Remedial Waterproofing of Roofs and Terraces

1.0 Introduction

The failure of waterproofing system in roofs and terraces is very common in tropical climates leading to distress and damage of the structures. Though there are many remedial waterproofing systems, only a few of them are in practice due to lack of awareness and skilled manpower. When existing roof waterproofing system can no longer be repaired or maintained to satisfy its' functional requirement of preventing leakage or extending a roof system's useful service life, then a decision has to be taken to either do a removal or a remedial treatment over the existing system. It should also be considered in other situations, like when:

- Repair expenditures become excessive.
- Leakage becomes intolerable.
- Damage is occurring to structural components.
- Damage is occurring to building contents.

The first decision that needs to be made is whether the existing roof system can be re-covered or whether removal and replacement is necessary. This determination needs to be made on a case-by-case basis and is best made after a thorough evaluation of the existing roof system.

2.0 Causes of Failures

Roof systems can deteriorate from normal wear, severe weather conditions (e.g., wind and snow loads); building movement (e.g., settlement, material contraction/ expansion); and improper design, construction and maintenance. Any roof repairs not dealt with after the first signs of failure can result in increased damage to the building envelope and interior finishes, and loss of occupant productivity, if damage causes interruption in client services and program delivery. Failure of structural integrity can endanger occupant safety. The reasons of failure of systems are many; it could be wrong system application or the behaviour and limitations of the material itself in terms of adhesion or UV stability, etc. Over a period of time, excellent development for different types of waterproofing materials and systems have been taking place, keeping in mind the criteria or requirements for a good engineered and reliable roof waterproofing.

Rigid waterproofing barriers have shown limitations or failures when subjected to certain aggressive conditions or structural movements during its life span. Bituminous / Cementitious polymer modified / EPDM membranes / HDPE based systems do enable elongations but have limiting success, application difficulties and deteriorate with time in the limited life span of application.

Membrane-type waterproofing systems may not remain effective over prolonged periods of time on roofs or other structural elements which may have projections or other construction features. Usually the membrane slips down from vertical faces because it is difficult to fix the edges by properly matching the contour of the drain mouths. The joints of laminates are always vulnerable and moisture entrapped underneath the membrane causes problems frequently. Similarly the adhesive for laminates may be sensitive to moisture in the substrate, thereby precluding the application of laminates during the rainy season. Since these laminates are bitumen based, they absorb a great deal of solar heat.

NRCA's (National Roofing Contractors' Association) Project Pinpoint provides information on performance problems and membrane deficiencies from the data base in 1990 which is given in Table 1. The five most common problems for the types of membrane roofing such as elastomeric, thermoplastic, modified bitumen, and bituminous built-up are seam defects, puncture/ test, shrinkage, wind related and blistering. As is evident, seam defects in elastomeric and modified bitumen membranes occur more frequently than other problems for these types of membranes. Moreover, even in the case of thermoplastic membranes where unsatisfactory seam performance is generally not considered to be a problem, it has been reported that the seam defects are among the five most common problems. In the case of built-up membranes, blistering and splitting are reported as the two main problems. This is not unexpected as blistering and splitting has long been reported as two of the major problems recurring with BUR membranes.

Table 1: The most common problems for each of the main types of roof membranes*

Membrane Type	**Elasto-meric**	**Modified Bitumen**	**Thermo-plastic**	**Built-Up**
Type of Failures	Percentage failures			
Seam Defects	50	36	9	
Puncture/Tear	21		17	
Shrinkage	13	11	42	
Wind Related	10	2	3	3
Blistering	5	10	29	24
Embrittlement		8		
Splitting				22
Slippage				6
Ridging				18
Others	1	33		27

*Source: Cullen, William c., "Project Pinpoint's Database continues to Grow," Professional Roofing (April 1990), .pp. 28-31.

