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## 1. Introduction

### 1. Background

Water is the single most common cause of deterioration in buildings. Of all the elements of a building, the slab, and especially the roof slab, is the most exposed to rain, sun, temperature variation, and standing water. In a country like India, where the monsoon brings intense rainfall for several months and summer temperatures cause large daily thermal movement, a slab that is not properly waterproofed will begin to leak within a few years of construction. Once water enters a reinforced concrete slab, it dampens ceilings and walls, stains finishes, grows fungus and, most seriously, reaches the steel reinforcement and starts corrosion.

Concrete is often thought of as a waterproof material, but this is only partly true. Even well-made concrete is a porous material containing capillary pores, micro-cracks and shrinkage cracks. Water, dissolved salts and carbon dioxide travel through these pathways. In addition, concrete slabs crack because of shrinkage, thermal expansion and contraction, structural deflection and settlement. A separate waterproofing system is therefore needed to make a slab genuinely watertight and durable.

Slab waterproofing has become an important part of construction practice because of the growth of multi-storey buildings, terraces used as living or parking spaces, podium decks, wet areas such as bathrooms and kitchens, basements and water tanks. The cost of waterproofing is only a small part of the total construction cost, usually a few per cent, but the cost of repairing a leaking slab after construction can be many times higher, and the nuisance to occupants is considerable.

## 2. What Is a Slab Waterproofing System?

A slab waterproofing system is a combination of materials, layers, details and workmanship applied on or within a concrete slab to prevent the entry or passage of water into the structure and the spaces below it. It is not a single product. A complete system includes:

- **Slab and substrate:** a sound, properly compacted and cured concrete slab with correct slopes to drain water.
- **Surface preparation:** cleaning, repair of cracks and honeycombs, and formation of cove (goal) at junctions.
- **Primary waterproofing layer:** a cementitious coating, liquid-applied membrane, bituminous membrane, single-ply sheet or crystalline treatment.
- **Protective and wearing layers:** screed, insulation, tiles, concrete topping or reflective coating that protect the membrane from damage and ageing.
- **Drainage elements:** outlets, rainwater pipes, scuppers, gutters and slopes that remove water quickly.
- **Detailing:** treatment of parapets, expansion joints, pipe penetrations, thresholds and edges, where most leaks begin.
- **Testing and maintenance:** ponding tests, inspection and periodic repair.

Waterproofing is different from damp-proofing. Damp-proofing resists the passage of moisture, such as capillary rise or vapour, while waterproofing resists water under pressure, including standing water and rain. Slabs exposed to rain and ponding need waterproofing, not just damp-proofing.

## 3. Objectives of This Report

This report aims to:

1. Explain the causes and mechanisms of water leakage through slabs.
2. Describe the properties, advantages and limitations of the main waterproofing materials and systems.
3. Present the correct procedure for surface preparation, application, detailing and testing.
4. Discuss defects, repair methods, maintenance, economics and sustainability.
5. Provide a practical set of design guidelines and a checklist that can be used in site work and project study.

## 4. Scope and Structure

The report begins with the understanding of the problem (Chapters 2 and 3), followed by design principles and preparation (Chapters 4 and 5). Chapters 6 to 8 describe waterproofing materials, application by slab type and detailing. Chapters 9 to 11 cover testing, defects and maintenance. Chapters 12 to 15 deal with case scenarios, economics, sustainability and safety. Chapter 16 gives guidelines and checklists, followed by the conclusion, glossary and references.

## 2. Understanding Slab Leakage: Causes and Mechanisms

### 1. Types of Slabs Requiring Waterproofing

Different slabs face different types of water exposure, so the waterproofing system must be chosen according to the location and the nature of exposure.

| Slab type                             | Water exposure                                 | Main concern                                               |
|---------------------------------------|------------------------------------------------|------------------------------------------------------------|
| Roof or terrace slab                  | Rain, sun, ponding, thermal movement           | Cracking and leakage through surface; UV and heat          |
| Bathroom, toilet and kitchen slab     | Frequent splashing, standing water in wet area | Leakage to the floor below through pipe sleeves and joints |
| Balcony and sunshade slab             | Rain, direct sun, edge exposure                | Cracks at wall junction; water entering at edges           |
| Basement or raft slab                 | Groundwater, hydrostatic pressure              | Seepage through slab and construction joints               |
| Podium, parking deck and planter slab | Rain, vehicles, soil and irrigation water      | Roots, load, chemicals and long-term moisture              |
| Water tank and swimming pool slab     | Continuous water contact                       | Permanent immersion and hydrostatic pressure               |

## 2. How Water Enters a Slab

Water travels through a slab by several mechanisms, and effective waterproofing must address all that apply.

- **Gravity flow through cracks:** the most common path. Any crack wider than a hairline allows water to pass under the force of gravity or pressure.
- **Capillary action:** water is drawn into fine pores of concrete and mortar, as in a thin tube, and can move horizontally and upwards.
- **Hydrostatic pressure:** standing water or groundwater exerts pressure that pushes water through pores and joints.
- **Permeation:** slow movement of water through the pore structure of poorly compacted or high water-cement ratio concrete.
- **Wind-driven rain:** rain forced sideways into wall junctions, parapets and openings.
- **Vapour movement:** water vapour moves from warm, humid areas to cooler surfaces and condenses, causing dampness even without a visible leak.

## 3. Common Causes of Slab Leakage

### Defects in concrete

- High water-cement ratio, poor grading of aggregates or inadequate cement content, leading to a porous and permeable slab.
- Poor compaction, causing honeycombing and voids, particularly around reinforcement and at beam-slab junctions.
- Inadequate curing, which leads to plastic and drying shrinkage cracks. Slabs should normally be cured for at least 7 to 10 days.
- Cold joints and construction joints that are not properly treated.
- Insufficient cover to reinforcement or displaced reinforcement, which allows early corrosion and cracking.

### Cracking

- **Plastic shrinkage cracks:** appear within hours of casting due to rapid loss of surface moisture.
- **Drying shrinkage cracks:** appear over days or weeks as concrete loses water.
- **Thermal cracks:** caused by daily and seasonal temperature differences. A roof slab can reach a surface temperature far higher than the air temperature in summer.

- **Structural cracks:** caused by deflection, overload, settlement or poor design.
- **Dynamic (moving) cracks:** cracks that open and close with temperature or load; these need flexible waterproofing materials.

### Design and detailing faults

- Insufficient or incorrect slope, resulting in water ponding on the slab. Ponded water increases pressure and speeds up deterioration.
- Inadequate number or size of drain outlets, or outlets placed above the general slab level.
- No cove (gola) at wall-slab junctions and no proper termination of membrane on the parapet.
- Lack of expansion joints or poorly sealed joints in large slabs.
- Pipes, sleeves and conduits penetrating the slab without proper collars and sealing.
- Waterproofing extended for too little height on walls, or not turned into drain outlets.

