ReBuild

Vol. 7 No. 4 (Oct – Dec 2013)

A Quarterly Newsletter

WATERPROOFING

PART - 7

WATERPROOFING OF PODIUM SLABS, PLANTER BOX & GREEN ROOF SYSTEM

Dr. Fixit Institute

of Structural Protection & Rehabilitation

A Not-for-Profit Knowledge Centre

From the Editor's Desk

Many high rise buildings and high end projects today incorporate landscaped basements and roofs commonly known as plazas or podiums. The basement can vary from habitable space to commonly used car parking. Whatever the usage, it is vital that the correct waterproofing system is selected when waterproofing podium decks. Depending upon the type of the podium deck, the waterproofing system that needs to be installed is determined. A garden bed type podium will require a different system compared to a trafficable podium system or a tiled podium system or a podium having a swimming pool.

There are many considerations to be taken into account while waterproofing podium decks, such as deck movement, differential movement, drainage, waterproofing continuity at expansion joints, drainage outlets and landscaping. The use of a seamless liquid applied membrane than the use of a sheet membrane is preferred thus disallowing any chance of delamination at any seam or junction.

It is also important to design the deck slab as watertight concrete and accordingly use such waterproofing materials during the laying of the concrete. The pore blocking admixtures and integral crystalline are more commonly added to the concrete mix. Drainage is an integral part of the podium waterproofing system and can be laid over the flexible waterproofing layer. It will also act as an effective drainage medium, channeling water to the drainage outlets. Drainage boards can also be used over the flexible waterproofing membrane, to create both a drainage layer and a water storage layer where required. Adequate drainage needs to be factored into podiums due to the large volume of water they can collect very quickly due to their size. In the garden roof system, a root barrier is very important since it prevents the migration of plant roots and prevents them from damaging the membrane. Similarly the growth medium has to be designed for different types of extensive, semi-intensive or intensive plantings. Extensive planting uses a narrower range of species limited to herbs, low-growing grasses, and mosses, whereas a semi-intensive roof garden system uses a combination of plant species that may include small shrubs and species like grasses and herbs. However, an intensive garden roof system uses a wide variety of plant species that may include trees and shrub.

Green or vegetative roof systems perceived by many as durable, sustainable, energy-efficient and high-performing, comprise layered assemblies combining landscaping, thermal insulation, waterproofing components and other elements to provide a functioning system. Green, or vegetative roof systems are one of the ways we can introduce and improve ecosystem services in urban areas. Vegetative roofs can manage storm water runoff, reduce energy use and noise, mitigate the urban heat island effect, alleviate air pollution, increase biodiversity and wildlife habitat, and add value to a building. Finding ways to improve, expand or increase the number of urban ecosystems may offer solutions to many environmental challenges by green or vegetative roofing. Sustainability and energy efficiency of the built environment have become essential parameters of any development. A high performance green roofing system is also based on the concept of the 5 Es: Energy, Environment, Endurance, Economics and Engineering. The roof garden system or vegetative roof system includes the concept of the 5 Es and moves towards sustainable development. We need to catch up to the fast trend of vegetative roofing system and participate in green technology for the cause of global sustainability, and the environment.

We have covered some of the aspects of podium waterproofing along with green or vegetative roofing in this issue, where waterproofing is the key issue for the success of these systems. We hope everybody contributes to create awareness, promotes the technology and takes active steps in green roofing. We will focus more on low energy conservation roofing systems along with waterproofing for a sustainable construction in the next issue of our ReBuild.

Design Considerations for Roof Garden Systems

[Excerpts from The NRCA Vegetative Roof Systems Manual, 2009]

1.0 Introduction

In the present sustainable development scenario, the roof garden concept has become an important component. Sustainability and energy efficiency of the built environment have become essential parameters of any development. A high performance roofing system is also based on the concept of 5 Es: Energy, Environment, Endurance, Economics and Engineering. The garden roof system includes the concept of the 5 Es and moves toward sustainable development. Based on the utility of the roof system, it can be categorised into a roof garden and a roof vegetable garden. Deciding which utilization to focus on is crucial and has to be considered as early as the planning stage. Estimation of the maximum load bearing capacity, maintenance, plant selection, substrates and expense budgeting must correspond with the desired roof garden type.

A roof garden system is a roof area where plants or a landscape is installed above a waterproofed substrate. It consists of a waterproofing system and its associated components such as a protection course, root barrier, drainage layer, thermal insulation and aeration layer, and an overburden of growth medium and plantings.

To understand the installation of the roof garden system, a few guidelines are available in some countries. The guidelines mainly cover the types of garden roofs, the various vegetation types, the requirement for the building techniques, the garden roof procedures and the upkeep and maintenance of the garden roof. . A terrace garden also called as roof garden or a green roof on the roof of a building. Besides the decorative benefit, roof gardens provide food, temperature control, hydrological benefits, architectural enhancement, habitats for wildlife, and recreational use. Apart from the roof the terrace garden can be created on balconies and other extended areas of a building. In rooftop garden, space becomes available for localized small-scale urban horticulture. Available gardening areas in cities are often lacking, which is likely the key requirement for many roof gardens. Roof gardens look good if they are proportionate with lawns, shrubs, ground covers, sitting area, bar, barbecue and small trees. One can also incorporate the concept of water bodies or rock garden or create a shady structure (Pergolas) on roof garden.

Terrace garden not only improves the aesthetic environment in both work and home settings but has various economical as well as environmental benefits as follows:

- **Economical benefits:**
  - » Doubles the life of the conventional roof.
  - » Reduces air conditioning cost by 25% to 50%.
- **Environmental benefits**
  - » Insulates the building against heat and cold.
  - » Reduces indoor temperature by 6 - 8 degree.
  - » Reduces sound pollution.
  - » Increases the amount of oxygen in air.
  - » Filters air borne particles from air.
  - » Controlling storm water runoff, erosion and pollution

2.0 Design Criteria Consideration

The roof garden waterproofing system criteria which need to be considered while installing the system are:

- Climate and geographical location
- A buildings intended use and design life expectancy
- Exterior and interior temperature, humidity and conditions for use
- Building code requirements
- Type and condition of substrate
- Structural system
- Slope and drainage
- Waterproofing membrane
- Garden roof system type, including overburden
- Accessibility and building configuration
- Building movement
- Type and amount of insulation, protection and drainage needed
- Need for ventilation during installation
- Compatibility with adjacent building and/or system components
- Construction sequencing
- Worker safety
- Potential building additions
- Odour generated by certain system application methods
- Water-retention loads
- Construction traffic
- Penetrations
- Landscape maintenance

The success or failure of the terrace garden assembly basically depends on the above considered criteria. It must be ensured that the terrace / roof is strong enough to bear the load of the terrace garden waterproofing systems.

