over the drain mouth to protect chocking caused by leaves, stones, etc. A typical figure of rainwater pipe fixing at roof level is shown in Fig. 2.

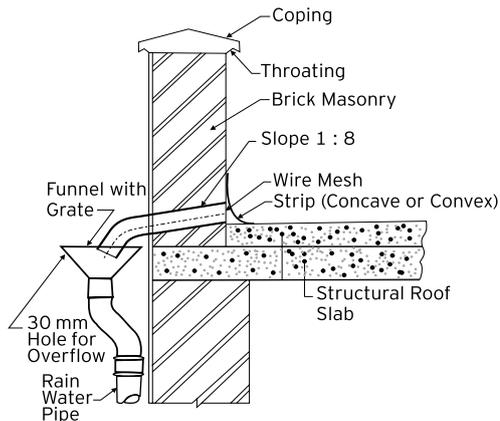


Fig. 2: Rain water pipe fixing arrangement

### 4.3 Upturns

The upturns are important features for the functioning of waterproofing. They ensure that water that ponds for whatever reason cannot penetrate underneath the roofing and into the fabric. Usually the height of an upturn is 300 mm above the finished surface and on roofs at least 100 mm above the overflow level. A 100 mm upturn is acceptable at door thresholds. However, in these cases, it must be ensured that the connection with the door assembly and the wall is absolutely watertight.

With rubber bitumen membrane roofing, the roofing is cut along the edge of the upturn and the upturn is constructed of a separate piece of membrane. The upturn is secured with mechanical anchors and it is protected with flashing. The detailing at junction of parapet and roof slab of a waterproofing system is shown in Fig. 3.

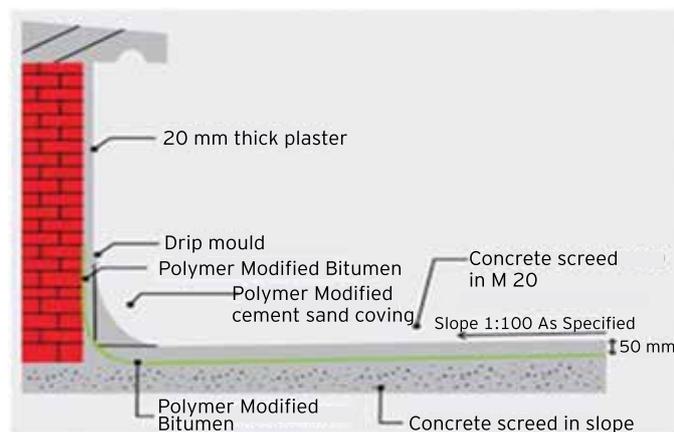


Fig. 3: Detailing at junction of parapet and roof slab

### 4.4 Parapet Walls

The parapet walls should be properly leaned and waterproofing coating should be applied on internal and external faces. Provide some slope to top of parapet walls to drain off rainwater from it. Necessary grooves shall be provided in the walls to terminate the waterproofing treatment. At the junction of the wall and the floor, a round or triangular fillet of size 200 mm x 200 mm shall be provided with cement and sand mortar admixed with SBR latex waterproofing compound. The entire surface shall be cured for minimum 14 days by storing water to a depth of at least 150 mm in the entire area.

### 4.5 Movement Joint

Rubber bitumen membrane roofing does not require separate movement joints for the waterproofing itself. In the event of a structural movement joint under membrane roofing an approximately 500 mm unbounded strip can be used between the slab and base sheet. If necessary, a separate design detail of the movement joint should be provided.

### 4.6 Expansion Joint

Expansion joints and control joints are used to minimise the effects of stresses and movements of a building's components and prevent these stresses from splitting, buckling / ridging or damaging a waterproofing system. Expansion joints in a waterproofing assembly, which includes a waterproofing membrane and wall / slab / deck, should be placed in the same location as the building's structural expansion joints. Each of a building's components has varying coefficients of expansion, and each is subjected to varying temperature changes and resultant thermal movement. In the design and placement of waterproofing expansion and control joints, it is recommended a designer should consider the following:

- Thermal movement characteristics of a building
- Structural supports and wall /slab / deck
- Waterproofing system
- Climatic conditions
- Proper detailing

Expansion joints should allow for movement in several directions and are best located on curbs with a minimum height of 250 mm. Roofs should be sloped so that expansion joints are at high points with drainage directed away from them. The detailing of expansion joint of a roof slab is described below and shown in Fig. 4.

- Clean the substrate with broom brush or compressed air.
- Construct a masonry upstand to a minimum height of 250 mm.
- Form 50 x 50 mm triangle fillet on all vertical upstands. The fillet should be prepared in concrete admixed with 10-15% SBR latex, by weight of cement.

