Waterproofing of New Roofs and Terraces

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7.6 EPDM Preformed Membrane Installation Method

EPDM (Ethylene Polypropylene Diene Monomer) is a synthetic rubber material that can be formulated with extensive flexibility for use as membrane sheet roofing. Chemically, EPDM is an elastomeric compound synthesized from ethylene, propylene and a relatively small amount of diene monomer. When ethylene propylene, which is derived from oil and natural gas, are combined with diene, a flexible rubber matrix is formed. EPDM generally is manufactured as a vulcanized (cured) membrane sheet but also can be formulated and produced in a nonvulcanized (uncured) state, which usually is used as membrane flashing material for detailing. EPDM membranes exhibit good resistance to ozone, ultraviolet (UV) rays, weathering and abrasion. EPDM also has good low-temperature flexibility. EPDM is resistant to some acids; alkalis; and oxygenated solvents, such as ketones, esters and alcohols. On the other hand, exposure to aromatic, halogenated and aliphatic solvents, as well as animal and vegetable oils and petroleum-based products, should be avoided to prevent membrane swelling and distortion.

EPDM sheets used for roofing applications are usually black in colour and range in thickness from 1.2 mm to 3 mm.The reinforcement used in reinforced EPDM sheets is typically a polyester scrim or fabric that is positioned during manufacturing near the middle of the finished thickness of the EPDM sheet. Some EPDM sheets are also manufactured with nonwoven polyester fleece backing adhered to the underside of the sheet. Fabric-backed EPDM sheets are typically manufactured using non-reinforced EPDM sheet. Fabric backed EPDM may facilitate adhesion to a substrate and/or serve as a separator from the substrate.

EPDM is a rubber based prefabricated membrane which is most durable membrane having highest service life of 15 to 20 years. The thickness of such preformed membrane available in the market varies between 1.2 mm to 1.5 mm having roll width of 1.2 m wide and length 20 m. The width of roll goes up to 3 m and roll length of 20 m which can be used for larger roofs. It can be used for large commercial roofs of concrete, wood, asbestos and metal sheets. It exhibits a high degree of resistance to water, ozone, UV, weathering, abrasion, extreme temperatures, acids, alkalis and oxygenated solvents. It can be laid quickly and easily, without any maintenance requirement.

7.6.1 Installation of EPDM on Large RCC Roof Slab

7.6.1.1 Surface Preparation

Prior to installing any membrane system, it is essential that the substrate to which it is being applied to is appropriately prepared. The substrate needs to be sound, smooth, dry and free of sharp edges, loose or foreign materials, oil, grease and laitance, etc. This can be achieved by rubbing the surface with a wire brush (Fig. 16a) so that all the loose particles comes out from the surface by vacuum sucked as shown in Fig. 16b. The mechanical surface preparation methods are strongly suggested to ensure proper adhesion of the membrane. The concrete or metallic substrate must be completely dry before taking up the application. If some moisture exists, it must be expelled with a blow torch or a flame torch. The moisture content of the substrate should be less than 4% and can be easily measured by a moisture meter if available otherwise the simplest way of checking the moisture content of the substrate is by enclosing a small unit area with a polythene sheet and edges wrapped with masking tape for a period of 16 hour and then inspection to be made for the presence of moisture or a dark colour of the substrate. Since the roofing is very large in case of EPDM membrane application, the expansion joints need to be properly attended prior to fixing of the membrane.

Fig. 16a: Rubbing the surface by wire brush for surface preparation

Fig. 16b: Mechanical cleaning of the surface

7.6.1.2 Installation

The application must start from the outlet, going towards the centre of the roof area. The step-by-step application method is described below and shown in Fig. 16.

- Before laying the sheets, mark out datum lines with chalk,

etc., so that the membranes can be arranged properly and parallelly with reference to the edges of the roof area.

- Then first arrange to lay the membrane according to datum line from one side of the roof, and fold back to half its length.
- The bonding adhesive should be a synthetic rubber based solvent containing contact adhesive specially designed for fixing EPDM of either single-component adhesive for membrane to substrate and membrane bonding or two-component adhesive for membrane to membrane bonding.
- The bonding adhesive should be applied on to the clean and prepared substrate (Fig. 16d). Before applying bonding adhesive, the materials must be stirred in the container to achieve a uniform mix with no sediment at the bottom.