Along with the mentioned criteria, the terrace garden application also depends on a structurally sound deck. Provisions which need to be included while designing a deck structure for the terrace garden are:

- Live loads such as snow, ice and rain

- Construction loads such as moving installation equipment, workers and materials
- Dead loads such as mechanical equipment, duct work and piping, and conduits such as fire sprinklers and electrical lines
- Dead loads such as waterproofing systems, saturated growth mediums, concrete toppings and pavers
- Deck strength (gauge, density, type and thickness)
- Expected deflection
- Drainage
- Placement of expansion joints
- Placement and structural support of the curb, and penetration members and details
- Attachment provisions for a deck
- Suitability for the adhesion/attachment of a waterproofing membrane
- Suitability for water test loads

3.0 Surface Preparation

Surface inspection is recommended before starting the installation of a terrace garden waterproofing system. Visual inspection is required to ensure a clean, smooth and dirt-free surface. All visible defects and unsound patches in the substrate should be noted and corrections should be made before installing the terrace garden.

4.0 Roof Garden System

A roof garden system comprises of a roof system, landscaping concepts and components and waterproofing.

The basic principle of a roof garden system is that it consists of a roof waterproofing membrane which prevents moisture from entering a habitable building or space.

Garden roof systems can be divided into three categories: extensive, semi-intensive and intensive, which are defined as follows:

- Extensive (shallow) roof garden system: Roof system with garden that has medium plants with approximately 50 mm to 150 mm deep roots
- Semi-intensive (moderate) roof garden system: Roof system with garden that hasmedium plants with approximately 150 mm to 250 mm deep roots
- Intensive (deep) roof garden system / roof garden: Roof system with a garden that has plants with roots that are more than 250 mm deep

The waterproofing membrane component is the same in all three types. However, the other system components vary based on the plants and landscapes placed above the waterproofing system.

The followings properties and requirements of a roof garden waterproofing system need to be satisfied:

- A roof garden system needs to be compatible with the plants and vegetation, and must resist contamination from fertilizers and other chemicals and materials used in conjunction with the vegetation.
- A roof garden system is more susceptible to mechanical damage and abuse, especially during installation.
- A roof garden system must be protected from the tools used to maintain the overburden / vegetation.
- A waterproofing roof membrane for a roof garden system is not readily accessible after the overburden is installed. Designers should be more conservative with their design, membrane selection and detailing.
- A roof garden system is exposed to landscaping, cultivation, vegetation work and human error. The landscape portion of a roof garden system will require periodic maintenance. Maintenance workers should be made aware that they should not damage exposed materials, especially the waterproofing layer and flashings. Specific safety precautions may need to be followed by maintenance and landscaping trades working in a roof environment.
- A roof garden system is protected from ultraviolet (UV) exposure and impact but is still exposed to thermal and environmental changes.
- The substrate for the roof garden waterproofing membrane should be sloped to provide positive drainage. To achieve the necessary slope throughout the entire surface area, a designer should consider the following:
  - » Structural framing for the deck
  - » Deck type and its characteristics
  - » Overburden material
  - » Type of membrane specified
  - » Penetration locations
  - » Varying deck deflections
  - » Building and deck layout
  - » Flashing termination heights

5.0 Components of a Roof Garden System

The various components of a roof garden system are as follows:

- Adhered roof waterproofing membrane
- Protection course
- Root barrier
- Drainage layer
- Moisture-resistant insulation (optional)
- Aeration layer
- Moisture-retention layer
- Reservoir layer
- Filter fabric layer
- Growth medium with plantings

5.1 Waterproofing Membrane

A roof garden system incorporates a waterproofing system that is directly adhered to the substrate. The membrane should be able to provide hydrostatic resistance based on the expected amount of water drainage and retention. The types of membranes recommended are as follows:

- APP and SBS-polymer-modified bitumen sheet membrane
- EPDM membrane
- Polyvinyl chloride (PVC)
- One and two component liquid-applied elastomeric membranes

Regardless of the membrane type, the roof garden waterproofing membranes should have the following properties:

- Low water absorption
- Low vapour transmission
- Puncture resistance
- Chemical resistance (e.g., fertilizer)
- Ability to resist design forces through tensile strength or elongation

5.2 Protection Course

Protection course is a separate layer of material which is installed over the waterproofing membrane to protect it from damage after installation. The material of the protection course depends on the type of membrane and its thickness depends on the type of overburden. A roll of protection board is shown in Fig. 1. Materials that can be used as a protective course are:

- Asphaltic boards
- Asphaltic sheets
- Extruded polystyrene boards
- PVC sheets

Fig. 1: A protection board

5.3 Root Barrier

Roots can penetrate the waterproofing membrane and potentially create leak locations. A root barrier is typically a separate layer of material installed on top of the protection course, but it may be combined with a protection course or drainage course. It prevents the migration of plant roots from damaging the membrane. Its material type depends on the type of membrane and plants used for a roof garden system.

The following materials may be used as a root barrier:

- High-density polyethylene (HDPE) boards
- Granulated polymer-modified bitumen membranes with root-inhibiting additives (e.g., copper sulphates)
- Polyethylene sheets

5.4 Drainage Layer

Drainage layer provides a way or path for moisture to move laterally through the roof garden system. This layer enhances the performance of the waterproofing material by relieving hydrostatic pressure from the material's surface and its associated weight. The following are the most common types of drainage layers:

The following are the most common types of drainage layers:

- Drainage mat (Fig. 2)
- Insulating drainage panels

Fig. 2: A Drainage mat

5.5 Moisture-Resistant Insulation

Moisture-resistant insulation may be installed above the membrane. This provides thermal protection to the membrane, reducing the overall temperature gradient that a membrane experiences. Additional insulation may be considered because of the expected loss of R-value when insulation is located in a moist environment.

XPS (Extruded Polystyrene) insulation can be used as the thermal insulating material for roof garden systems. The compressive strength of XPS should be based on the expected loading requirements, such as the weight of saturated medium growth plants.

Expanded Polystyrene (EPS) insulation is sometimes used as the filler material, not as the primary insulating material, to reduce the total weight of the roof garden system and provide a contour of the final surface. EPS retains water, and, therefore additional weight should be accounted for when determining the total dead load of the system.

5.6 Aeration Layer

The composition of an aeration layer is similar to that of a drainage mat. An aeration layer allows air to move across the top surface of the insulation layer. Additionally, the aeration layer allows moisture to drain from the top side of the insulation. Aeration layers are needed when insulation is used above the garden roof waterproofing membrane, so that the insulation will retain its R-value.

Where insulation is used above the membrane without an aeration layer, the in-place R-value of the insulation will most lilely be less than the design R-value of the insulation, because of the moisture retained within the insulation.

5.7 Moisture Retention Layer

A moisture-retention layer is typically an absorptive mat consisting of recycled polypropylene fibers. A moisture-retention layer retains or stores moisture for plant growth. This layer is typically located above the drainage layer (or it can be combined with the drainage layer) in uninsulated systems or above the aeration layer in insulated systems. The materials for a moisture-retention layer depend on the overburden type.