- Apply the waterproofing system as selected for the area, the upstand area, depending upon the type of roof, etc. The treatment should always be taken up over these angle fillets.
- All vertical upstands will be terminated as per standard termination details.
- Seal the expansion joint with filler board, with a backer rod of closed cell polyethylene foam or of extruded polystyrene, inserted.
- Fill the joint with two component flexible Polysulphide sealant.
- Place expansion joint cover over the joint as shown in the drawing, in such a way that water will drain off on to the roof.
- Seal horizontal joints with a seal tape.

- 1 Roof Deck
- 2 Upstand
- 3 Expansion Joint Cover

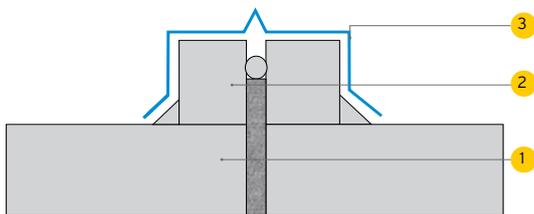


Fig. 4: Detailing of expansion joint in roof slab

The expansion joint in the roof shall be so designed as to not impair the effectiveness of waterproofing treatment with the joint treated with suitable non-absorbent compressible, non-brittle and watertight sealants.

#### 4.7 Insulation

If any protective layer is provided to prevent the waterproofing membrane from damage by construction activities, the finishes on top of this protective layer should be of sufficient weight to prevent the uplift of this protective layer under all conditions. The choice of the type and thickness of this layer depends on the overall thermal insulation required by statutory requirement.

#### 4.8 Dish Antenna

Typically, any dish antenna is installed in the parapet wall directly on the top portion with the mounting bracket. It is directly fastened in wall through bolts, and generally bolts penetrate through the roof material into a concealed wood nailer, which causes penetration of water and leakage. The remedy for the same is to install the antenna in counter flashed panel or railing. Provision of this type of panel or railing should be incorporated at the time of parapet design.

#### 4.9 Plumbing: Service Pipes

Pipes should be 50 mm to 75 mm away from face of the wall. Fix all service pipes by clamps of one's choice. Use anti-corrosive anchor fasteners only for fixing the clamps. Arrangement of plumbing service pipes are shown in Fig. 5.

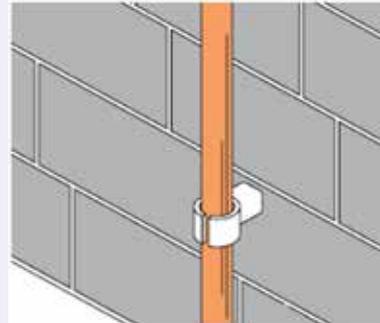


Fig. 5: Service pipe arrangement

#### 4.10 Stair Cover (or MUMTY) and Canopy

These are the locations which are not cleaned for earth, debris and waste material for years. Water stagnates and slab deteriorates severely. The design of stair cover should consider the following:

- RCC slab in such a shape so that water does not stagnate.
- By light weight pipe structure with transparent sheets for good light / ventilation / excellent aesthetics.

#### 5.0 Drawbacks of Traditional Waterproofing Systems

The Brickbat Coba treatment though successful in the damp heat of coastal region; cracks up completely on contact with the dry heat of North India, besides having the disadvantage of imposing higher dead load on the system (Fig. 6).



Fig. 6: Three layers of Brick-bat-coba increasing the dead load on the structure

The Brickbat Coba treatment is not flexible enough to withstand thermal and physical stresses and developing cracks or de-bonding. Brick being a porous material absorbs more water through the cracks and causing the corrosion of reinforcement which ultimately leads to spalling of ceiling concrete of the roof slab. An Indian Patent Stone (IPS) is basically surfacing used either as a surface barrier treatment over a new surface or at a location where the ingress of water has taken place. A 25 - 40 mm thick layer of cement concrete 1:1:2 (8 mm to 10 mm size stone aggregate) is laid over a flat surface, giving it a correct slope before IPS is laid on top of the same. Joints on IPS are filled with a suitable sealant like bitumen, mastic, etc. Leakage may also take place through the joints of IPS or cracks of China Mosaic system due to ageing (Fig. 7) which develops with time. Lime concrete terracing in coastal humid climates is however most successful where temperature variation is less since the lime concrete itself crack under wide temperature changes, hence may not suitable hot and humid regions. Mud Phuska with brick tiles in a hot and arid climate of rural Punjab, Rajasthan and Uttar Pradesh is more common which basically acts more as insulation rather than waterproofing.