3.0 Condition Assessment

The serviceability of the existing waterproofing system depends on the repair and maintenance of the system. A proactive periodical maintenance will increase the service life of the existing system. Regular inspection of building roof waterproofing systems will lead to early detection of roof problems. The objective of roof inspection should be as follows:

- To determine if the roof waterproofing system is performing according to its intended function
- To identify signs of weakness, deterioration or hazard
- To identify needed repairs

While inspecting, the general roof conditions need to be ascertained such as debris on roof, drainage, physical damage, structural deformation, if any. The waterproofing system needs to be checked for condition of the coating/membrane, granular loss, punctures, cracks/alligatoring, blisters/fish mouths, water ponding or any other defects. In addition to that, the various roof features such as fascia, soffit, flashing gutters/drains, skylights, chimneys/vents, drains, etc. needs to be checked for their performances. Similarly, the ceiling surface underneath the terrace roof needs to be checked for cracks, water staining, water leaks, etc. But in spite of all these, the failure of waterproofing system takes place for which remedial waterproofing needs to be carried out.

4.0 Remedial Treatment

4.1 Preparation of Existing Roof Surfaces

The following guidelines are specific to the preparation of existing built-up, polymer-modified bitumen and single-ply membranes prior to the installation of a re-cover roof system.

- Loose aggregate-surfacing, large buildups of bituminous coatings, and large buckles or blisters should be removed; any deficiency that prevents a proper installation of the re-cover roof system should be repaired.
- Areas of wet and deteriorated insulation to match the height of the existing system should be removed and replaced.
- Loose, damaged or otherwise incompatible existing base flashings should be removed.

If the existing uninsulated roof membrane is to be used as a vapor retarder, the flashings should remain in place and the existing membrane and flashings should be repaired sufficiently to perform as a vapor retarder. Only insulation boards should be used as separation layers over aggregate-surfaced built-up roof systems. Insulation boards, non-woven mats, mineral boards or base sheets are used as separation layers for granule-surfaced or smooth surfaced built-up or polymer-modified membranes. Existing single-ply membranes should be cut to relieve existing stress within the membrane. It is suggested to refer to the manufacturer of the re-cover membrane or system to determine whether the existing membrane is required to be cut or sliced.

4.2 Guidelines for Membrane Roof Systems

The general recommendations for recovering over an existing roof system with a new built-up, polymer-modified bitumen, single-ply or liquid-applied membrane roof system as follows:

- The existing roof system and new re-cover roof system must be compatible or appropriately separated.
- The roof deck should be secured to the structure of the building, support the design live load and dead load required for the building, and provide the necessary pullout resistance for fasteners used with a new mechanically attached re-cover roof system.
- If the new roof system is fully adhered to the existing roof system, the existing roof membrane and insulation, if any, should be secured to the roof deck according to appropriate wind uplift resistance requirements. The surface of the existing roof system may require preparation and/or may need to be primed with a compatible primer to enhance adhesion before application of the new adhered roof system.
- The existing roof system should be inspected and tested, if necessary, to determine whether excess moisture is present within the roof assembly. Wet insulation must be removed and replaced with compatible materials.
- The existing roof system should be inspected for shrinkage, ridging, splitting and cracking and then repaired appropriately. Portions that may present problems should be secured or removed.

4.3 Waterproofing System Configurations

Though there may be many configurations on the existing system, the most important factor that needs to be considered is the compatibility between the two systems. The designers can specify membrane roof systems in roof re-covering situations and can develop their own drawings and specifications for specific projects. Some of the most commonly systems being used are given as follows:

- Torch-applied APP/SBS polymer-modified bitumen roof system over existing bituminous roof system
- Adhered EPDM roof system over existing roof system
- Liquid-applied roof system over existing roof system

While selecting preformed membrane system for very old surfaces, the APP membrane can be suitable, provided there are no projections or upstands and in such cases, a heavy-duty microfiber reinforced acrylic based flexible terrace waterproofing coating would be more suitable. For longer durable service life, one can choose an EPDM type of membrane. The cost also factor needs to be analysed for each system.

4.4 Repair of Existing Roof System

Proper maintenance and repair of roofing system always prolongs and enhances the roof's service life. Any defects or problems in the roofing system should be rectified or tackled considering the age, condition and the maintenance history of the existing roof system. The levels of repair broadly can be divided into three categories: spot patching, general repairs, and major repairs and maintenance.