5.8 Reservoir Layer

The reservoir layer is typically located above the moisture-retention layer. A reservoir layer retains or stores moisture for overburden growth. The materials for a reservoir layer depend on the overburden type, but typically consist of polyethylene-based panels, formed into a three-dimensional array of water reservoir cups and drainage channels. The panels are designed to hold a specific amount of moisture by using overflow holes which limit the capacity of the cups. The reservoir cups are graduated in size for differing amounts of water storage, as required for the growth medium and plantings. Reservoir layers typically include aggregate when used under intensive roof garden systems, because of the large water storage requirement.

5.9 Filter Fabric or Geotextile

This is a tightly woven fabric, typically polyester or polyethylene / polypropylene, used to restrict the flow of fine growth medium particles and other contaminants while allowing water to pass freely through, thereby protecting drainage systems from clogging. Filter fabric is often laid directly over the top surface of the drainage layer and is generally installed just prior to the placement of the growth medium.

5.10 Garden Growth Medium

Growth medium is typically a lightweight aggregate-based medium and is specially formulated to provide a proper growing environment for specific plants to be included in a roof garden system.

Growth media are mixtures of mineral, organic and synthetic components. The components are blended in appropriate ratios to provide the needed characteristics of the medium. Growth medium considerations include vegetation requirements, moisture and nutrient retention, drainage, pH level, porosity and compaction, erosion resistance, weight restrictions based on structure, resistance to fire propagation and structure for plant anchorage.

Keeping in mind all these, a schematic diagram of an advance roof garden system component is shown in Fig. 3, and a simplified roof garden system is shown in Fig. 4.

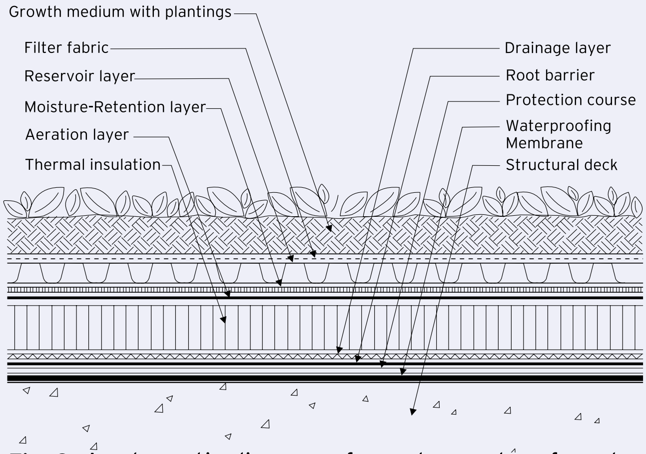


Fig. 3: A schematic diagram of an advanced roof garden component system

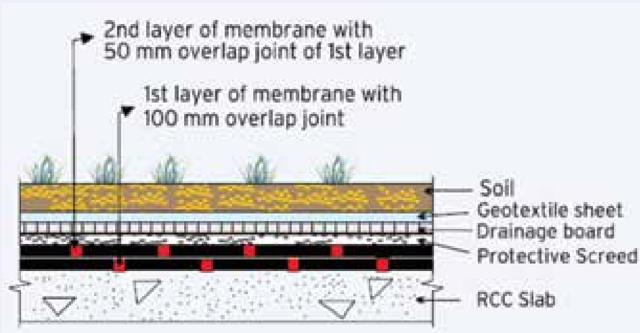


Fig. 4: A schematic diagram of a simplified roof garden component system

5.10.1 Extensive (Shallow) Roof Garden Systems

Extensive roof garden systems use a narrower range of species limited to herbs, low-growing grasses, mosses and drought-tolerant succulents such as the sedum—a plant variety, which is known for its tolerance to extreme conditions. Extensive roof garden systems require a root barrier and moisture-retention layer and generally do not require irrigation.

5.10.2 Semi-Intensive (Moderate Depth) Roof Garden Systems

Semi-intensive roof garden systems use a combination of plant species that may include small shrubs and species like grasses and herbs. They are generally limited to low-slope structures of 2:12 or less. Semi-intensive roof garden systems have landscaping that require more regular maintenance than an extensive system, but have limited plant selection because of shallower growth medium depths, such as a sod grass lawn. These systems will require a reservoir layer and may require an irrigation system.

5.10.3 Intensive (Deep) Roof Garden Systems

Intensive garden roof systems use a wide variety of plant species that may include trees and shrubs, and are generally limited to low-slope structures of 1/4:12 or less.

The use of large plants requires a deeper growth medium layer, typically 250 mm or more, which results in greater weight and the need for an increased structural load capacity of the building. Intensive garden roof systems typically require a heavy root barrier and often require irrigation. These systems require a reservoir layer.

Additionally, an efficient drainage layer may be required because of the quantity of water from irrigation and project conditions.

6.0 Cost of Green Roofing

The cost of a green roof varies considerably depending on the type and factors such as site location, depth of growing medium, selected plants, use of irrigation, water proofing area, and requirement of different garden elements and accessories. The initial cost of terrace garden is higher than a normal roof, though in the long run the saved energy pays the investment back.

7.0 Conclusions

Earlier, roof garden systems were considered only for high-end luxury projects for luxury purposes. However, now days most medium to large projects are adopting roof garden systems. They are also being considered energy efficient and eco-friendly and have achieved a green rating, due to which more and more builders and developers have started building green roofs. However sometimes this becomes miserable when the right approach towards designing and waterproofing such a system is not adopted. It will be immensely helpful if one pays attention to all these components while designing a roof garden system. This will help in providing a durable service life for such green roofs.

Podium Waterproofing

[Excerpts from Dr. Fixit Booklet "A Systems Solution to Waterproofing", 2013, pp.28-31; http://www.doctor-fixit.com/professional-podium.html]

1.0 Introduction

Many high rise buildings today incorporate landscaped basements and roofs commonly known as plazas or podiums. The basement can vary from habitable space to car parking, however, whatever the usage, it is vital the correct waterproofing system is selected when waterproofing the podium deck. There are many considerations to be taken in to account including deck movement, differential movement, drainage, waterproofing continuity at expansion joints, drainage outlets, landscaping, and most important utilities below the deck. The various usages of over deck slab of podium can be selected based on the client's requirement. Podium slabs is an area where one can plan for facilities such as water bodies, landscape, children play area, sports facilities and car parking etc.

Proper waterproofing system helps to keep out water and pollutants thereby preventing leakages and also protecting structural elements and embedded steel reinforcement from corrosion damage.

2.0 Functional Requirements

There are various functional requirements of a podium slab which need to be satisfied depending on the utility and requirement. The some of the major functional requirements need to be considered are given as follows:

- Large open areas-Excellent tensile and elongation properties to accommodate thermal movements
- Water bodies-Excellent barrier to water ingress and continuous exposure to water
- Landscaping-Resistant to root penetration even for intensive roots
- Sand Filling-Enable sand filling directly on the membrane without protection screed
- Chemical Resistance-Resistance to pesticides
- Medium duty traffic-Resistance to dynamic and Impact load
- Very high impact and puncture resistance-Able to sustain mechanical abuse during construction
- Zero VOC-Environmental friendly, meet the norms of Garden products for waterproofing

3.0 Waterproofing of Podium Slab

The bare podium means the slab which does not provide any service such as water bodies, children play area, roof garden and vegetative garden etc. but only acts as space for car parking has to be waterproofed for rain water only while other podium slabs require much more detailing. In such bare podium one can use a spray applied highly elastomeric and puncture-resistant waterproofing coating if podium is very large or else a brush applied pitch modified polyurethane membrane coating can be used in relative smaller podium slabs.