Fig. 16c: Checking the moisture content of the substrate by enclosing with polythene sheet

Fig. 16d: Application of bonding adhesive

- Adhesive must be then trowel applied in a thin even coat on membrane and the substrate. An excess of adhesive will prolong the drying time.
- Care must be taken not to apply bonding adhesive over an area that is to be cleaned later and overlapped to the adjacent membrane (from its underside). This is to be done also at the peripheries of the membranes or their termination (from the underside). Use a chalk line mark or a masking tape on the area to be overlapped (splicing area) and the ends of the membrane (for 50-70 mm) that has to remain clean.
- The porous substrates may require a second coat, which can be applied after 5 to 10 minutes of first coat. Let the solvent evaporate naturally until the adhesive attains a tacky condition. Drying time will defer depending upon the climatic conditions and coverage rate. Never use a hot air dryer to accelerate the process. The substrate should be in tacky condition after 15 to 20 minutes in normal room temperature. If the temperature of the substrate is between 30 to 35°C, then drying time may be approximately 5 to 10 minutes.
- The substrates bonded after prolonged open-time and in the absence of tack may result in inferior coalescence and bond strength.
- The membrane should be opened from sealed cover (Fig.16e) and the bonding adhesive should also be applied on to the back of the membrane that has been folded.
- The first half of the EPDM membrane should be unfolded back carefully to ensure that there are no wrinkles during the sticking process. The sticking process can be done with a roller. While laying and installing the membrane (Fig. 16f); the parallel position should be maintained with reference to the datum lines, spread and sticking, is very important.
- The bonding procedure for other half of EPDM membrane should be repeated. This procedure for every roll to complete the laying of EPDM membrane should be repeated for the entire area.
- The bonding adhesive should be allowed to dry completely for two days to avoid any joint failures before taking up slicing of the joints.

Fig. 16e: Opening the membrane from sealed cover

Fig. 16f: Aligning and laying the membrane over primed surface

- An overlap of 50-70 mm along the length or as specified is a must. A masking tape must be first stuck to the laid membrane.
- Splice adhesive should be used to adhere to the overlapped membrane portions.
- Now, from the underside, the masking tape should be removed. Thereafter, two coats of splice adhesive wet on wet on the underside of the first membrane should be applied and a similar procedure is to be followed on the topside of the adjacent overlapping membrane. Overlapping portions must be abraded with an emery paper thoroughly and wiped / cleaned properly with a dry cloth. The overlapping in case of EPDM application is done by tucking it below the earlier membrane.

- Thoroughly roll on the overlapped area with a 50-70 mm wide metallic roller.
- The membrane must go over the angle fillet at the parapet junctions and all angles and abutments upstands at parapet for which cut piece members may be needed. This can be made by taking the measurement exactly as per the requirement of the cut piece (Fig.16g) and cutting into smaller pieces of the membrane (Fig.16h)

Fig. 16g: Taking the measurement for a cut piece member

Fig. 16h: Cutting into smaller piece of the membrane

- The bonding adhesive is to be applied on the substrate and on the back side of the cut piece member and aligned and laid over the primed surface (Fig. 16i) and the fixing of the cut piece members should be made at the termination end (Fig. 16j)
- At the corner junction the marking should be made on the membrane for splicing of the cut piece (Fig. 16k) and the bonding adhesive should be applied for fixing the cut piece membrane (Fig. 16l). Thereafter the bonding adhesive should be applied on the back of the splice membrane(Fig.16m) and the splice membrane should be fixed (Fig. 16n) at the corner junction.

Fig. 16i: Aligning and laying the cut piece membrane

By following this step-by-step method one can easily do the waterproofing of roof by EPDM membrane.

Fig. 16j: Fixing the cut piece at termination end

Fig. 16k: Marking on the membrane for splicing of cut piece at the corner junction

Fig. 16l: Applying the bonding adhesive for fixing the cut piece membrane

Fig. 16m: Applying the bonding adhesive on back of splice membrane

Fig. 16n: Fixing the cut piece membrane at the corner junction

Fig. 16: Step-by-step method of installation of EPDM membrane

7.6.2 Installation of EPDM on Profiled Metal Sheet

7.6.2.1 Surface Preparation

Check to ensure that metal roof is properly fitted with screws and fasteners. Replace all of the vents on the roof; never leave anything on the roof that could cause a problem. Gaps, if any, between the sheets shall be filled using a PU Sealant. Clean the surface well to remove dirt, dust, grease, etc.