4.4.1 Spot Patching of Isolated Locations

Installation of isolated patches to repair deficient or degraded locations in the membrane comes under spot patching category. Spot patching might be applicable in the given scenario.

If the membrane is relatively new and in good condition with a few isolated sections that need to be repaired, upgrade & reinforce to improve the performance of the roof. This is mainly in case of deficient application.

If the membrane life is not so long but due to some unavoidable reasons, it can't be replaced, spot patching can help to repair specific leakages.

4.4.2 General Repairs

This category is more comprehensive than spot patching. It deals in numerous deficiencies throughout the field, including various details and flashings of a roof system.

4.4.3 Major Repair and Maintenance

This category includes a repair regime for preventive maintenance. For example, a smooth surfaced modified bitumen roof system may need maintenance for a long service life, along with an application of the correct reflective coating. Some common problems for specific membrane type and its repair approach are discussed below:

4.4.4 Built–up Roof Membrane (BUR)

Built-up roof membranes are mainly composed of bitumen, glass fiber, polyester or organic reinforcing felts and commonly surfaced with aggregate, mineral granular or liquid applied coatings. For repair work, it should be ensured that repaired material must be compatible with the membrane being repaired. Blistering and splits are common problems faced in built-up roof type membrane system.

Blisters: This type of problem can be repaired by either cutting and removing or patching over to reinforce, based on situation or judgment. Surface of the membrane should be free from debris, contamination and loose particles. The area for repair should be extended up to 460 mm beyond the defect, to provide sufficient area for proper patch bonding. Carefully cut and remove the blistered materials until good adhesion of the membrane is reached. If water infiltration is suspected, inspect the deck for damage and repair the same with polymer modified mortar. Prime the surface of the membrane to enhance adhesion and allow it to dry. Install the same number of piles as were removed. Any liquid applied membrane should be installed as per the manufacturer's instructions, which may include the waiting time between the coatings for different coats.

Splits: The following procedure does not include the repair of splits caused by structural movement or other forces placed on the membrane. Preparation of surface by ensuring removal of debris, contaminants, aggregate of loose surface of the membrane. The repair area should be extended enough, approximately 610 mm on each side of the split and 915 mm beyond the end of the split to provide ample clean work area. Cut or remove loose felt from the split area. If water infiltration is suspected, inspect the deck for damage and repair the same with polymer modified mortar. At each end of the split, extend the split approximately 305 mm further in length by cutting through the membrane. At this new end of the split, make a T-cut approximately 150-200 mm on both sides. Prime the surface of the membrane. After the primer has dried, apply a piece of granular surfaced sheet approximately 230 mm wide and of sufficient length to cover the split from end to end. Install the same number of piles as in the original roof.

4.4.5 Modified Bitumen Membrane

Polymer modified bitumen membranes are mainly asphalt based membranes. The following procedures are the generic repair procedures.

Membrane Patch Repairs: Patch repair procedure for pre-formed membrane has to be started from surface preparation, deck repair (if required), and then priming the surface of the membrane. Patch must be cut in greater size, almost 203 mm larger in all dimensions than the defect to be repaired. Corner must be rounded to a 76 mm radius. Install the patch in hot asphalt, cold adhesive or by heat welding in accordance with the patch material manufacturer's recommendation over the repair area, extending 203 mm in all directions from any part of defects. Apply moderate pressure to the patch to insure proper adhesion to the existing membrane.

Blisters: Remove the blistered membrane until good adhesion is reached. If water infiltration is suspected, inspect the deck for damage and repair the same with polymer modified mortar. Preparation of surface is one of the most important factors for good repair work. It must be ensuring removal of debris, contaminants, aggregate of loose surface of the membrane. Clean the surface of the membrane as well. Prime the surface with the asphalt primer and allow it to dry. The patch must be larger by 203 mm in all dimensions than the defects to be repaired.

Install the patch. Installation must be done as per the manufacturer's guidelines. Apply moderate pressure to the patch to insure proper adhesion to the existing membrane.

4.4.6 Thermoset Membranes

This is a rubber-like membrane. Application defects are the main problem faced in thermoset membranes.