3.1 Surface Preparation

Removal of all surface imperfections, protrusions, structurally unsound and loose concrete is important for waterproofing and repairing of the unsound patch with polymer modified mortar using SBR latex for waterproofing is recommended.

Angle fillets all around the periphery of the podium wall with polymer modified mortar prepared with SBR latex for waterproofing and repairs is also a mandatory. Clean all surfaces with compressed air, and ensure they are free of loose materials, oils, form release agents and other contaminants.

Podium having swimming pool, water bodies etc has to be taken further care. Carry out the grouting for light fitting casings, pipes, inserts, etc., provided in the concrete raft floor and walls using a Non-shrink grout for pipe fitting. Wrap the inserts with Leak-proof sealing tape for pipe wrapping to ensure a watertight fitting, before grouting the inserts.

3.2 Priming

Priming is generally not required on concrete substrates for highly elastomeric and puncture resistant waterproofing coating.

3.3 Application

The following characteristics should be considered when selecting waterproofing materials for podium slabs with landscaping and swimming pools. The materials must be:

- Resistant to and unaffected by the liquid it is containing and function under constant submersion and high levels of hydrostatic pressure
- Able to resist the combined effects of exposure to sunlight, weather and intermittent wetting when exposed above the contained liquid's surface
- Compatible with and able to conform to the surfaces to which it is installed, including rough concrete walls, work slabs and compacted earth

The following waterproofing materials are appropriate for use as waterproofing membranes with concrete and masonry substrates:

- APP and SBS polymer-modified bitumen sheet membrane
- Self-adhering polymer-modified bitumen sheet membrane
- EPDM membranes
- PVC (thermoplastic) membrane
- Fluid-applied elastomeric materials
- Cementitious waterproofing
- Crystalline waterproofing

The following waterproofing materials are appropriate for use as waterproofing membranes with earthen substrates:

- Bentonite
- EPDM membranes
- PVC (thermoplastic) membrane
- Polyethylene sheets should not be considered as waterproofing membranes but can be used as vapour retarders.

3.3.1 With spray applied highly elastomeric and puncture-resistant coating for very large bare podium

Apply a highly elastomeric and puncture resistant waterproofing coating to achieve minimum thickness of 1.5 mm. For spray applied application, ensure that only compatible equipment can only be used. It cannot be sprayed through other types of commonly available sprayers.

Place a geotextile fabric of 300 gsm over the membrane before laying the concrete screed of 75 mm (average) modified with Integral liquid waterproofing compound for plaster and concrete with 1 : 100 slopes.

It should be properly aligned with drain outlets for efficient drainage of water. A schematic diagram of waterproofing of a bare podium slab is given in Fig. 1.

1. Slab	2. Dr. Fixit Extensa
3. Geotextile	4. Angle Fillet
5. Drip Mould	6. Screed

Fig. 1: Schematic diagram of waterproofing of a bare podium slab

3.3.2 With pitch modified polyurethane membrane coating for smaller bare podium

Apply pitch modified polyurethane membrane coating by a brush or trowel or squeegee in two coats maintaining the spreading rate to achieve the desired dry film thickness or DFT of 1.5 mm. Air-cure pitch modified polyurethane membrane coating membrane for a minimum of 72 hours at 27°C before placing the protection. Once the coat is dry, lay a layer of geotextile membrane of 300 gsm. After laying the geotextile membrane, overlay a screed of 75 mm (average) of M 20 concrete grade for the protection of the membrane and to provide a proper slope for effective draining of rain water.

3.3.3 Waterproofing of Podium Slab with Landscaping and Swimming Pool

The detail step-by-step procedure is e xplained as follows:

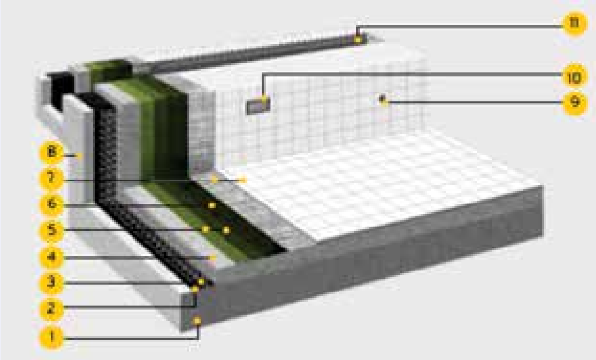
Apply spray applied highly elastomeric and puncture-resistant waterproofing coating to achieve a minimum thickness of 2 mm. Apply highly elastomeric and puncture-resistant waterproofing coating using only designated equipment. It cannot be sprayed through any other type of commonly available sprayers.

Extend highly elastomeric and puncture-resistant waterproofing coating up to the top and cover the overflow concrete channels all around the periphery of the pool. Over this, place a 3.5 mm fleece backed self-adhesive membrane. Being self-adhesive, it will stick to Spray applied highly elastomeric and puncture-resistant waterproofing coating and will serve as protection for the subsequent short-creting that needs to be done (in case of a swimming pool). Carry out the short-creting over a steel reinforcement installed in accordance to the engineer's advice, and to the required thickness. Use a wooden float to give it a smooth finish. After a thorough curing of at least 3 – 4 days, take up high-performance polymer modified for application over the short-creted surface. Just before this, apply angle fillets in polymer modified mortar admixed with SBR latex for waterproofing and repairs all round the periphery of the swimming pool floor, at the parapet wall junctions. Initiate the application of high-performance polymer modified over a saturated surface dry short-crete. A total of three coats should be applied in all, ensuring that each coat of application dries before taking up the next.

Treat the areas in the pool around the insert pipes and the wall-to-floor junctions by embedding a glass fibre mesh of 2.5 mm x 2.5 mm weighing 50 gsm between the first and second coats. Place them when the first coat is still wet. This will increase the waterproofing protection in these areas.

While the third coat of high-performance polymer modified is wet, broadcast with clean and washed sand liberally and set along with the application. This will provide a key for the subsequent tile adhesives that will be needed to fix the swimming pool tiles. After completing the tiling work, apply epoxy grout to fill the gaps in the tiles. Protect the entire application against chlorine in the water that is generally used to clean the pools. For waterproofing of landscapes, it is extremely important to place self-adhesive bituminous membrane over spray applied highly elastomeric and puncture-resistant waterproofing coating. Provision of slope becomes mandatory in landscaping whether on roofs or podiums. Place drain cell boards from standard companies over this. The specification of the drain board generally depends upon the amount of water discharge and the kind of landscaping as proposed by the architects. If the drain cell board does not have a geotextile membrane over it, place an appropriate membrane which allows water to trickle through to the underside.