Fig. 7: Cracks developed in China mosaic waterproofing system

## 6.0 Modern Waterproofing Systems

### 6.1 Waterproofing Materials

In order to overcome the problems arising from the progressive deterioration of traditional weathering courses, the advanced practices involve the provision of impermeable membranes. One of the simplest ways of providing impermeable membranes is to use multiple coats of a waterproofing co-polymer and cementitious materials. Traditionally, waterproofing barriers consists of multiple layers of bituminous-saturated felt or fabric bonded together with hot-applied coal tar pitch or asphalt for positive side applications, i.e. the same side as the hydrostatic pressure. Today a number of other positive side waterproofing barriers can be selected, which include cold-applied systems. The positive as

well as negative side waterproofing materials with their broad chemical compositions are given below:

- Hot applied bituminous materials: Bituminous substances with fabrics or felts
- Cold applied bituminous materials: Asphalt emulsions or asphaltic mastics, reinforced with fabric
- Liquid applied membranes : Single or multi-component products such as neoprene, neoprene-bituminous blends, polyurethane, polyurethane bituminous blends, and epoxy-bituminous blends. Epoxy emulsions allow the concrete to breathe but not allow rainwater ingress.
- Sheet-applied materials : Neoprene, Butyl, EPDM, PVC, etc. which are joined by adhesive sealing or chemical welding (solvent bonding)
- Cementitious membranes

The thickness of membrane can vary depending on the type of material, its physical and environmental exposure, and loading conditions. The roof is normally waterproofed with the application of waterproofing membrane and membrane should be protected from traffic and weathering.

Based on the type of material the roof waterproofing systems can be broadly classified under two categories:

- Liquid applied membrane system (LAM)
- Prefabricated or preformed membrane system (PFM)

### 6.2 Liquid Applied Membrane (LAM)

Liquid applied membranes are well-accepted systems throughout the globe. The membranes formed are water-resistant and also not affected by weather conditions like humidity, rain or extreme hot weather. Moreover, the liquid waterproofing system is easy as well as economical to repair as compared to preformed membrane.

The liquid applied membrane should be laid according to the manufacturer's recommendation. The shelf life of the liquid applied membrane should be checked. Single-component membranes solidify by evaporation of solvent or reaction with moisture in the air. Therefore, once the original packing seal is broken, the material should be used within the recommended pot life. Curing rates of single component materials depend on the temperature; the higher the temperature, the faster the solidification. Materials should be stored at recommended temperature range. Two-component materials solidify by chemical curing which starts as soon as the two components mix. They should be stored separately.

For multi-coating application, different colours for each coat may be used to ensure detection of uncompleted coverage. During application and initial curing, liquid applied membrane should be protected from rain. The method of application such as brush, roller, trowel, squeegee or spray should be predetermined. All termination details also should be predetermined.

Liquid applied membrane could be most advantageous in congested areas and on irregular surfaces. It is capable of bridging hairline cracks on concrete surfaces. It may be very useful as fillet material or reinforcement material at inside corners, as flashing material around drains, protrusions, curbs and parapets, and as a sealing material at terminations. A schematic diagram of the liquid applied membrane system is shown in Fig. 8.

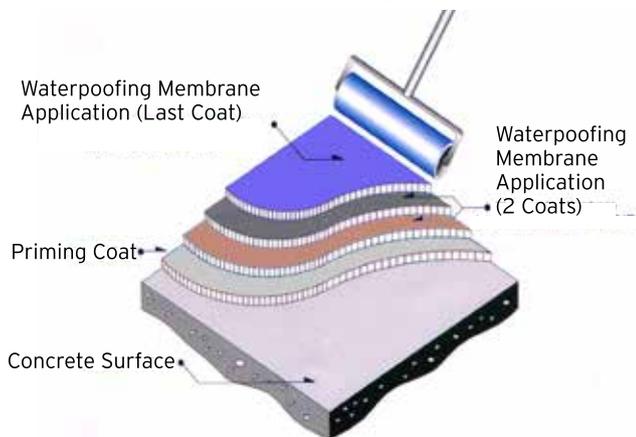


Fig. 8: Typical sketch of liquid applied waterproofing system

These liquid applied membranes are available in an extensive range of materials and colours, suited to different types of roofing. The different kinds include fibre incorporated water based acrylics, Polyurethane, Polymer modified bitumen, Polymer modified cementitious, etc. They are normally formulated from single or multiple component products produced from a variety of chemical bases. The final dry film thickness of liquid applied membrane is important.

The schematic diagram of bitumen coating system is given in Fig. 9.