Membrane Patch Procedure (Repair with adhesive): In the very first step of the repair procedure, surface preparation is required by removing debris, contaminants and ballast or removing the surface coating. Wash the area using a mild soap. Dust must be removed from the area. The cleaned area must be extended by a minimum of 152 mm beyond the defect area. Rinse thoroughly with clean water and allow the membrane to dry. Cut a piece of like membrane large enough to extend 103 mm beyond any part of the defects. Round corners of the patch to prevent peeling of the square corners. Apply appropriate manufacturer-recommended primer to both surfaces to be mated, and allow drying. Apply proper adhesive to the membrane and the patch as per instructions given by the adhesive manufacturers. Allow time for the adhesive to dry. When the adhesive is ready, mate the two surfaces and smooth out with pressure from a gloved hand.

4.4.7 Thermoplastic Membrane

This is mainly composed of polymers which soften when heated and harden when cooled.

Membrane Patch Procedure: The surface of the membrane should be free from debris, contamination and loose particles. Wash the area using a mild soap and ensure that dust is removed from the area. Rinse thoroughly with clean water and allow the membrane to dry. Cut a piece of like membrane large enough to extend 103 mm beyond any part of the defects. Round corners of the patch to prevent peeling of the square corners. Allow the surface of the membrane and patch to air-dry. Weld the patch in place. After the welded area has cooled, check application for voids with a round tip probe such as a screwdriver. Where patches are made with reinforcement membrane materials, application seals the outer perimeter with sealant compatible with the membrane.

5.0 Conclusion

The roof and terrace waterproofing is the most crucial for durability in case of the 'building envelope' concept of the waterproofing system. No single material or system seems to be ideal for all the different cases of remedial waterproofing. It is easier to design and achieve the desired service life of any new waterproofing system if all the detailing is made properly. But while designing any remedial waterproofing system, the success depends on the exact condition assessment of the existing roof substrate and selection of a more compatible new system with proper adhesion to the old system.

Case Studies of Remedial Waterproofing

1.0 Remedial Waterproofing with APP Torchshield Membrane

Durgapur Chemical Limited has more than 400 residential accommodations in their township. Majority of the roofs in the townships quarters have suffered water seepage in roof and parapet walls. For waterproofing initially PVC membrane was applied in roof, which was found in a brittle and water-soaked condition during the site investigation.

It was decided to do re-roofing for which the entire PVC membrane was removed from the roof surface. The proper gradient of the roof slab was made after repairing cracks and damages patched with polymer modified mortar followed by curing of the surface. After surface preparation, priming was done and torch-on application of APP preformed membrane of 3 mm thick on the roof was done after terminating it up to 300 mm on the parapet wall: (Source: Archives of doctor-fixit)

2.0 Remedial Waterproofing with Heavy-Duty Microfiber Reinforced Acrylic Based Liquid Applied Coating

2.1 Commercial Building of MAGENCO, Chandrapur

The present case study of MAGENCO at Chandrapur in Maharastra covers remedial waterproofing with liquid waterproofing coating. The structure has been started with construction since the year 2001 and completed in 2006. This 8-storey building is used as a commercial call centre. This site has a huge terrace of approximately 12000 m^2. The large terrace of this building is occupied with big chillers and A/C, pipes, water tank, etc and below this terrace there were well-furnished international call centre which was taken on rent. During monsoons, there were heavy leakages from all the sides of terrace and because of all this, the call centre unit was affected. Due to heavy chillers and A/C pipes on the terrace, it was difficult to do any kind of waterproofing treatment. During site visit, it was observed that the surface is uneven, surface cracks were observed in all parts of the terrace, due to heavy chillers and large obstacles. A heavy-duty microfiber reinforced acrylic based flexible terrace waterproofing coating was applied after proper surface preparation. (Source: Archives of doctor-fixit)

2.2 Canteen Building of an Engineering College

Bhagavan Mahaveer Jain College of Engineering under Jain Deemed University in Karnataka located at Bangalore Kanakapura Highway has leakage problem from the tiled roof, made out of Mangalore tile in their