### Material and workmanship faults

- Application on a dirty, dusty, oily or wet surface, which prevents bonding.
- Incorrect mixing ratio, insufficient thickness or skipping coats.
- Choosing a material that does not suit the exposure, for example a rigid cementitious coating over a moving crack, or an unprotected membrane exposed to sunlight.
- Damage to the membrane during later work, such as tile laying, plumbing and installation of solar panels or water tanks.
- No testing before covering the waterproofing layer.
- Use of unskilled labour without supervision.

### Ageing and lack of maintenance

All waterproofing materials age. UV radiation, heat cycles, algae, plant roots and chemical attack reduce their performance. Blocked drain outlets, accumulated debris and vegetation growth on terraces are among the commonest reasons for leakage in old buildings.

## 4. Thermal Movement of Slabs

A concrete slab expands when heated and contracts when cooled. The change in length can be estimated by the formula:

$$\Delta L = \alpha \times L \times \Delta T$$

where  $\Delta L$  is the change in length,  $\alpha$  is the coefficient of thermal expansion of concrete (about  $10$  to  $12 \times 10^{-6}$  per  $^{\circ}\text{C}$ ),  $L$  is the length of the slab and  $\Delta T$  is the temperature change. For a 20 metre slab and a temperature change of  $30^{\circ}\text{C}$ , the movement is about 6 to 7 millimetres. Such movement is enough to open a crack or break a rigid coating, which is why large terraces are divided with expansion joints and why flexible or elastomeric membranes are preferred for exposed roofs.

## 3. Impacts of Slab Leakage

### 1. Damage to the Building

- **Corrosion of reinforcement:** moisture and dissolved salts or carbon dioxide reach the steel and cause rusting. Rust occupies a larger volume than steel and breaks the concrete cover (spalling), exposing the bars further.
- **Loss of strength and durability:** long-term leaching of lime, freeze or thermal cycles and chemical attack weaken concrete.

- **Damage to finishes:** peeling paint, blistered plaster, damaged false ceilings, lifted flooring and damp patches.
- **Efflorescence:** white salt deposits on ceilings and walls.
- **Damage to contents and services:** electrical short circuits, damage to furniture, books, equipment and records.

## 2. Health and Comfort Impacts

Persistent dampness causes mould and fungal growth, musty smell and poor indoor air quality. These can trigger respiratory problems, allergies and asthma, especially in children and older people. Leakage through electrical fittings is also a safety hazard, with risk of shock and fire.

## 3. Economic Impacts

- **Repair cost:** repairing leaks after construction involves breaking tiles and screed, re-waterproofing, and reinstating finishes, which is far more expensive than doing it correctly during construction.
- **Reduced property value:** buildings with visible dampness are valued lower and are difficult to sell or rent.
- **Disputes and liability:** leakage is among the most frequent causes of complaints between builders, contractors and owners.
- **Indirect costs:** loss of use of rooms, repainting, temporary relocation and business interruption.

## 4. Impacts on Energy and the Environment

Wet insulation loses much of its thermal resistance, which raises cooling energy needs. Repeated demolition and reconstruction generate construction waste and carbon emissions. A durable waterproofing system therefore also supports sustainability by extending the life of the building.

# 4. Principles of Slab Waterproofing Design

## 1. Prevention Better Than Cure

Waterproofing should be planned during the design stage and not added as an afterthought. The building design should include correct slopes, drain locations, parapet heights, sunk slabs in wet areas, expansion joints and provision for membrane details. The waterproofing contractor should be involved before the slab is cast, and the specification must be included in the tender documents.

## 2. Core Design Principles

1. **Good concrete first.** A dense, low-permeability, well-compacted and well-cured slab is the foundation of the system. Waterproofing is a second line of defence, not a substitute for good concrete.
2. **Drain the water.** Water should leave the slab quickly. A minimum slope of about 1 in 100 (10 millimetres per metre) towards outlets is generally recommended, and ponding should be avoided.
3. **Select the system for the exposure.** Consider whether the slab is exposed to sun, subject to movement, under a finish, in permanent contact with water or accessible to traffic.
4. **Continuity.** The waterproofing must form a continuous skin without gaps, extending up walls, parapets and into outlets.
5. **Flexibility where needed.** Use elastomeric or bridging materials at cracks, joints and movement-prone areas.

6. **Protect the membrane.** Provide a screed, tiles, boards or reflective coating to protect it from mechanical damage and UV.
7. **Compatibility.** Primers, membranes, sealants and protective layers must be chemically compatible with each other.
8. **Redundancy at critical points.** Use extra reinforcement, double coats or additional layers at corners, drains and joints.
9. **Test before covering.** Always conduct a flood or ponding test before laying finishes.
10. **Plan for maintenance.** Provide access for inspection, keep drains clear and allow for repair or replacement of surface layers.

### 3. Positive Side and Negative Side Waterproofing

Waterproofing applied on the side from which water arrives (the top of a roof slab, or the outside of a basement) is called positive-side waterproofing. It is the most effective method, because it prevents water from entering the concrete at all. Waterproofing applied on the inside, opposite to the direction of water pressure, is called negative-side waterproofing and is used for repair when the outside is not accessible. Negative-side systems, usually cementitious or crystalline, resist water pressure only as long as they remain bonded to the substrate, so positive-side application should be used wherever possible.

### 4. Roof Configurations

- **Conventional (warm) roof:** the waterproofing membrane is placed above the slab, with insulation, if any, above or below it. The membrane is exposed to temperature extremes unless protected.
- **Inverted roof:** insulation is placed above the membrane, so that the membrane is kept cooler and protected from damage and UV. The insulation must be water resistant, such as extruded polystyrene, and ballasted.
- **Protected membrane with finishes:** screed with tiles, China mosaic or concrete topping over the membrane.
- **Exposed membrane:** uses UV-resistant or reflective-coated materials, such as sheets with mineral surface, TPO or acrylic top coats.
- **Green or garden roof:** a root-resistant membrane, drainage layer, filter fabric, soil and plants above the slab.

### 5. Selection Criteria for Waterproofing Systems

- Type of slab and exposure (roof, wet area, basement, tank, podium).
- Expected crack movement and slab size.
- Finish and traffic above (tiles, parking, garden, solar panels, bare).
- Service life expected and warranty available.
- Climate, particularly temperature and rainfall.
- Substrate condition and moisture content.
- Cost, including life-cycle cost, and availability of trained applicators.
- Safety and environmental needs, such as ventilation, flammability and VOC content.

## 5. Surface Preparation and Pre-Treatment

### 1. Importance of Surface Preparation

Many waterproofing failures are caused not by the product but by poor preparation. A membrane can only perform if it bonds to a sound, clean and suitably dry surface. Surface preparation typically takes more time than the application itself, and should be inspected and approved before the waterproofing material is opened.