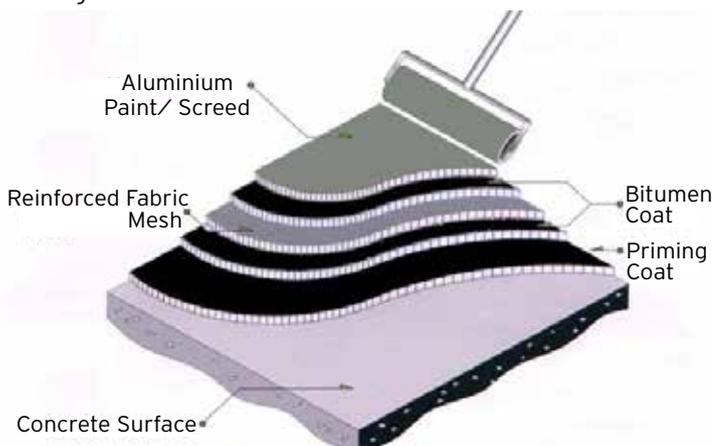


Fig. 9: Typical sketch of bitumen waterproofing system

### 6.3 Preformed Membrane (PFM)

Preformed membrane can be bonded or unbonded system. Bonded system is normally preferred as it has the advantage over the unbonded system due to its leak-localising

capability. In case of leakage, it can be easily traced and thus, the repair to damage in the waterproofing system can be easily carried out. The unbonded system can be used where the condition of the substrate does not allow the materials to be fully bonded.

#### 6.3.1 Preformed Membrane - Bonded System

The method of installation using bituminous compound, solvent, adhesive, self-flashing or hot-air jet should be as prescribed by the manufacturer. The laying of membrane should proceed in a manner to ensure that the membrane is fully bonded to the substrate with no air being trapped beneath the membrane.

Joints between sheets of the preformed waterproofing membrane should be checked for end laps and side laps according to manufacturers' recommendations. End laps between each roll should be staggered. The laps should be fully fused or bonded to form continuous watertight seams. Expansion joints should be sealed with an approved sealant. Wherever possible, expansion joints should be sited at the summit of run-off.

For waterproofing system where protection layer is required, no traffic other than human traffic should be allowed until the protective layer has been laid over it. Mechanical plants and equipment should be raised and supported on concrete plinths. The commonly used prefabricated waterproofing membranes form durable waterproof barriers and very effective for flat roofs of large areas are Polymer Modified Bitumen (APP / SBS) and EPDM Rubber. The other types of preformed membrane used for waterproofing are neoprene, butyl, PVC and synthetic rubber.

#### 6.4 Comparison between LAM and PFM

- LAMs create seamless waterproofing membranes while PFMs form joints at regular intervals.
- LAMs are highly elastomeric while PFMs are rigid in nature.
- LAMs show increased bridging capabilities in comparison with PFMs.
- On application, LAMs are ideal for small roofs with complicated shapes and details like penetrations, upstands, joints, etc. PFMs are ideal for long large roofs with minimum projected structures.
- LAMs are cannot be easily guaranteed for a fixed consumption and thickness as they are dependent on the substrate porosity and applicable conditions. On the other hand, PFMs can be specified with consumption with specified lap joints.
- Both systems are vulnerable to stagnated water.
- Both systems normally need appropriate primers.
- Both the systems are prone to blistering if the surface contains excess moisture before the application.

## 6.5 Selection of Material

The selection of waterproofing membrane should consider the type of loading on the roof such as public access or vehicular traffic, environmental exposures, thermal insulation and aesthetics. Different membranes have their own characteristics and the choice of a particular membrane depends on the main properties such as tensile strength, elongation, crack bridging capabilities, weathering and UV resistance, ease of application, puncture resistance and expected life, where applicable. The other properties are chemical and alkali resistance, good bonding strength, low water absorption, withstanding hydrostatic pressure, breathable, permeable to vapour transmission, good colour retention and algae and fungus resistance. In a particular generic base of the material the active solid contents need to be checked for its effective performance. The final dry film thickness of liquid applied membrane is important and depends upon active solid contents of the material.

## 6.6 General Requirements for Preformed and Liquid Applied Membrane

The surface to receive membrane should be cleaned, dried, free of sharp protrusions and surface defects such as cracks, voids and protrusions. It is desirable that the concrete surface to be waterproofed should be finished to provide a plain and even finish to receive the membrane.

Primed surfaces to receive the preformed waterproofing membrane should not be covered until the primer is fully cured. Areas exposed to rainfall should be sufficiently air-dried before commencing or resuming installation. The concrete or screeding should be allowed to cure for at least 7 days before the laying of the membrane. The application of the membrane to uncured concrete may result in moisture being trapped between the concrete and membrane causing blisters to be formed and affecting bonding of the membrane to the substrate.

All openings, penetrations, upturns, corners, etc, should be properly detailed to ensure watertightness. Generally more layers of waterproofing membrane are provided at these locations.

Upturns at parapet walls should be at least 150 mm high. The membrane should be tucked into the chase formed along the full length of wall. Flashing may be installed above the chase to provide additional protection.

A fillet of 45° of minimum leg size 50 mm should be formed at all intersections where the horizontal and vertical surfaces meet.