Provision of drainage is absolutely essential, which should be provided by the customer on the advice of the architect or the consultant. Place soil over the geotextile membrane. A schematic diagram of waterproofing of a podium slab having swimming pool and landscaping is given in Fig. 2.



1. Floor Concrete
2. Dr. Fixit Extensa
3. Steel Cage with Pedestal
4. Short Crete
5. Dr. Fixit Fastflex (2 coat)
6. Dr. Fixit Fastflex (3 coat with sprinkled sand)
7. Roff NSA & Roff RTM Tile Grout
8. Concrete Wall
9. Pipe Inlet fitting Dr. Fixit Bathseal Tape & Grout
10. Light fitting casing with Dr. Fixit Bathseal Grout & Dr. Fixit Bathseal Tape
11. Steel Grating

Fig. 2 Schematic diagram of waterproofing of a podium slab having swimming pool and landscaping.

5.0 Leakage Test

Prior to the installation of the landscaping or screeding as the case may be, the waterproofing layer should be subject to a thorough leak test either by water ponding or electronic test method. The usual procedure of water ponding for 48 hrs may be adopted. Any defects in the waterproofing system then can be easily rectified.

6.0 Conclusions

Podiums have multiple utilities and high movement, which means joint-based membrane waterproofing, proves ineffective. A superior seamless membrane with better concrete adhesion and elongation properties can be adopted for a durable waterproofing. Such modern waterproofing material provides a service life of 15-20 years. Podium landscaping is also concept of green roofing and an eco-friendly system.

Case study of Podium Waterproofing

[Excerpts from archives of Dr. Fixit case studies]

1.0 Background

Hiland wood was a major residential project of the Bengal United Credit Belani Group in Kolkata.The entire podium area was 1600 m^2. The client was interested in an economical waterproofing solution. The architect recommended a cementitious polymeric waterproofing system with a protective screed over it with anti-root treatment.

2.0 Recommendations

- It was suggested for a cementitious grouting to the roof slab as the structure was constructed one year back and grade of concrete was only M25.
- Also suggested to use a priming coat before the cementitious polymeric coating for better bonding.
- Advised to use a fiber mesh on entire cementitious coating and to make a screed over it.

3.0 Working Methodology

- Pressure grouting on roof slab was carried out with a cementitious grout (Fig. 1)
- The Surface preparation was carried out by wire brushing (Fig. 2) to remove the loose and unsound concrete cleaning etc.
- Groove cutting, halloring and patch repairing (Fig.3) were carried out with patch repair mortar, modified with acrylic co-polymer emulsions and additives as per the recommended dosages
- An Acrylic bonding agent (Fig. 4) was used as a slurry coat as primer
- A cementitious polymeric waterproofing coating system (Fig. 5) was applied at SSD condition and entire surface was covered with a fiber mesh (Fig. 6)
- Protective screeds of average 75 mm (Fig. 7) was laid over fiber mesh admixed with liquid waterproofing compound.
- Water curing was done over entire surface for minimum 7 days
- A Polymeric bituminous coating was applied over the screed as anti-root treatment, followed by soil filling and plantation (Fig. 8)

Fig. 1: Surface preparations

Products used: Dr. Fixit, Pidilite

Consultants: 1. Dulal Mukherjee & Associates, Kolkata & 2. M. N. Consultant, Kolkata

Waterproofing of Planter boxes, on terrace

[Excerpts from ReBuild, Vol. 5 No. 1 (Jan-Mar 2011), pp-15]

1.0 Introduction

Planters provide an elegant way to display a variety of flowers however, planters made of decorative stone or brick are prone to leaking around the seams and joints and in most cases seepage of water takes place through the roof slab thus damaging the roof slab and causing corrosion of reinforcement. The water leaking out of these crevices is laden with minerals and other deposits that can cause stains. It's easy to prevent these issues by waterproofing the inside walls of planter, so the water will only drain out the bottom as intended.

The planters on a roof garden may be designed for a variety of functions and vary greatly in depth to satisfy aesthetic and recreational purposes. These planters can hold a range of ornamental plants: anything from trees, shrubs, vines, or an assortment of flowers. As aesthetics and recreation are the priority they may not provide the environmental and energy benefits of a green roof. Planting on roof tops can make urban living more self-sufficient and make fresh vegetables more accessible to urban people. The urban kitchen garden concept works on the potted plant model; it averts the bottlenecks of waterproofing of entire roofs, the major hassle in establishing a terrace garden. One can have the vegetable farm on their terrace, where they can grow everything in pots with proper waterproofing and drainage system. But all these required a proper waterproofing system.

2.0 Waterproofing System

Planters are structures made from masonry or concrete. Waterproofing for planters is usually applied between the masonry or concrete structure and the planting material and liquid being contained. The most significant of these is the necessity for adequate drainage. Planter boxes must have a graded base to the drainage outlet and the drainage system must prevent the water level from rising above the overflow level of the membrane. A filtered drainage riser must also be provided to relieve hydrostatic pressure, to provide access for cleaning, and as an emergency overflow in the case of excessive rain. The following characteristics should be considered when selecting waterproofing materials for these structures. The materials must be:

- Safe for use in direct contact with planting materials (e.g., soil, fertilizer) intended to support plant life
- Be able to resist root penetration
- Resistant to and unaffected by the solid materials and liquid water it is containing and function under constant submersion and potentially high levels of hydrostatic pressure
- Able to resist the combined effects of exposure to sunlight, weather and intermittent wetting when exposed above the planting material's surface
- Compatible with and able to conform to the surfaces to which it is installed, including rough concrete walls, masonry and work slabs

The following waterproofing materials are appropriate for use as waterproofing membranes for planters:

- APP and SBS polymer-modified bitumen sheet membrane
- Self-adhering, polymer-modified bitumen sheet membrane
- EPDM membranes
- Fluid-applied elastomeric materials
- Cementitious waterproofing

The waterproofing membrane must be extended up the sides of the planter box to a minimum height of 100 mm above the soil level and must be protected with a drainage cell wrapped in geo-textile fabric or a similar suitable material The top edge of the membrane must be appropriately sealed and protected with either a flashing or capping tile or similar. The detail of waterproofing system of a planter box is shown in Fig. 1.