### 2. Inspection of the Slab

- Check the level and slope of the slab and the position of the outlets using a spirit level or water test.
- Identify cracks, honeycombs, cold joints, exposed reinforcement and loose or weak areas.
- Check the depth of the screed and that it has cured and is not hollow or cracked.
- Verify that sleeves and pipes have been fixed before waterproofing and that no further drilling is planned.
- Measure surface moisture where needed; most materials need a dry or damp-but-no-standing-water surface, and polyurethane systems usually need a dry surface (commonly about 5 per cent moisture or less, as per manufacturer).

### 3. Cleaning

- Remove dust, dirt, laitance, loose particles, oil, grease, curing compounds, paint and algae using wire brushes, scrapers, grinders or light shot-blasting.
- Vacuum or wash the surface and allow it to dry as required by the product.
- Remove protruding nails, binding wire and sharp edges.

### 4. Repair of Defects

#### Cracks

- **Hairline cracks (up to about 0.3 mm):** may be covered by flexible coatings or bridged with a reinforcing fabric.
- **Wider static cracks:** open the crack in a V-shape (chase), clean, fill with polymer-modified mortar, epoxy or polyurethane sealant, and cover with a bandage of reinforced membrane.
- **Moving cracks:** fill with an elastomeric sealant over a backer rod, and bridge with a flexible strip.
- **Leaking cracks:** inject polyurethane or acrylic grout to stop active flow before surface treatment.

#### Honeycombs and spalled concrete

Break out loose concrete until sound material is reached, clean and treat any exposed steel with an anti-corrosive primer, apply bonding agent and fill with non-shrink polymer-modified repair mortar in layers.

#### Pipe penetrations and sleeves

Fix sleeves before the slab or screed is cast, and provide a recess around pipes. Fill the gap with non-shrink grout and apply a flexible sealant at the top. Fix a collar or puddle flange where possible.

### 5. Forming the Cove (Gola)

Sharp 90-degree corners between the slab and the wall are weak points because membranes stretch and crack there. A cove or fillet of about 75 to 100 millimetres in radius, made from polymer-modified cement mortar, should be formed at all wall-slab junctions and around upstands. For roof slabs, the membrane is carried up the parapet to a height of at least 150 millimetres above finished surface level and terminated in a groove (Reglet), then sealed.

## 6. Slope Screed (Brickbat Coba)

In traditional Indian practice, slope is created above the slab by brickbat Coba, which is a layer of broken bricks bedded in lime or cement mortar, finished with a cement mortar screed. Lightweight concrete screed or modern lightweight, thermally insulating materials may also be used. Key points are:

- Average thickness is usually 75 to 100 millimetres, with a minimum of about 40 millimetres at the outlet.
- Slope should not be flatter than about 1 in 100 towards outlets.
- The mix should be well compacted and cured for at least 7 days, and finished with a smooth surface.
- The screed should be divided into panels by joints in large areas to avoid cracking, with the joints sealed.
- Sloping can alternatively be done in the structural slab itself, which is better because it reduces weight and eliminates one layer.

## 7. Priming

Most membranes need a primer to improve adhesion and seal the pores of the substrate. Bituminous membranes use a bitumen primer; polyurethane and epoxy systems use specific primers; cementitious coatings usually need the substrate to be pre-wetted but with no standing water. The primer must be allowed to dry fully before the membrane is applied.

## 6. Waterproofing Materials and Systems

### 1. Classification of Waterproofing Systems

Waterproofing systems for slabs can be grouped into the following categories:

- Integral (admixture) waterproofing, mixed into concrete or mortar.
- Cementitious coatings (rigid and polymer-modified).
- Crystalline waterproofing.
- Liquid-applied membranes (acrylic, polyurethane, bituminous, epoxy).
- Preformed bituminous sheet membranes.
- Single-ply synthetic membranes (PVC, TPO, EPDM, HDPE).
- Injection grouts and sealants for repair of cracks and joints.
- Traditional systems such as brickbat Coba and lime terracing.

### 2. Integral Waterproofing Compounds

Integral compounds are added to the concrete or mortar mix to reduce its permeability. They work as water-reducing agents, pore blockers or hydrophobic (water-repelling) agents. Specification for such compounds in cement mortar is covered by IS 2645. The dosage should be as recommended by the manufacturer, commonly in the range of about 0.5 to 2 per cent by weight of cement.

- **Advantages:** simple, economical, no separate application stage, and effective on the whole thickness of concrete.
- **Limitations:** does not bridge cracks, is dependent on uniform mixing, and cannot be used as the only protection for exposed roofs. It is best used together with a surface-applied system.

### 3. Cementitious Waterproofing

These are cement-based coatings, usually containing fine sand, polymers and additives, supplied as two-component (powder and liquid polymer) or single-component products. They are applied by brush, roller or trowel in two or three coats, giving a total thickness of about 2 to 3 millimetres, with each coat cured before the next.

- **Rigid cementitious:** with no or little polymer. Suitable for basements, tanks and areas with no movement.
- **Flexible (polymer-modified) cementitious:** contains acrylic or SBR polymer, able to take small crack movement, and suitable for bathrooms, balconies, planters and sunken slabs under tiles.
- **Advantages:** compatible with concrete, breathable, non-toxic, can be applied on damp surfaces, good bond to tiles, economical.
- **Limitations:** limited crack-bridging, not recommended for exposed roof surfaces with large movement unless it is a high-flexibility product; needs proper curing.

### 4. Crystalline Waterproofing

Crystalline products, supplied as a slurry coat or as a dry-shake powder or admixture, contain active chemicals that react with water and the by-products of cement hydration (such as calcium hydroxide) to form insoluble crystals in the pores and fine cracks of the concrete. These crystals block the pathways of water. The system becomes part of the concrete and can continue to react if water enters later, so it has a self-sealing ability for fine cracks.

- **Uses:** basement slabs and rafts, water tanks, swimming pools, tunnels and foundations.
- **Advantages:** works under hydrostatic pressure, permanent as it is inside the concrete, can be applied on the positive or negative side.
- **Limitations:** cannot seal wide or moving cracks and depends on the presence of moisture and cement hydrates; not a membrane for exposed terraces.

### 5. Liquid-Applied Membranes

Liquid membranes are applied by brush, roller, squeegee or spray, and cure to form a seamless, continuous, rubber-like film. Seamlessness is a major advantage over sheets, especially around complex shapes and many penetrations.

#### Acrylic (polymer) membranes

Water-based, single-component, easy to apply, with good UV resistance and reflectivity. They are widely used as roof coatings in two to three coats, often with a polyester or glass-fibre mesh at joints and cracks. Typical dry film thickness is about 1 to 1.5 millimetres. They need a dry period without rain after application and can degrade if ponding water remains for long periods.

#### Polyurethane (PU) membranes

Solvent-based or solvent-free, single- or two-component, with high elongation and excellent crack-bridging. Typical thickness is 1.5 to 2 millimetres. Aromatic PU needs a UV-resistant top coat or protective layer, while aliphatic PU has better UV resistance. PU is very sensitive to moisture in the substrate and requires special primers. Fumes require ventilation during application.