Proper detailing should be provided for the bridging of the membrane over expansion joints. Consideration should be given to the movement of the joints and where necessary, additional flashing and kerbs should be installed to ensure complete watertightness. Watertightness test should be specified for the waterproofing work. The minimum flooding period should be 24 hours. No dampness should be observed within an hour after the test duration.

## 7.0 Application Methodology

### 7.1 Fibre Reinforced Water Based Acrylic Coating Application Method

The fibre reinforced water based acrylic coating can be applied directly on sloped or flat roof surface without any Brickbat Coba thus reducing the cost and increasing the life span of the coating system. The film physical property requirement of such acrylic coating for roof slab as per ASTM D 6083-05 is given in Table 1. A schematic diagram of this coating system is given in Fig. 10.

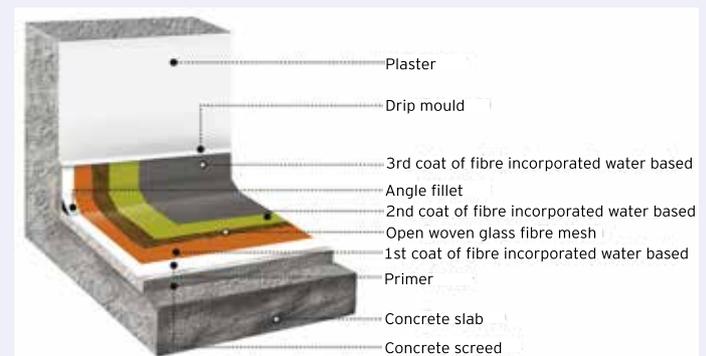


Fig. 10: Waterproofing system for exposed new flat roof

Table 1: Film physical property requirements for acrylic roof coatings

Reference: Table 2, ASTM D 6083 - 05		
Physical Property	ASTM Designation	Requirement
Initial percent elongation (break)	D 2370	Minimum 100% 23°C
Initial tensile strength (maximum stress)	D 2370	Minimum 1.4 MPa 23°C
Final percent elongation (break) after accelerated weathering 1000 h	D 2370	Minimum 100% 23°C
Permeance	D 1653	Maximum 2875 ng(Pa.s.m <sup>2</sup> )
Water swelling	D 471	Maximum 20% (mass)
Accelerated weathering 1000 h	D 4798	No cracking or checking
Adhesion	D 903	Minimum 350 N wet
Fungi resistance	G 21	Zero rating
Tear resistance	D 624	>21.0 kN/m
Low temperature flexibility after 1000 h accelerated weathering	D 522	Minimum pass 13 mm mandrel -26° C

## 7.1.1 Surface Preparation

Ensure slope of the parent roof is between 1: 80 to 1: 100. Prepare the surface thoroughly by cleaning, washing and removing dust, dirt, oil, grease and loose particles. The cleaning by power washing at a pressure is most effective for new surfaces.

## 7.1.2 Priming

Apply water-based primer on clean smooth prepared surface. The primer should be applied in SSD (surface saturated dry) condition. After primer the surface is allowed for drying for 4 to 6 hour.

## 7.1.3 Application

Apply first coat of fibre reinforced water based acrylic in prescribed coverage. The best way to achieve the coverage is by marking the square grids either of 1 m<sup>2</sup> or of 4 m<sup>2</sup> and applying the material in same grid to achieve the desired thickness. Alternatively, a comb notch should be used to measure the wet film thickness during the application so as to get the desired dry film thickness of the coating. In large roof open woven glass fibre mesh of size 2 mm x 2 mm must be sandwiched between first and second coat and immediately the second coat needs to be applied with a squeegee or a roller to ensure that coat is evenly pressed into the fibre mesh. Each coat is applied in perpendicular direction to the previous coat to avoid any misses at a particular point. The drying time between two coatings must be 6 to 8 hrs. Apply second and third coats of acrylic coating perpendicular to each other. The minimum dry film thickness in three coats should not be less than 1 mm and with mesh reinforcement the thickness of the waterproofing system should not be less than 1.2 mm. The system is allowed for air-drying for minimum of 7 days.

The step-by-step application method is shown in Fig.11



a. Applying the primer



b. Applying the 1st coat



c. Applying the 2nd coat



d. Applying the 3rd coat perpendicular to 2nd coat

Fig. 11: Acrylic based applied coating liquid application method

## 7.2 Polymer Modified Bitumen Emulsion Application Coating Method

It is based on bituminous emulsion, polymer and additives in water as a medium. It is highly viscous dark brown cloured paste used for waterproofing of flat roof terraces under Brickbat Coba, or having complex surfaces such as projections on roof, ducts and upstand or sloped roofs. The schematic diagram of such coating system is given in Fig. 12 and its different components are as follows :