7.6.2.2 Installation

Whenever EPDM membrane is being installed on the metal roof surface, it is highly recommended that the membrane shall be laid at the position and allowed to relax for at least 45 minutes. This will help releasing the tension in the membrane. Install insulation boards over the entire roof; to attain a smooth surface to lay the membrane roofing on metal roof. The insulation is fastened with epoxy-coated screws and insulation fastening plates; the plates give more surface area to the screw head and securely fasten the insulation to the roof deck. The membrane is secured with the same epoxy-coated screws and smaller seam fastening plates. Each successive course of membrane overlaps an area about 150 mm where the fasteners hold the membrane in place. Handheld hot air welding machine is used to safely heat the membrane to bond all of the seams and flashings. The welds are as strong as the material itself and they require no adhesive or maintenance. The seam in the membrane is also welded. The membrane is fastened at the walls with the same seam plates and screws. The membrane must be secured with screws and plates at any angle change or transition. The screws and plates at the wall are covered with another layer of membrane. This flashing covers the parapet dividing wall and waterproofs the perimeter of the roof. The membrane wall flashing is then welded to the roof deck membrane.

8.0 Criteria for evaluation of Lowslopped Roof Membranes

As recommended by NRCA (National Roofing Contractors' Association) an outline in performance format of criteria for seams is given in Table 2 which includes suggestions for requirements, criteria, and evaluative procedures for membrane attributes other than water tightness. In the case of water tightness, criteria suggested for development not only include mechanical-load resistance, which addresses delamination of the seam, but also permeability and puncture resistance. These last two requirements consider ways for a membrane to lose water tightness in a seam in a manner comparable to that through the membrane material itself. They are included in the seam criteria so that the set will be complete and stand alone. In practice, the criteria and test methods for permeability and puncture resistance should not differ for the membrane material. The key requirements for seams in single-ply membranes other than two major attributes of water tightness and maintainability are health and safety, environmental impact, and appearance. A flow chart in the performance approch to developing the roof membrane criteria is given in Fig. 17.

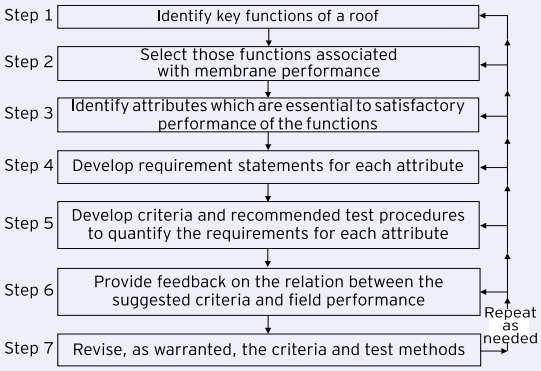

Fig. 17: Steps in the performance for developing roof membrane criteria

Table 1 : Performance criteria of membrane

Performance	Requirement	Criterion evaluation test
Attribute :Water tightness of a seam		
Resistance to Mechanical Loads	The seam shall be capable of sustaining, without loss of water tightness, the mechanical loads expected to be imposed in service from internal or external causes.	Peel strength, Shear strength, Creep resistance in peel, Creep resistance in shear, Cyclic movement resistance, Flexure resistance
Puncture Resistance	The seam shall be capable of withstanding, without loss of water tightness, the static and dynamic puncture loads expected to be encountered in service.	Static puncture Dynamic puncture Hail resistance
Resistance to Water Transmission	The seam shall prevent the passage of water through the roof under expected service conditions.	Permeability to liquid water
Effects of the Environment	The seam shall not be affected by internal and external environmental factors expected to be encountered in service to an extent that their ability to prevent water ingress will be impaired over the design life of the membrane.	Heat, Moisture, Solar radiation Airborne pollutants Chemicals
Attribute : Maintainability		
Sheet Condition	The properties of the membrane materials shall not be altered during exposure to the extent that a seam cannot effectively and economically be patched or otherwise repaired in the event of an unforeseen leak.	Peel strength, Shear strength, Creep resistance in peel, Creep resistance in shear, Cyclic movement resistance, Flexure resistance

Source : NISTIR 4638, Performance Approach to the Development of Criteria for Low-Sloped Roof Membranes, 1991 of NRCA