#### Bituminous and bitumen-polymer coatings

Cold-applied coatings based on bitumen emulsion or modified with rubber or polymers. These are economical and suitable for basements, foundations, and slabs that will be covered with a protective screed. They are not UV stable and become brittle if left exposed.

## Epoxy coatings

Used mainly on tank interiors, chemical-resistant floors and areas that need very high adhesion and hardness. They are rigid, so are not suitable for slabs with moving cracks.

## 6. Preformed Bituminous Sheet Membranes

These are factory-made sheets of bitumen reinforced with polyester or glass fibre, usually 3 to 4 millimetres thick. The bitumen is modified with APP (atactic polypropylene) or SBS (styrene-butadiene-styrene) to improve flexibility, heat resistance and ageing.

- **APP-modified:** good UV and heat resistance, suitable for hot climates.
- **SBS-modified:** excellent flexibility at low temperatures and high elasticity.
- **Application:** torch-applied (heat-fused with a gas torch), self-adhesive or hot-bitumen bonded. Laps are typically 100 millimetres for side laps and 150 millimetres for end laps, fully sealed.
- **Advantages:** uniform factory-controlled thickness, long service life, and good performance in flat roofs and below ground.
- **Limitations:** needs skilled workers; open-flame torching has fire risk, particularly near combustible materials; many joints and details; mineral-surfaced or protected finishes are needed for exposure.

Traditional bitumen felts, covered by IS 1322 and the code of practice IS 1346 for waterproofing of roofs with bitumen felts, have been widely used in India, though modern modified sheets perform better.

## 7. Single-Ply Synthetic Membranes

Single-ply sheets such as PVC (polyvinyl chloride), TPO (thermoplastic polyolefin), EPDM (ethylene propylene diene monomer) and HDPE are used on large roofs, podiums and tunnels. They are 1.2 to 2 millimetres or more in thickness, with joints formed by heat welding (PVC, TPO) or adhesive or tape (EPDM). They can be mechanically fixed, fully adhered or loose-laid with ballast.

- **Advantages:** high durability, good UV resistance (especially TPO and PVC), reflective white surface reduces heat, welded seams are very strong.
- **Limitations:** higher initial cost, need trained installers, and special flashing details are required. Punctures must be repaired by patching.

## 8. Injection Grouting and Sealants

For repair of leaking cracks and joints, low-viscosity grouts are injected under pressure into the crack through packers. Polyurethane grouts expand on contact with water and stop active leaks. Epoxy grouts restore structural bond in dry cracks. Acrylate gels are used for fine cracks and for curtain grouting. Sealants (polyurethane, polysulphide, silicone) fill expansion joints and perimeter gaps.

## 9. Traditional Systems

Brickbat Coba with lime concrete and lime terracing has been used in India for centuries and provides thermal insulation and slope. It is heavy and can crack with time. It is still used as a base for modern systems, but on its own is not reliable for long periods without maintenance.

## 10. Comparison of Common Systems

The following table compares typical characteristics. The values are indicative and may vary with product, application and site conditions.

| System                 | Crack bridging | UV exposure         | Typical life (years) | Best application              |
|------------------------|----------------|---------------------|----------------------|-------------------------------|
| Integral compound      | None           | Not applicable      | Same as concrete     | Basement, tank, supplementary |
| Rigid cementitious     | Low            | Good (under finish) | 5–10                 | Bathrooms, sunk slabs, tanks  |
| Flexible cementitious  | Low to medium  | Good (under finish) | 8–12                 | Balcony, bathroom, planter    |
| Crystalline            | Hairline only  | Not applicable      | Life of concrete     | Basement, raft, tank          |
| Acrylic liquid         | Medium         | Good                | 5–10                 | Exposed terrace roofs         |
| Polyurethane liquid    | High           | Needs top coat      | 10–15                | Roofs, balconies, podium      |
| Modified bitumen sheet | High           | Needs protection    | 15–20                | Roofs and basements           |
| PVC / TPO sheet        | High           | Very good           | 20–30                | Large roofs, podium decks     |

## 7. Application by Slab Type and Location

### 1. Roof Terrace Slab

#### Typical layers (from bottom to top)

1. Structural RCC slab.
2. Cleaning, crack repair, cove and primer.
3. Slope screed (brickbat Coba or lightweight concrete), cured and dry.
4. Waterproofing membrane (liquid, bituminous, or single ply), turned up to parapet.
5. Separation layer or protective screed (about 25 to 40 millimetres).
6. Thermal insulation if required (above or below membrane).
7. Finish: tiles, China mosaic, concrete topping, reflective coating or green cover.

For exposed roofs without finish, the membrane is applied directly on the screed, with a reflective top coat. Acrylic or PU systems, or mineral-surfaced bituminous sheets, are most common. At least two crossed coats should be applied, with reinforcing mesh at cracks, corners and joints.

### 2. Bathroom, Toilet and Kitchen Slab

Wet areas leak mainly because of poor treatment at pipe sleeves, floor drains, wall-floor junctions and door thresholds. Common practice is:

1. Provide a sunk slab or depression, typically 50 to 150 millimetres below the adjoining floor, so that water cannot spread.
2. Fix all plumbing and sleeves before waterproofing; seal around pipes with non-shrink grout and sealant.
3. Fill the sunk portion with lightweight or brickbat Coba, laid to slope towards the floor drain.
4. Apply flexible cementitious or PU coating on the entire floor and turn up the walls to at least 150 to 300 millimetres, and to full height in shower areas.
5. Provide a seamless coat at drains with a bond to the drain flange, and an additional strip at the door threshold.

6. Conduct a flood test for 24 to 48 hours before tiling, and fix tiles with polymer-modified adhesive and sealed joints.

### **3. Balcony and Sunshade Slab**

Balconies are exposed on three sides. The slope should be away from the building, and the waterproofing should be turned up under the door frame and onto the parapet or kerb. The edge or drip mould should be formed to throw water clear of the wall. Flexible membranes with mesh at the wall junction are recommended, because cracks usually form here.

### **4. Basement and Raft Slab**

Basement slabs are subject to hydrostatic pressure from groundwater. The best system is a positive-side membrane, such as modified bitumen sheets or HDPE or PVC sheets, laid below the raft over lean concrete, with water bars at construction joints. Crystalline waterproofing or integral admixtures may be used to supplement this. Water bars (PVC or hydrophilic strips) are installed in all construction joints. Where the water table is high, drainage and sump pumps may also be provided.

### **5. Podium, Parking Deck and Planter Slab**

These slabs carry soil, vehicles or heavy loads above, so the membrane must be robust and protected. Typical features are a root-resistant membrane, a protection board or screed, a drainage layer or drainage cell, filter fabric and then soil or wearing course. Planter walls are waterproofed on the inside face and up to the soil level. Drainage of the podium must be designed to prevent saturation of the soil layer from forming a permanent water load.