1. Slab
2. Primer
3. Angle Fillet
4. Polymer Modified Bitumen
5. Geotextile
6. Brickbat coba
7. Drip Mould

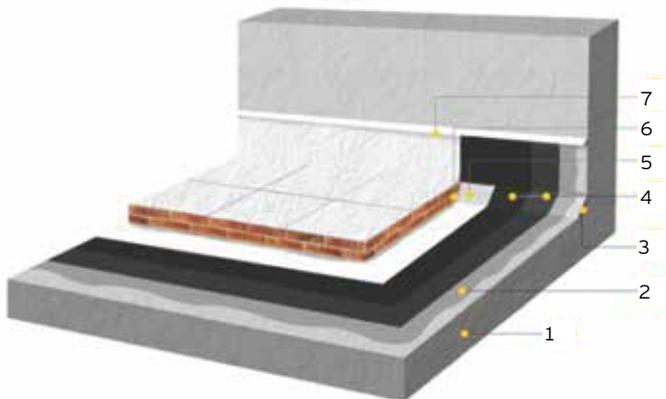


Fig. 12: Polymer modified bitumen emulsion coating system

### 7.2.1 Surface Preparation

The surface should be cleaned thoroughly of all contaminants like dust, traces of curing compound, oil and grease. All surface imperfections, protrusions, structurally unsound and loose concrete must be removed and repaired with polymer modified mortar. Make angle fillets all around the periphery of the terrace with cement-sand mortar admixed with SBR latex.

### 7.2.2 Priming

Apply same polymer modified bitumen diluted with water in 1:1 proportion as primer on clean and smooth surface by brush or roller in saturated surface dry condition and allow it to dry completely.

### 7.2.3 Application

Apply first coat without any dilution and allow it to dry completely. Start second coat with a roller or a rubber squeegee and allow it to dry completely. Place loosely laid geotextile fabric of 300 to 500 gsm after 48-72 hours over the polymer modified bituminous coating for protection. Carefully lay Brickbat Coba / screed to provide slope between 1 : 80 to 1 : 100 for effective drainage for flat roofs only. Always try to avoid the Brickbat Coba unless the surface is having much undulation or otherwise lay a 50 mm thick screed of M20 grade on flat roofs. A bituminous aluminium paint or acrylic emulsion resin emulsion with mineral filler on sloped roof or over screed on flat roofs should be provided at the top. Screed can be cast in alternate bays method and each bay should not be more than 10m<sup>2</sup>. After drying and curing of the screed the joints of the bays should be filled with a compressible board, e.g. bitumen impregnated board or extruded polystyrene sheets and the top of the joints should be filled with a PU sealant.

### 7.3 Polyurethane Based Liquid Applied Coating Application Method

This polyurethane (PU) based membrane coating system is very much suitable for large span roof usually used as podium slab. It is highly flexible and having a tough and puncture-resistant property that also sustains structural movement. A schematic diagram of this coating system is given in Fig. 13.

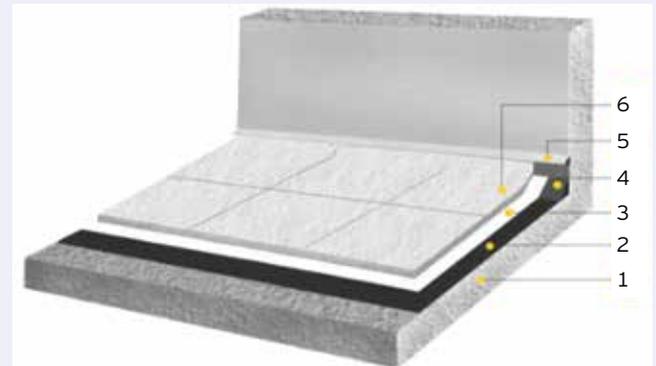


Fig. 13: Polyurethane based liquid applied coating system

1. Slab
2. Polyurethane
3. Geotextile
4. Angle Fillet
5. Drip Mould
6. Screed

### 7.3.1 Surface Preparation

All surface imperfections, protrusions, structurally unsound and loose concrete must be removed and repaired with polymer modified mortar using SBR latex. Make angle fillets all around the periphery of the wall with polymer modified mortar prepared with SBR latex. All surfaces must be cleaned with compressed air, free of loose materials, oils, form release agents and other contaminants.

### 7.3.2 Priming

Priming is not normally required on good quality concrete substrates. But for absorbent surfaces such as porous concrete, sand / cement and cement boards will require priming.

### 7.3.3 Application

PU can be applied by brush, trowel, and squeegee in two coats maintaining the spreading rate to achieve the prescribed DFT. PU membrane must be air-cured for a minimum of 72 hours at 27°C before placing protection. After drying of the coating, lay a layer of geotextile membrane of 300 gsm and after laying the

geotextile membrane a screed of 75 mm (average) must be overlaid in M 20 grade of concrete for the protection of membrane and to provide a proper slope for effective draining of rainwater.