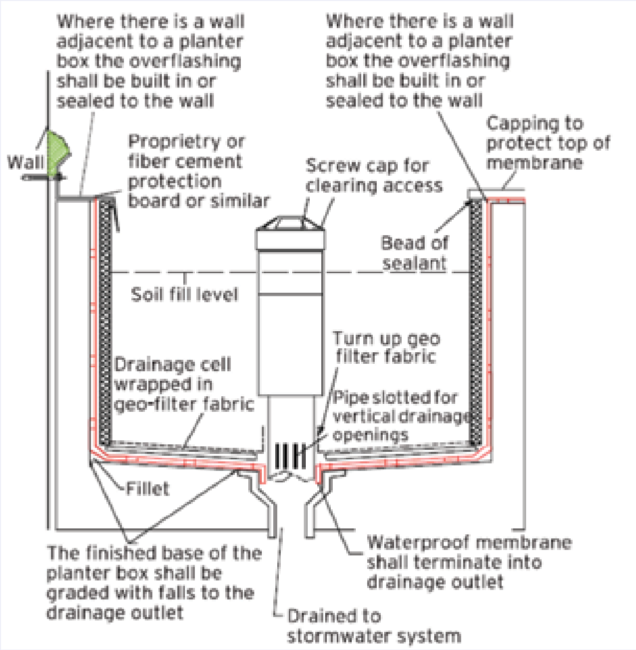


Fig. 1: Surface preparations

3.0 Conclusion

Care must be taken when selecting the type of plants to be grown in planter boxes. Those with aggressive root systems that may damage the membrane or clog the drainage system should be avoided. Trees or shrubs should not be planted that grow and cause damage to the planter. Finally, planter boxes require regular inspection and maintenance, perhaps more than any other membrane system. Prompt repair and maintenance should be undertaken based upon these inspections.

The First Green Roof of India – A Case Study

[Excerpts from Guest feature article "Green Buildings in India" by Christine Thüring,http://www.greenroofs.com/content/guest_features005.htm]

1.0 Introduction

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, by partnering industry and government alike through advisory and consultative processes. The CII-Sohrabji Godrej Green Business Centre (also known as CII or CIIGBC) at Hyderabad (Fig. 1) is the first "LEED Platinum" building in India inaugurated in 2004 and as an entity the centre is a unique and successful model of the public-private partnership between the Government of AP, Godrej & Boyce Mfg Co and the Confederation of Indian Industries, with technical support from USAID. During this decade IGBC is promoting the concept of green buildings in India. The beneficial facts of green building as compared with normal buildings are given below:

- 35% reduction in potable water use
- 50% savings in overall energy consumption
- 88% reduction in lighting consumption
- 80% of materials used are either recycled or recyclable
- 20% of the building's energy requirement is provided by photovoltaics
- 15-20% less load on AC by using aerated concrete blocks in facades
- Zero water discharge building
- 90% of the building is daylit
- 75% of occupants have an outside view

Fig. 1: An aerial view of The CII-Sohrabji Godrej Green Business Centre (also known as CII or CIIGBC), Hyderabad

This centre serves as a demonstration, but is also considered an experiment "to see what can be achieved." It comprises a balance between imported and locally-available technologies, with some imports currently being indigenised. From performance windows to waterless urinals, wind towers and biological water treatment ponds, this building is as modern as it gets. Of the 20,000 ft^2 footprint, 55% of the CII-building is covered by an extensive green roof (Fig. 2). The green feature the CII building with great value is the "roof garden" because of its insulating qualities. Measurements attest that the green roofs provide valuable insulation for the conference centre and offices, but this benefit is not likely to be perceptible under the concrete walkways. Given the minimal highlights or information about the green roofs at the CII building, it is clear that they are only part of a much greater package.

Fig. 2: Extensive green roofs, or roof gardens, cover 55% total roof surface area.

2.0 Concept and Design of Green Roof at The CII-Sohrabji Godrej Green Business Centre

The green roofs on the curvy building are divided into parcels that are separated by parapets. On top of a concrete roof, the green roof system begins its build-up with three layers of waterproofing. A leaky waterproofing is the paramount concern with regard to green roofs. All wastewater and runoff generated by the building is recycled by "root zone treatment", where specially selected plants purify and filter the water that irrigates them (Fig. 3). Water leaving the "root zone treatment" is directed to one of three ponds, (Fig. 4) thereafter to be used for domestic purposes. The building achieves a 35 percent reduction of municipally supplied potable water, in part through the use of low-flush toilets and waterless urinals.

Fig. 3: Extensive green roofs, or roof gardens, cover 55% of the total roof surface area.

The green roof system comprises 50 mm of sandy soil topped with the same pervious paver blocks used at grade, and overlain with a uniform grass sod. In their appearance and composition, the green roofs are identical to the grassy pedestrian and parking areas at grade. The section of the CII green roof shown in Figure 5 reveals a section of structural pavers where the sod is thinned, likely a seam. It can also be noted that the puddling is in the next level up.

Fig. 5: Above figure reveals a section of structural pavers where the sod is thinned, likely a seam

The grassy rooftops were being irrigated to the point of puddling. The pervious paver blocks prevented any compaction. Water is definitely a key design consideration for green buildings in India, where a hot and dry season is sandwiched by two monsoons (SW Summer Monsoon and NE Retreating monsoon). Of the 810 mm annual precipitation in Hyderabad, for example, most of it occurs during the monsoon months of June – October. As part of the zero discharge design, recycled water from the building is used for irrigation and any runoff is directed to percolate at grade (Fig. 6 & 7). During the dry season, the green roofs are irrigated daily.

3.0 Conclusion

India is in a fascinating position with regard to issues of global sustainability and the environment. Rather than playing catch-up with the West, it has begun to tap into cutting edge technology and enforce visionary policies, all the while maintaining clear sight of its traditions, which may hold immense meaning for the global economy and the global environment. With the world's 12th largest economy at market exchange rates and the 4th largest in purchasing power, it is one of the world's fastest growing economies. Still a developing nation, however, India is not bound by the Kyoto Protocol and suffers from various internal issues, such as its emissions are growing as steadily as its economy, its middle class, the use of motorized vehicles, and the trendiness of shopping malls. In Hyderabad, the construction sites and the visibly burgeoning middle class have presented the concepts of a global ecological footprint on perfect display. What will our world be like when the new transportation infrastructure is in place, and the up-scale residences occupied? Will green buildings in India assume their true potential? Will green technology assume the dominant status quo that so many states would like but few will commit to?

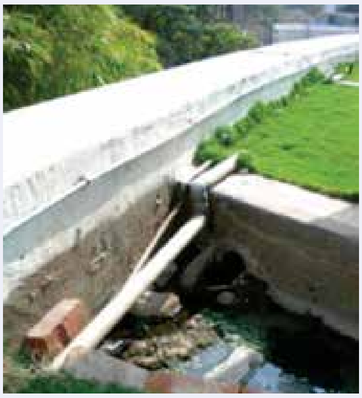


Fig. 6: Water recycling in green roof system

Fig. 7: Being the first of its kind on the subcontinent, the green roof's drainage system is exemplary of pioneering resolve and locally-inspired innovation.

Performances of Green/ Vegetative Roof System

[Excerpts from "Digging into Green", Professional Roofing of NRCA, October 2011, pp.31-36]

1.0 Introduction

Urban areas face numerous environmental challenges because of their dense human populations and high percentage of impervious surfaces, such as rooftops and parking lots. As world population increases and urban populations expand, finding solutions to environmental issues becomes increasingly imperative to maintain viable and habitable cities.

Despite consisting largely of a built environment, urban areas still may contain diverse ecosystems, all of which provide various services that help maintain life. Trees, parks, gardens, rivers, streams and lakes offer air filtration, noise reduction, food production, micro-climate regulation, rainwater infiltration, flood control and recreation. Finding ways to improve expand or increase the number of urban ecosystems may offer solutions to many environmental challenges by green or vegetative roofing. The some of the performances of such green roofing are being discussed in subsequent sections.