### **6. Water Tanks and Swimming Pools**

Water retaining structures require concrete designed to IS 3370 and waterproofing suitable for continuous immersion. Crystalline, polymer-modified cementitious, and epoxy or specialised potable-water grade coatings are commonly used. For tanks holding drinking water, only materials certified as non-toxic and suitable for potable water should be used. After application, tanks are filled and tested for leakage over several days.

### **7. Overhead Water Tank Slabs and Machine Rooms**

Roof slabs carrying water tanks and mechanical equipment should be waterproofed before the equipment is installed. Bases and supports should have their own sealed upstands so that the membrane is not punctured later, and walkways should be provided to protect the membrane from foot traffic during maintenance.

### **8. Detailing at Junctions, Outlets and Penetrations**

Most leaks do not occur through the open field of a membrane but at its edges and details. About three quarters of failures are said to arise from details such as terminations, penetrations and joints, so extra care must be taken at these locations.

#### **1. Wall-Slab Junctions and Parapets**

- Form a cove of 75 to 100 millimetres.
- Carry the membrane up the wall to at least 150 millimetres above the finished roof level.
- Terminate in a groove (Reglet) about 25 millimetres deep, fill with sealant, and cover with a cement mortar fillet or metal flashing so water cannot run behind the membrane.
- Parapet top should be sloped inwards and may be covered with a coping with a drip.

## 2. Drain Outlets and Rainwater Pipes

- Outlets should be set slightly lower than the surrounding slab, in a shallow depression, so that water flows into them.
- Use drain pipes with a flange or collar that the membrane can be sealed to, and extend the membrane into the outlet.
- Provide domed gratings or leaf guards to stop leaves and debris from blocking the outlet.
- Provide enough outlets so that no point on the roof is far from an outlet and an overflow or scupper is available if the main outlet blocks.
- Outlet pipe size should be selected for the design rainfall intensity and area drained.

## 3. Expansion and Movement Joints

Large slabs should be divided by expansion joints, typically at intervals of about 20 to 30 metres or as per structural design. The waterproofing across the joint must accommodate movement. Typical details are a backer rod and elastomeric sealant, with a compressible filler below, covered by a bridging strip of flexible membrane that is loose (not bonded) over the gap in a U-shaped loop, and protected by a cover or kerb. Rigid cementitious coatings must never bridge a movement joint.

## 4. Pipe and Conduit Penetrations

- Fix sleeves and collars before waterproofing, with a raised upstand of at least 100 to 150 millimetres on roofs.
- Seal the annular gap with non-shrink grout and a flexible sealant.
- Finish the membrane up the pipe, with a reinforcement strip, and fix a clamp or collar over it where possible.
- Group the penetrations where possible, and avoid placing them in low points.

## 5. Thresholds, Door Openings and Edges

At doors opening on to terraces and balconies, the waterproofing should rise under the threshold and the finished floor level outside should be lower than inside by at least 25 to 50 millimetres, where permitted. The edges of balconies should be given a drip mould or kerb. Membrane edges must always be terminated and sealed, never left open.

## 6. Treatment of Cold Joints and Construction Joints

Construction joints in water-retaining slabs and basements need water bars, hydrophilic strips or crystalline treatment. The joint surface should be roughened, cleaned and treated with slurry before the next pour so that the joint is as dense as the surrounding concrete.

## 7. Reinforcement of Weak Points

Weak points should receive an additional layer of reinforcing fabric (polyester or glass mesh) embedded in the first coat, with a second coat applied over it. Corners, drains, penetrations and joints are the prime examples.

## 9. Testing, Quality Control and Standards

### 1. Testing of Waterproofing

#### Ponding (flood) test

The ponding test is the most reliable site test for horizontal slabs. After the membrane has cured, the outlets are plugged and the slab is flooded with water to a depth of about 50 to 100 millimetres, typically for 48 to 72 hours (24 to 48 hours for wet areas). The water level is marked, and the ceiling below is inspected for dampness. A drop in level beyond evaporation, or any damp patch below, means that there is a leak, which must be located and repaired and the test repeated. The structure should be checked to ensure that it can carry the load of the water.

#### Other methods

- **Visual inspection:** for blisters, pinholes, uneven thickness, loose edges and incomplete laps.
- **Wet film and dry film thickness measurement:** to confirm coverage and consumption of material per square metre.
- **Adhesion (pull-off) test:** to check bond between membrane and substrate.
- **Spark or holiday testing:** for detecting pinholes in some membranes.
- **Electronic leak detection (ELD):** uses electrical conductivity to find breaches in membranes laid on conductive substrates.
- **Infrared thermography:** detects wet insulation or moisture beneath roofing as temperature patterns.
- **Moisture meter:** to check the substrate before application and the screed after repair.

### 2. Quality Control During Execution

1. Approve materials: obtain technical data sheets, batch numbers and test certificates; store them as per instructions, protected from sun and water.
2. Approve the substrate in writing before application (hold point).
3. Check weather: avoid application during rain, in very high humidity or direct hot sun, and when the temperature is outside the product limits.
4. Check mixing ratios, pot life, number of coats, coverage rate and curing or recoating intervals.
5. Record the thickness and area of every application, with photographs.
6. Do the flood test and obtain approval before covering the membrane.
7. Protect the membrane from damage by other trades, and restrict access.
8. Maintain a handover file with materials used, test records, warranty and maintenance instructions.

### 3. Indian Standards and Codes

Some relevant Indian Standards are listed below. The latest version of each standard and the manufacturer data sheets should always be checked before use.

| Standard | Subject                                                                                                        |
|----------|----------------------------------------------------------------------------------------------------------------|
| IS 456   | Plain and reinforced concrete: code of practice                                                                |
| IS 3067  | General design details and preparatory work for damp-proofing and waterproofing of buildings: code of practice |
| IS 2645  | Integral waterproofing compounds for cement mortar: specification                                              |
| IS 1346  | Waterproofing of roofs with bitumen felts: code of practice                                                    |
| IS 1322  | Bitumen felts for waterproofing and damp-proofing: specification                                               |

| Standard | Subject                                                          |
|----------|------------------------------------------------------------------|
| IS 3370  | Concrete structures for the storage of liquids: code of practice |

International standards from ASTM, EN and BS, and technical guidance from industry bodies, are also referred to for membranes, sealants and test methods, as well as manufacturer warranties.

#### 4. Warranty and Responsibility

Reputable manufacturers and applicators give written warranties, commonly 5 to 15 years depending on system. A warranty is valid only if the system was applied by an approved applicator as per the specification and the maintenance conditions are followed. The agreement should clearly define scope, exclusions, response time and who bears the cost of reinstating finishes.