## 7.4 Polymer Modified Cementitious Coating Application Method

It is acrylic cementitious, polymer modified elastomeric, waterproofing and protective coating composed of best quality Portland cement, properly selected and graded aggregates, additives and acrylic emulsion polymer as a binder. It is applied to waterproof and protect concrete and masonry substrates. It is very good for waterproofing of sloped roofs. It can be used as a waterproof coating for smaller roofs and terraces of areas up to 100 -150 m<sup>2</sup> only.

### 7.4.1 Surface Preparation

The surface of application must be thoroughly prepared by mechanical means, to remove all loose particles, laitance, etc. Oil and grease, if any, must be removed with suitable solvents. It then must be washed off with jet of water and brought to touch dry state. Any surface undulations, cracks and crevices must be duly filled or repaired with cement-sand mortar mixed with latex polymers such as SBR latex.

### 7.4.2 Mixing

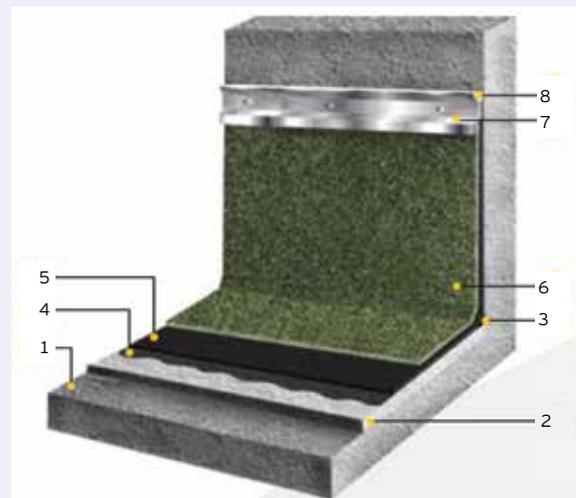
This type of coating material is usually available in two components. Use a heavy-duty, slow speed mechanical mixer fitted with a suitable paddle for mixing the two components of the material. In a mixing vessel, slowly add the powder component in to the liquid under continuous stirring. Continue to stir thoroughly to achieve lump free homogenous slurry.

### 7.4.3 Application

It is mandatory that all works of plumbing and sanitation must be complete before taking up application of the coating. The surface of application must be pre-wetted thoroughly with water and brought to a touch-dry state. Take up the first coat application with a stiff nylon brush. Work well into the substrate, to ensure that all small undulations are completely filled with the coating. After completion of 6 to 8 hrs of first coat, take up application of the second coat in a direction perpendicular to the first. Complete the application and leave to air-cure for 2 days. A moist hessian cloth can be kept over the coated surface to protect it from the effect of direct sunlight. Leave the coating without water curing for 2 days at least. If the membrane is applied in areas exposed to foot traffic, it must be protected with a screed overlaid, during the application itself.

## 7.5 Polymer Modified Bitumen (APP / SBS) Torch-on Installation Method

The prefabricated membranes are manufactured by coextrusion of a waterproofing polymer and nonwoven polyester fabric. APP modified membranes are tough and have excellent high temperature resistance while SBS modified have excellent low temperature capabilities and are true elastomeric in nature. In Indian climate, APP membrane is more suitable. The membrane is torched on with a minimal propane gas over a bituminous primer. The underside of the prefabricated membranes are protected by a nonstick polyethylene film that melts on torching. The top surface of such membranes on laying may be protected by a uniform layer of natural rock chips or by other decorative options. The thickness of such preformed membrane may be 3 mm or 4 mm having roll length usually 1 m wide and 10 m long. This type of membrane gives a long durable service life of 7 to 10 years. These membranes have excellent heat-resistance and cold temperature flexibility properties with high tensile strength, tear- and puncture-resistance. The physical properties of APP modified bituminous sheet materials using polyester reinforcements is shown in Table 2. A schematic diagram of this coating system is given in Fig. 14.



**Fig. 14:** Polymer Modified Bitumen (APP / SBS) Torch-on membrane system

1. Slab
2. Screed
3. Angle Fillet
4. Solvent Based Bitumen Primer
5. Polymer Modified Bitumen Membrane
6. Mineral Finished Polymer Modified Bitumen Membrane
7. Aluminium Flashing
8. Sealant