2.0 Storm water runoff

The design of a vegetative roof system significantly affects the quantity and quality of storm water runoff. Key design factors include the type of growth media, its depth, the plants selected, the type of system (built-in-place or modular) and fertilization regime. In a field study at SIUE using built-in-place vegetative roof models, Green Roof Blocks (modular units) and model roof decks with standard black EPDM membrane only, storm water runoff quantity and quality were monitored for almost for three years. The vegetative roof growth media was composed of 80 percent Arkalyte (a 6- to 9-mm expanded clay) and 20 percent composted pine bark. Results indicate a 10-cm built-in-place system is the best choice among 5-cm, 15-cm and 20-cm depths for a green roof in the Midwest in terms of storm water retention and plant coverage by sedum. This depth provides the same storm water retention and plant coverage as deeper depths but costs and weighs less, resulting in potential installation and structural savings.

A 5-cm medium depth is inadequate to provide sufficient plant growth to reach 100 percent roof coverage in a reasonable time, an important factor for visible vegetative roof systems. However, 100 percent of the sedums planted in the 5-cm growth media depth have survived during the subsequent six-year period. Sacrificing 100 percent roof coverage by using a 5-cm growth media depth or greater planting density with a 5-cm depth may be a viable option for those wishing to have a vegetative roof system on a facility that cannot accept a higher weight load.

In a second study on SIUE's Engineering Building roof, two modular systems (Green Roof Blocks and Green Paks) were used to evaluate water loss through evapotranspiration. Both systems were 10 cm deep. Various growth media were used in a ratio of 80 percent inorganic to 20 percent composted pine bark.

In general, the bag system (Green Paks) lost more water than the tray system (Green Roof Blocks) for all media types. Typically, the growth media Arkalyte lost the least water and had the lowest sedum roof coverage while lava (natural volcanic rock) lost the most water and had the highest sedum roof coverage. The greater water loss from lava may be a result of the relatively high percentage of plant coverage and its porous surface. The porosity may allow water to be more readily available to the plants, which results in greater coverage, and may enhance evaporative losses from exposed media.

Although greater medium depths appeared to reduce nitrate concentration, their greater roof-loading weight must be considered. Vegetative roof systems appear to slightly reduce the pH of runoff compared with a typical EPDM roof, and it appears plants have more effect on pH reduction than the growth media.

Vegetative roof systems are an important tool to ad-dress storm water runoff quantity, particularly in urban areas. Questions remain regarding their effect on the runoff's quality. It is clear the design of a vegetative roof system (type of system, growth media depth, type of growth media, plant choice, etc.) is critical to the roof system's ultimate performance and that the performance will change as plant coverage increases and growth media weathers. A roof system's desired performance must be balanced with the site's design constraints, such as load limits and aesthetic requirements.

3.0 Roof runoff quality

In an urban environment, roof runoff can contain pollutants such as pesticides, hydrocarbons and heavy metals. These pollutants may originate from the roofing materials, gutters or other building components. Rain, snowfall and dry deposition can be other sources of pollutants in roof runoff.

Because vegetative roof systems retain storm water, you may assume pollutants also would be retained. This is not always the case. Recent work by our research group and others has shown some materials intended for use in vegetative roof systems could release heavy metal pollutants into the environment.

There are a variety of media that have been considered as substrates for vegetative roof systems. Some substrates are used in their natural form (such as gravel and lava rock). More commonly, substrates for vegetative roof systems are natural materials that either are blended with other materials or modified to alter their characteristics (such as diatomaceous earth, expanded clays or shale). Waste materials, byproducts from industry and some recycled materials (such as coal bottom ash, blown glass and crushed brick) also are proposed substrates. The chemical composition of these potential substrates often varies, is proprietary or simply not available. A lack of information makes it difficult to determine whether a substrate would be a source of pollutants without testing it for the presence of heavy metals.

Several observations made in the field study suggested heavy metals in the runoff may have come from the vegetative roof system structure (either the materials that comprise the modular system or components of the built-in-place system) rather than the substrate that filled each vegetative roof.

4.0 Thermal performance

Greening the building envelope is considered to deliver several thermal benefits, such as reducing heating and cooling energy costs and decreasing the heat island effect in highly populated cities. Fig. 1 illustrates the change in ambient temperature caused by the heat island effect in urban and rural areas.

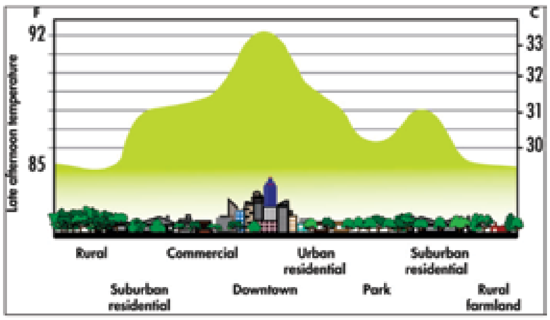


Fig. 1: Temperature variation caused by the heat island effect

G.R.E.E.N. theoretically and experimentally studies vegetative roof systems' energy saving benefits. For the heat transfer analysis, the plant canopy and growth medium regions can be combined to form a single do-main. An energy balance can be defined between the plant canopy-growth medium coupling and remaining roof layers. This analysis involves radiative and convective heat transfer to and from the vegetation's upper surface and conduction through the coupled system and the roof system layers below, such as the roof membrane, insulation and structural materials of the roof deck and building.

By obtaining varying daily outside temperatures, irradiation values and convective heat transfer coefficient, heat fluxes through different roof systems can be computed and compared for energy analysis.

5.0 Wind uplift

Wind uplift of vegetative roof system components and systems has been a topic of considerable debate recently. There are ongoing efforts to develop a wind standard and wind design guidelines for vegetative roof systems. However, other than some anecdotal evidence in the U.S. of a few vegetative roof systems that have survived significant wind events, little scientific testing has been presented or published that would steer development of standards or guidelines.

At the conclusion of our tests, all fully vegetated modules reached wind speeds of 120 mph for five minutes in the wind tunnel with no displacement of growth media. We also determined there is a minimum level of vegetation required to bind the green roof growth media. In all tests with partially vegetated modules (less than 100 percent roof surface coverage by vegetation, modules vegetated before testing), scouring of growth media occurred after reaching wind speeds of 75 mph. In tests using only growth media (no vegetative roof coverage), scour occurred at wind speeds as low as 30 mph. Therefore, 100 percent vegetation coverage or a binding agent is necessary to bind the growth media to prevent scour at wind speeds above 75 mph.

In addition, two of the four binding agents evaluated in this experiment prevented wind scour of growth media. No wind scour was observed at 140 mph when a commercial liquid binding agent was applied 48 hours before testing to a module containing only growth media. In addition, no wind scour was observed at 140 mph when a commercial liquid binding agent was applied to a partially vegetated module 48 hours before testing. Further, no wind scour was observed with speeds above 120 mph when 100 percent natural burlap was used as a surface treatment.