## 10. Defects, Failures and Remedial Measures

### 1. Common Defects in Waterproofing

| Defect                          | Likely cause                                                             | Remedy                                                                        |
|---------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Blistering or bubbles           | Trapped moisture or air; application on wet substrate; no breathing path | Cut open, dry, patch with reinforced membrane; use vents or breathable system |
| Peeling or delamination         | Dirty or smooth surface, no primer, moisture                             | Remove loose film, clean, prime, reapply with overlap                         |
| Cracking of coating             | Rigid material on moving crack, thin coat, thermal movement              | Open and seal crack, apply flexible coating with mesh                         |
| Pinholes                        | Poor application, air bubbles, insufficient coats                        | Apply additional coat; check by ponding test                                  |
| Leakage at outlets and pipes    | No collar, poor sealing, outlet above slab level                         | Reseal, install collar, lower the outlet, add reinforcement strip             |
| Leakage at parapet junction     | No cove or termination, top edge unsealed                                | Rake out, seal termination, add cove and flashing                             |
| Ponding water                   | Insufficient slope, settled screed, blocked drain                        | Rectify slope with polymer mortar, clear drains, add outlets                  |
| Chalking or UV degradation      | Exposed unsuitable material                                              | Apply UV-stable top coat or reflective coating                                |
| Efflorescence or dampness below | Water passing through slab or condensation                               | Locate leak; treat from the positive side; ensure ventilation                 |

### 2. Diagnosing a Leak

Water often travels some distance along the slab or reinforcement before appearing as a damp patch, so the visible stain is not necessarily below the point of entry. A systematic investigation should be done:

1. Mark the damp areas on the ceiling and relate them to the slab above.
2. Inspect the slab above for cracks, damaged membrane, outlets, joints, pipe penetrations and parapet junctions.
3. Check plumbing lines, leaking pipes and tanks, as they may be the source rather than rain.
4. Perform sectional ponding tests by isolating areas with temporary bunds.
5. Use moisture meter, thermography or electronic leak detection where needed.

### 3. Repair Methods

- **Local patch repair:** cut out damaged membrane, clean, and apply a new reinforced patch lapping at least 100 millimetres on to sound material.
- **Crack injection:** polyurethane or acrylic injection for active leaks, epoxy for structural cracks.
- **Re-coating:** apply a new compatible coating over an existing sound membrane after cleaning and priming, where the old system is well bonded.
- **Full replacement:** remove failed screed and membrane completely and reinstall a new system when the slab is saturated or widely damaged.
- **Overlay systems:** apply a new membrane over old bitumen, with a suitable primer, or a new single-ply over a separation layer.
- **Drainage corrections:** fix slopes, enlarge or add outlets, and clean gutters.

### 4. Why Old Terraces Fail Repeatedly

Repeated failure is usually because the repair treats the symptom (a damp patch) rather than the cause (slope, drainage, movement, incompatible layers). A repair should be preceded by diagnosis, selection of a compatible material and an improved detail, followed by testing.

## 11. Inspection, Monitoring and Maintenance

### 1. Why Maintenance Matters

Even the best system needs care. Studies of roofing performance regularly find that roofs which are inspected and maintained last much longer than those which are left alone. Maintenance is cheap compared to replacement.

### 2. Inspection Schedule

| When                       | What to check                                                                                  |
|----------------------------|------------------------------------------------------------------------------------------------|
| Before every monsoon       | Clear outlets and gutters; inspect membrane, joints and parapet junctions; repair minor damage |
| After heavy rain           | Look for ponding, damp patches below, and blocked drains                                       |
| Every year                 | Full inspection of membrane, sealants, coping, flashing and protective coating                 |
| After any work on the roof | Check for punctures, displaced finishes and damage from equipment installation                 |
| Every 5 to 10 years        | Re-coat reflective or protective topcoats; renew sealants; evaluate the need for major repair  |

### 3. Maintenance Practices

- Keep outlets, gutters and gratings free of leaves, plastic and debris.
- Remove vegetation, moss and algae; never allow plants to grow in joints.
- Restrict traffic; provide walkway pads where regular access is needed.
- Do not drill, fix or install anything on the terrace without checking the membrane; reseal any penetration made.
- Repair minor damage immediately; small defects can become big leaks within one monsoon.
- Keep records of inspections, repairs and warranty documents.

- Do not store sharp or heavy materials or dump construction debris on the roof.

## 4. Monitoring Technologies

Modern buildings can use moisture sensors embedded in roofs, periodic thermographic surveys, and drone inspections of large roofs to detect problems early without foot traffic damaging the membrane. These tools are especially valuable for large commercial and institutional buildings.

## 12. Case Studies and Field Scenarios

The following scenarios are illustrative examples based on common site situations in residential and institutional buildings, intended to show how the principles of this report apply in practice. They are not records of specific named projects.

### 1. Scenario 1: Leaking Terrace of a Residential Building

**Problem:** A five-year-old apartment building has damp patches on the top-floor ceilings every monsoon. Inspection shows a cracked cement screed with no cove at the parapet, one choked outlet, and ponding near the centre.

**Solution:** The old Coba and cracked screed were removed locally, the slab was cleaned and cracks were chased and sealed. A new lightweight screed was laid to slope, with a cove at the parapet. A polyurethane or acrylic membrane was applied in two coats with mesh at junctions, turned up 150 millimetres and terminated in a groove. Outlets were enlarged with grating, and a ponding test was conducted for 48 hours before a reflective top coat was applied.

**Lesson:** Fixing slope, drainage, and details is as important as the membrane.

### 2. Scenario 2: Bathroom Leakage to the Flat Below

**Problem:** Water stains appear on the ceiling of the flat below a bathroom. The tiles are intact, but plumbing sleeves and the floor drain were not sealed, and there was no waterproofing at the wall-floor junction.

**Solution:** The tiles and screed were removed, the sleeves were grouted and sealed, a flexible cementitious coating was applied with a 300 millimetre upturn on walls and full height in the shower, and a flood test was done for 48 hours. New tiles were laid with polymer-modified adhesive.

**Lesson:** Wet areas need waterproofing at floors, wall junctions, and penetrations, and should always be flood tested before tiling.

### 3. Scenario 3: Basement Raft with Groundwater Seepage

**Problem:** A basement parking floor shows seepage at construction joints during the monsoon, when the water table rises.

**Solution:** Active leaks were stopped with polyurethane grout injection, cracks and joints were treated, and a crystalline slurry coat was applied over the cleaned surface. A drainage channel and sump pump were added for water removal.

**Lesson:** Negative-side repair can control seepage, but new construction should use positive-side membranes and properly treated joints from the start.

### 4. Scenario 4: Podium Deck with Landscape

**Problem:** Leakage into a parking level below a landscaped podium garden. Tree roots had damaged an ordinary membrane, and the drainage layer was choked with silt.

**Solution:** On redesign, a root-resistant membrane (such as a PVC or modified bitumen sheet with root-resistant layer) was installed with protection board, drainage cell, filter fabric and inspection chambers for outlets.