**Table 2:** Physical properties of APP modified bituminous sheet materials using polyester reinforcements

Reference: Table 1, ASTM D6222/D6222M - 11,		
Property	Type 1	Type 2
Peak load at 23 + 2°C MD* and XMD**, before and after heat conditioning, kN/m, minimum	8.8	14
Elongation at 23 + 2°C MD and XMD, before and after heat conditioning, at peak load, % minimum	23	40
Peak load at -18 + 2°C MD and XMD, kN/m, minimum	10.5	15.8
Elongation at -18 + 2°C MD and XMD, at peak load, % minimum	10	15
Ultimate elongation at 23 + 2°C MD and XMD, % minimum	30	50
Tear strength at 23 + 2°C N, minimum	311	356
Low temperature flexibility, before and after heat conditioning, °C, maximum		
Dimensional stability, % change, maximum	1	1
Compound stability, °C minimum	110	110
Granule embedment, Grade G only, maximum loss, grams	2	2
Water absorption, % maximum	3.2	3.2
Moisture content, % maximum	1	1
Low temperature unrolling, °C, maximum	5	5

\*MD : Machine Direction \*\*XMD : Cross Machine Direction

### 7.5.1 Surface Preparation

- Entire roof should be covered with M20 grade of concrete
- Integral waterproofing additive should be added
- Slope of 1 in 100, with at least 50 mm thickness at the drain outlet
- Screed must be cured and dried completely

### 7.5.2 Priming

Prime the surface with solvent based bitumen primer and allows it to dry for 8 to 10 hrs.

### 7.5.3 Application

The application must start from the outlet, going towards the centre of the roof area. Waterproof membranes rely on a complete system to ensure that the waterproofing of the roof or podium slab is not compromised.

The step-by-step application method is described and shown in Fig. 15.

- Any depressions, joints or cracks are filled and sealed as required.
- Any required reinforcing tape or bond breaker is applied to joints and cracks.

- Any necessary suitable primer is applied (Fig.15 a).
- Specified coverage thickness is maintained for liquid applied membrane.
- Re-coating times are adhered as per specification.
- For preformed membrane, rolled out and align the membrane over the primed surface. (Fig. 15 b).
- Torch on the membrane under side with acetylene gas to softening point (Fig. 15 c) and press hard on to the surface (Fig. 15 d).
- Keep an overlap for a minimum of 100 mm (Fig. 15 e).
- Finish the joints with slight torching (Fig. 15 f) and fix the membrane at the joints. While torching in the overlaps, bleeding must be ensured by pressing evenly to bleed out the bitumen out the overlap and a 'bead' formed thereof must not be flattened with the steel trowel.
- The membrane must go over the angle fillet at the parapet junctions and all angles and abutments upstands at parapet (Fig. 15g) should be sealed with extra care to ensure perfect bondage.



a. Application of the primer



b. Aligning the torch shield membrane



c. Torching the membrane by acetylene gas and pressing hard on the surface



d. Simultaneously doing the torch-on and pressing the membrane



e. Aligning the adjacent roll with an overlap of 100mm



f. Torch-on at the overlap portion at the joint



g. Torch-on for fixing at termination end of parapet

- Flashing on the parapet wall must be done with a C-shaped aluminium strip nailed (with SS screws) to the vertical substrate at the termination of the membrane.
- It can be tucked into a groove of 12 mm x12 mm into the parapet wall 15 to 20 mm above the angle fillet. Thereafter, it should be sealed well into grooves; protect the edges with

a single component polysulphide sealant or a 'neutral-cure' silicone sealant.

- The application of screeds or other finishes is not undertaken until the membrane has sufficiently cured.
- The surface is finished with aluminium paint (Fig. 15 h) for non-foot traffic and overlaid with a protective screed for foot traffic terraces.



h. Finishing with aluminium coat for non-foot traffic or else screeding for foot traffic

**Fig. 15:** Step-by-step method of installation of torch-on membrane

- The places where openings are encountered for rainwater down take pipes, the membranes shall be cut open by sharp knife in (+) sign in the center of an opening. Circular cutting shall not be done. Torching shall be done on the reverse side of these four triangular pieces. Bend all the four pieces inside and tightly press against pipe surface.
- Membranes should be appropriately protected from damage until floor finishes are installed. The torch-applied membranes shall be protected either with concrete screed laid to slope or by applying bitumen based aluminium paint in two coats for the sloped roofs.
- For the roof slabs used for human traffic or for any other purpose, concrete screed shall be laid as per the architect's specifications.
- For non-sanded membrane, sprinkle sand on the top surface of membranes after torching the top of the membrane for better adhesion with subsequent screed.

For high performance and a durable service life, double layered torch-on membrane may be provided and in such cases, the first layer of membrane of plain finished is laid up to over the angle fillet only. The second layer of mineral finished, is laid in a perpendicular direction to the first layer membrane, starting from 150 mm to 200 mm on the parapet wall, downward and covering the angle fillet. It should be terminated at a height of 200 mm. The top edge of the membrane will be finished with 2 mm thick aluminium flashing pointed with PS based elastomeric sealant. Apply aluminium paint for non-foot traffic area and an overlay of concrete screed mortar for foot traffic area in case of plain finish APP membrane only.

(To be continued in next issue of our ReBuild.)