9.0 Performance and Testing of Waterproofing System

After the installation of the waterproofing system, the water ponding test should be carried out at the site for a depth of 50 mm for 24 hour to check any seepage or dampness on the roof ceiling surface below the roof slab. The test should be conducted after closing all the openings. If the dampness and seepages are observed after the ponding test, the remedial measures are to be taken. However, the performance of the coating depends on satisfying some of the important properties which affects long-term durability. The tests that need to be performed for this are tensile strength (Does the membrane fracture when stretched?), flexibility, fatigue fracture and water transmission and water vapour transmission. Waterproofing membranes can be subjected to movements caused by thermal or moisture content changes in the surfacing or substrate materials. This form of movement is considered slow and over time, such strain may induce plastic and permanent deformation rather than purely elastic response. This repeated slow cycling may cause the membrane to eventually rupture. Materials used should be waterproofed or water-resistant for their intended service life and shall maintain their integrity in their intended use.

10.0 Maintenance and Costing of the System

10.1 Maintenance of Coating

The service life of the coating depends upon the application, quality of material, physical and environmental conditions. While the application is the most important factor for any failure of coating system, it also depends on proper surface preparation, proper installation method as recommended by the manufacturer and proper curing of the coating system. The application failure constitutes almost 60-70% of total coating failure before its anticipated service life. If the extreme weathering conditions and corresponding desired properties with the selected coating system is not available, the failure takes place which constitutes between 20-30% of total coating failure. There may be failure of material itself which may be 10%. But to achieve the desired service life of the system, periodical maintenance of the coating needs to carried out by inspection for any colour fading, adhesion, development of any coating defects and cracks in the substrate and opening of the joints in case of preformed membrane. All loose and peeling coating should be removed and adjacent areas should be roughened upto 50 mm beyond the repaired surface area. The remedial measures to be taken here are cleaning the surface, spot repair by priming and top coat only with a brush or laying and installing a cut piece membrane as required. But if extensive repair is required, then coating should be removed and recoated or membrane needs to be reinstalled once again.

10.2 Life Cycle Cost Analysis

There is a wrong perception that chemical waterproofing system is costlier than the traditional waterproofing system. This may be true while comparing with initial costs only but when one analyses the life cycle cost, then the chemical waterproofing system would be cheaper. The life cycle cost analysis of roof with traditional Brickbat Coba plus China Mosaic and with a heavy-duty reinforced acrylic coating has been taken for a comparison. The five-year roof coating cycle for both the systems has been taken. The cost involved for repair and maintenance after 5 years of Brickbat Coba plus China Mosaic system is plotted in the graph as Series1 whereas the periodical maintenance cost of heavy-duty reinforced acrylic throughout the life span is plotted in the graph as Series 2 in Fig. 18. As seen from the graph, after 20 years, the total cost of Brickbat Coba plus China Mosaic system becomes higher than the heavy-duty reinforced acrylic coating system. The life cycle has been analysed for cost only without taking environmental impact and other factors into consideration.

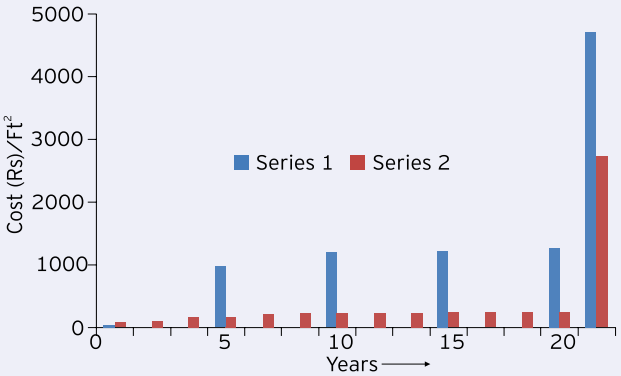

Fig. 18: 5-years roof coating life cycle cost analysis

11.0 Conclusion

The liquid applied coating system is easier for application whereas the preformed membrane needs skilled manpower and equipment for installation. The waterproofing is a specialised job for which applicators or contactors and their entire team needs to be trained properly.

Though the modern chemical waterproofing has been widely used by construction industries, acceptance in Government sectors is not encouraging because of non-availability of any codes of practices or standards from the Bureau of Indian Standard. In that case, it is only approved specifications of the concerned organisation for acceptance of these modern chemical waterproofing systems. So, there is a need of urgent code of practices in waterproofing covering all the modern waterproofing practices which will be helpful for durable structures.