**Lesson:** Podium systems need root-resistant membranes, effective drainage and access for maintenance.

## 5. Lessons from the Scenarios

- Most failures start at details: junctions, drains and penetrations.
- Correct slope and drainage are as important as the membrane.
- Material choice must match movement, exposure and finishes.
- Testing before covering saves large repair costs later.
- Maintenance prevents small defects from becoming major leaks.

## 13. Economics and Life-Cycle Cost

### 1. Cost as a Part of the Project

Waterproofing typically forms a small part of the construction cost of a building, usually in the range of a few per cent, but it has a very large influence on durability and on maintenance expenses. Waterproofing a slab during construction is generally much cheaper than repair later, because repair needs demolition of finishes, disposal of waste, re-waterproofing, replacement of finishes and repainting, and may need the occupants to vacate rooms.

### 2. Cost Factors

- Type of system and material quality.
- Area and complexity of details (number of outlets, penetrations, joints and upstands).
- Surface preparation required.
- Labour skill, accessibility and height of the site.
- Warranty period and applicator quality.
- Protective layers, insulation and testing.

### 3. Indicative Comparison of Systems

The table below shows relative initial cost and maintenance, which will change with market rates, location, and project details.

| System                           | Relative initial cost | Maintenance      | Service life    |
|----------------------------------|-----------------------|------------------|-----------------|
| Brickbat Coba with cement screed | Low                   | High             | Short to medium |
| Cementitious coating             | Low                   | Medium           | Medium          |
| Acrylic liquid membrane          | Low to medium         | Medium (re-coat) | Medium          |
| Polyurethane liquid membrane     | Medium                | Low to medium    | Medium to long  |
| Modified bitumen sheet           | Medium                | Low              | Long            |
| PVC / TPO single-ply sheet       | Medium to high        | Low              | Very long       |

## 4. Life-Cycle Cost Analysis

Life-cycle cost considers the initial cost, the cost of maintenance and re-coating, the cost of repair, and the cost of replacement over the life of the building. The cheapest option is often not the cheapest over 30 or 50 years. A simple method is to calculate the total cost per year of service life:

$$\text{Annual cost} = (\text{Initial cost} + \text{Maintenance} + \text{Repair} + \text{Replacement}) \div \text{Service life}$$

A system that costs 50 per cent more initially but lasts twice as long, with less maintenance, is typically more economical. Decisions should also account for disruption to occupants, which is difficult to measure but significant.

## 5. Cost Control Measures

- Decide the waterproofing specification at design stage and include it in the bill of quantities.
- Use competent, trained applicators and avoid selecting solely on the lowest bid.
- Invest in good surface preparation and testing, which are cheap compared to rework.
- Combine waterproofing with insulation and reflective coating on roofs for reduced cooling costs.
- Plan maintenance in the budget.

# 14. Sustainability, Climate and Future Trends

## 1. Climate and Waterproofing

Rising temperatures, more intense rainfall and longer dry spells followed by heavy storms place a higher demand on slab waterproofing. Heavy downpours stress drainage and increase ponding, while higher temperatures increase thermal movement and accelerate ageing of materials. Designers should therefore use higher drainage capacities, flexible and UV-resistant materials, and overflow provision on roofs.

## 2. Cool Roofs and Energy Efficiency

Reflective white or light-coloured waterproofing finishes (acrylic coatings, white TPO or PVC sheets, reflective paint and tiles) reflect solar radiation and reduce roof surface temperatures, decreasing heat transfer into the building and the load on air conditioners. This also reduces thermal stress on the slab and extends membrane life. Thermal insulation placed with the waterproofing system further improves energy performance.

## 3. Green and Blue Roofs

Vegetated (green) roofs retain rainwater, reduce runoff peaks, cool the building, and provide habitat. Blue roofs temporarily store rainwater. Both need a high-quality, root-resistant waterproofing system, because repair under a garden is very expensive. Combined with rooftop solar panels, they make the roof a multi-purpose surface. This ties directly to the concept of sustainable drainage and the reduction of urban flooding.

## 4. Environmental Considerations in Material Selection

- Prefer low-VOC, water-based and solvent-free products where performance allows.
- Choose durable systems to reduce waste from frequent replacement.
- Avoid hazardous materials, and manage the disposal of old membranes and waste properly.
- Consider recycled content and recyclability, for instance of TPO and PVC sheets.
- Avoid open-flame torching in sensitive buildings; use cold-applied or self-adhesive systems.

## 5. Emerging Innovations

- Self-healing and self-sealing materials that close small cracks automatically.
- Nanotechnology and hydrophobic coatings with improved water repellence and resistance to dirt.
- Spray-applied, fast-curing polyurea and polyurethane systems for quick installation.
- Smart roofs with embedded moisture sensors and electronic leak detection.
- Drone and thermographic inspection of large roofs.
- Bio-based and recycled bitumen alternatives.
- Building Information Modelling (BIM) used to coordinate details and quantities for waterproofing.
- Integration of solar panels with waterproofing and roofing systems.

## 6. Key Gaps and Research Needs

- Long-term field performance data for different systems under Indian climatic conditions.
- Standardised training and certification of applicators.
- Better and more widely adopted Indian standards for liquid-applied membranes.
- Affordable non-destructive leak-detection methods for existing buildings.

# 15. Health, Safety and Skills

## 1. Safety on Site

- **Work at height:** terraces and balconies need parapets, edge protection, safety harnesses and secure access.
- **Fire safety:** torch-applied systems use open flame and gas cylinders; keep fire extinguishers ready and keep flammable materials away. Bituminous primers and solvent-based products are flammable.
- **Chemical exposure:** use gloves, goggles and masks when handling polyurethane, epoxy and solvent-based products; ensure ventilation in confined areas such as tanks and basements.
- **Confined spaces:** tanks and basements may have poor air quality; use ventilation, a standby person and gas checks.
- **Hot work:** hot bitumen can cause serious burns; use proper equipment and protective clothing.
- **Slips and electrical safety:** keep the working area dry and use safe electrical equipment during wet application and testing.

## 2. Material Handling and Storage

Materials should be stored in a covered, cool, and ventilated place, away from sun and rain, with containers sealed and used within shelf life. Cement-based powders must be kept dry. Safety data sheets must be available on site.

## 3. Training and Skill Development

The best material will fail if it is applied badly. Applicators should be trained in surface preparation, mixing, application technique, detailing and testing, preferably through manufacturer or industry training programmes. Supervisors should be able to read drawings and specifications and to check thickness and coverage. Skilled workers deserve fair wages and recognition, as this helps raise quality in the industry.

## 16. Design Guidelines and Implementation Checklist

### 1. A Step-by-Step Framework

#### Step 1: Assess the slab and exposure.

- Identify the type of slab, the expected water exposure and the finishes above.
- Study climate, rainfall, temperature range and building use.

#### Step 2: Design for drainage.

- Provide slope of at least 1 in 100 and adequate outlets, with overflow provision.
- Avoid pockets and depressions where water can collect.