6.0 Conclusion

It is important to understand the performance of vegetative roof systems and their components, yet we still have more work to do. With the improvement in technology and new innovative vegetative roof systems, there also are more questions about performance and standards.

Green, or vegetative, roof systems are one of the ways we can introduce and improve ecosystem services in urban areas. Vegetative roofs can manage storm water runoff, reduce energy use and noise, mitigate the urban heat island effect, alleviate air pollution, increase biodiversity and wildlife habitat, and add value to a building.

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Venue : DFI-SPR, Mumbai

• Collaborative Programmes

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Date : 22 April 2013
Venue : C V Raman College of Engineering, Bhubaneshwar

Topic : Waterproofing of Roofs & External Walls
Date : 18 May 2013
Venue : IEI, Nashik

Topic : Structural Diagnosis and Condition Assessment of RCC Structures
Date : 20-21 May 2013
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Date : 15 June 2013
Venue : IEI, Vijaywada

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Topic : Building Maintenance, Waterproofing and General Repairs
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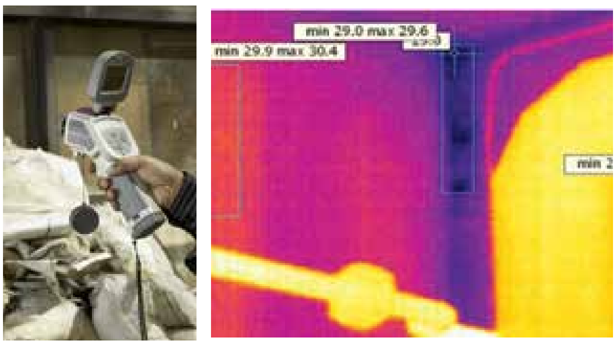

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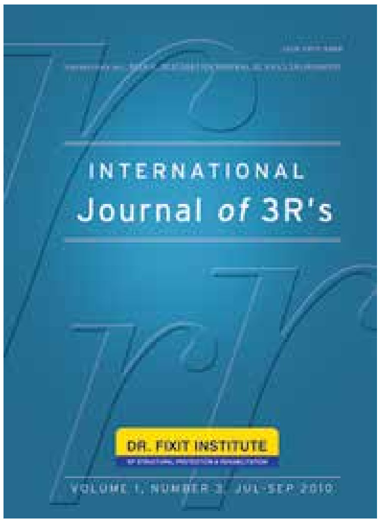

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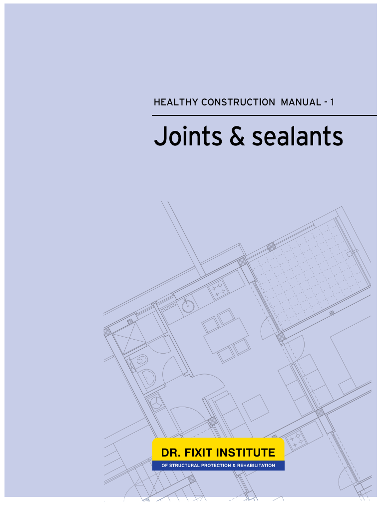

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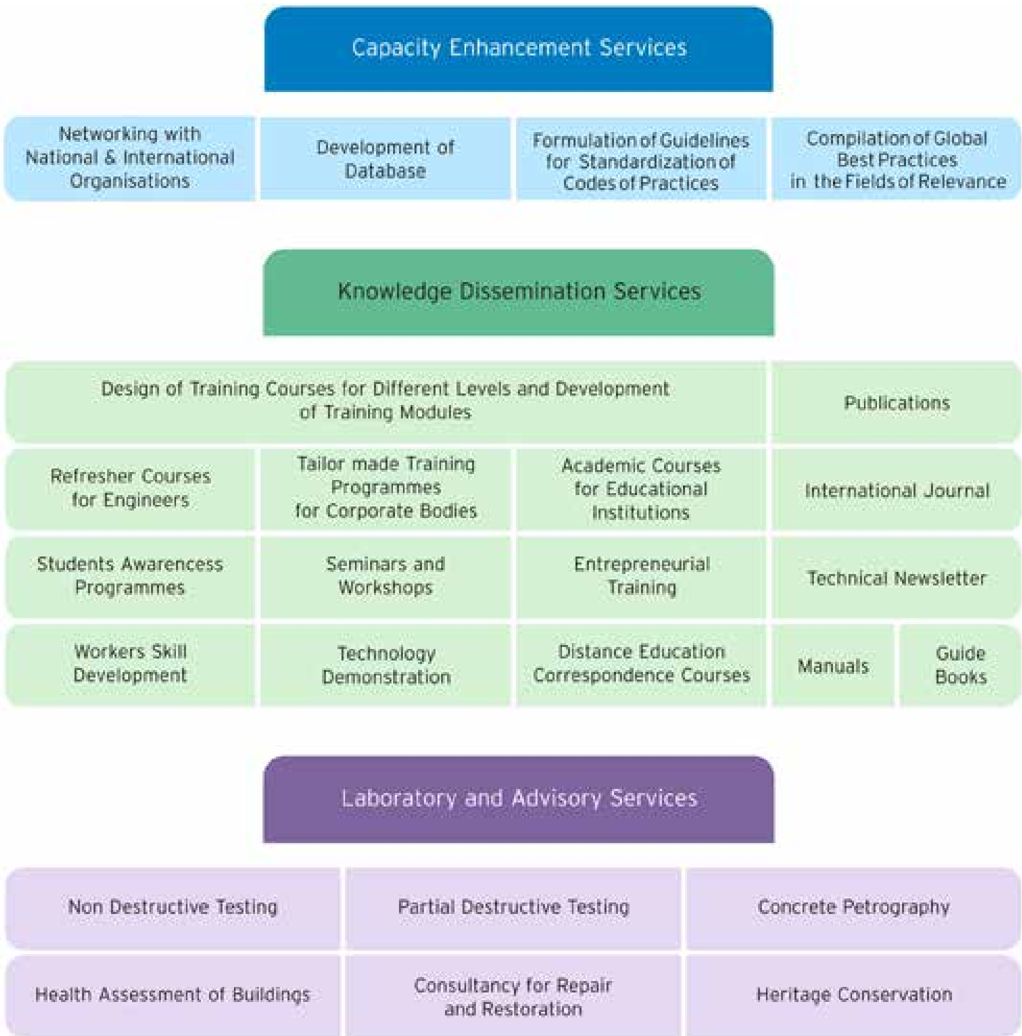

Editorial Advisor : Dr. A. K Chatterjee, Editorial Office : Mr. S. C. Pattanaik, Editor
Printed & Published by Dr. Fixit Institute of Structural Protection & Rehabilitation,
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C/o **Pidilite Industries Limited**
Ramkrishna Mandir Road, Andheri (E), Mumbai 400 059
Tel : 022 – 2835 7973
E-mail : suresh.pattanaik@pidilite.co.in
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