#### Step 3: Select the system.

- Choose material according to movement, exposure, finish and expected life.
- Check compatibility between all layers and obtain manufacturer approval.

#### Step 4: Prepare the surface.

- Clean, repair cracks, form coves, fix sleeves and apply primer.
- Check substrate approval before application.

#### Step 5: Apply the system.

- Follow the manufacturer instructions for mixing, thickness, coats and curing.
- Reinforce details and terminate edges properly.

#### Step 6: Test.

- Conduct ponding test for 48 to 72 hours and rectify defects.
- Document results.

#### Step 7: Protect and finish.

- Lay protective screed, insulation, tiles or reflective coating.
- Prevent damage from other trades.

#### Step 8: Maintain.

- Inspect before every monsoon and after heavy rain, clear drains and repair promptly.

### 2. Design Checklist for a New Building

- Concrete mix is dense, well compacted and cured for at least 7 to 10 days.
- Slab slopes are provided and checked, with outlets located at low points.
- Sunk slabs are provided in bathrooms and wet areas.
- Sleeves and pipes are fixed before waterproofing.
- Cove is formed at all wall-slab junctions.
- Parapet upstand is at least 150 millimetres with termination groove.
- Expansion joints are provided and detailed.
- Waterproofing system is specified with thickness, coats and warranty.
- Surface preparation is inspected and approved.
- Ponding test is carried out and recorded before covering.
- Protective layer, insulation and finish are installed.
- Maintenance instructions are given to the owner.

### 3. Checklist for Repair of an Existing Slab

- Source of leakage is diagnosed, including plumbing and drainage causes.
- Old damaged layers and loose material are removed.
- Cracks and joints are treated with suitable materials.
- Slope and drainage are corrected.
- New system is compatible with the existing substrate.
- Details at drains, penetrations and parapet are upgraded.
- Ponding test is performed and passed.
- A warranty and maintenance plan are in place.

### 4. Selecting a System: A Quick Guide

| Situation                              | Suggested system                                                                                          |
|----------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Exposed terrace roof, high movement    | Polyurethane or acrylic liquid membrane with mesh, or modified bitumen / TPO sheet with reflective finish |
| Terrace under tiles                    | Flexible cementitious or PU membrane, protected by screed                                                 |
| Bathroom, toilet and kitchen           | Flexible cementitious coating or PU, with sealed sleeves and flood test                                   |
| Balcony                                | Flexible membrane with mesh at wall junction, slope away from building                                    |
| Basement raft and tank                 | Positive-side sheet membrane, crystalline treatment, water bars                                           |
| Podium and landscape                   | Root-resistant sheet or liquid membrane, protection board and drainage layer                              |
| Large roof, long life needed           | PVC or TPO single-ply system, or SBS/APP bitumen sheet                                                    |
| Leaking existing slab, no access above | Crystalline or injection grouting as temporary negative-side measure                                      |

### 5. Common Pitfalls to Avoid

1. Relying on concrete or a single coat of paint-like coating as waterproofing.
2. Ignoring slope and drainage.
3. Applying on a dirty, wet or unprepared surface.
4. Using a rigid material over cracks or joints that move.
5. Neglecting details at parapets, outlets and pipes.
6. Not testing before laying the finish.
7. Allowing other trades to damage the membrane.
8. Skipping maintenance and inspection.

## 17. Glossary

- **Acrylic membrane:** A water-based liquid waterproofing coating that dries to a flexible film.
- **APP / SBS:** Polymers used to modify bitumen: atactic polypropylene and styrene-butadiene-styrene.
- **Brickbat Coba:** A layer of broken bricks in mortar laid on a roof slab to give slope and thermal insulation.
- **Capillary action:** The movement of water through very fine pores or tubes.

- **Cementitious coating:** A cement-based waterproofing coating, rigid or polymer-modified.
- **Cove (goal):** A curved fillet at the junction of slab and wall to avoid a sharp corner.
- **Crystalline waterproofing:** A treatment that forms insoluble crystals in the pores of concrete.
- **Damp-proofing:** Resistance to moisture or vapour, not to water under pressure.
- **Dry film thickness (DFT):** The thickness of a coating after it has cured.
- **Efflorescence:** White salt deposits left on a surface when water evaporates.
- **Expansion joint:** A gap that allows a structure to expand and contract without damage.
- **Flood (ponding) test:** A test in which the slab is filled with water to check for leaks.
- **Hydrostatic pressure:** Pressure exerted by water at rest.
- **Integral waterproofing:** A compound mixed into concrete or mortar to reduce permeability.
- **Membrane:** A continuous waterproof layer applied to or placed on a surface.
- **Negative-side waterproofing:** Waterproofing applied on the side opposite to the water pressure.
- **Parapet:** A low wall at the edge of a roof or terrace.
- **Positive-side waterproofing:** Waterproofing applied on the side from which water arrives.
- **Primer:** A preparatory coat that improves adhesion of the membrane.
- **Reglet:** A groove cut in a wall to terminate and seal the edge of a membrane.
- **Screed:** A layer of mortar or concrete laid to give a level or sloping surface.
- **Single-ply membrane:** A factory-made sheet such as PVC, TPO or EPDM used for roofing.
- **Water bar:** A strip placed across a joint in concrete to stop water passing.
- **Water-cement ratio:** The ratio of water to cement by weight in a concrete mix.

## 18. References

1. IS 456: Plain and Reinforced Concrete, Code of Practice, Bureau of Indian Standards.
2. IS 3067: Code of Practice for General Design Details and Preparatory Work for Damp-Proofing and Waterproofing of Buildings, Bureau of Indian Standards.
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13. Technical guidance from industry bodies and manufacturers, such as the Indian Concrete Institute and international roofing and waterproofing associations.

## 19. Conclusion

Slab waterproofing is one of the most important yet most frequently neglected parts of construction. Leakage through slabs causes corrosion of steel, damage to finishes, health problems and heavy repair costs, and shortens the life of a building. No single product can guarantee a leak-free slab. A reliable waterproofing system results from a combination of good concrete, correct slopes and drainage, a material suited to the exposure, careful surface preparation, proper detailing and testing, and regular maintenance.

Four ideas stand out from this report. First, prevention is better than cure: waterproofing must be designed at the beginning, together with slopes, outlets and details, rather than added later. Second, details decide success, since most leaks start at junctions, drains, pipes and joints and not in the open area of the membrane. Third, quality of workmanship and testing is as important as the quality of the material, so surface preparation, thickness control and ponding tests must never be skipped. Fourth, maintenance and life-cycle thinking are essential, because a slightly higher initial investment in a durable system and regular inspection usually costs far less than repeated repairs.

As cities grow and climate change brings more intense rainfall and higher temperatures, the importance of reliable slab waterproofing will increase. Combining it with insulation, reflective finishes and sustainable drainage can make roofs more durable, energy-efficient and environmentally friendly. A well-waterproofed slab is not just a protection against leakage but an investment in the safety, comfort and long life of the building.