International Journal of Engineering Research
Volume No.5, Issue Special 1 pp : 32-36
ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

Comparative Study of Conventional and Modern Waterproofing Techniques

Saurabh Borle, Ghadge A.N.
Department of Civil Engineering, Sardar Patel College of Engineering, Andheri (W), Mumbai-58, India
Email: saurabhborle@gmail.com, ghadgean@gmail.com

Abstract : Water leakage or water seepage is one of the major causes of common building defects. Leakage leads to dampness, corrosion of metals, fungal growth and also affects the structural properties of concrete as well as damage beauty of the structure. It also has an adverse effect on human health by creating unpleasant condition. If water leakage can be prevented, almost 80% building defects can be eliminated. Thus, selecting the best method for waterproofing plays a vital role in the safety of the structure. In construction, a building or structure can be waterproofed with the use of membranes and coatings to protect contents as well as protecting structural integrity. Waterproofing can be categorized under traditional (tarfelt, Brick bat coba) and advanced (coatings, integral) waterproofing techniques. The objective of this study is to compare the different waterproofing techniques by considering factors such as cost, durability and ease of use. The findings of this study suggests that traditional methods are simple in use; however they are uneconomical and can be easily disintegrated due to change in atmospheric conditions. Whereas, modern waterproofing methods like coating and membrane system gives better results but are costly and possess a great difficulty while installation. Coating method needs special attention during surface preparation which requires skilled workmanship. As compared to this, crystalline method posses a greater advantage of arresting cracks developed over a period of time by the reaction of water with crystals and hence provides better stability.

Keywords: Coatings, Crystalline, Leakage, Waterproofing

Introduction

Concrete is the most used human made material in the world. It is used twice as much as all the other materials combined. Concrete is utilized so much as it is multipurpose, has unique engineering properties, has low cost, and its ingredients are commonly available. Due to all these advantages it is preferred over other materials such as wood or steel. Concrete is durable and a strong material which has a long lifespan and it can be molded into any shape and size when freshly mixed.

The main reason for failure of concrete structure is lack of adequate durability rather than failure due to deficient strength. The root cause of concrete degradation is the presence of water or moisture within the concrete. The ingress of deleterious substances takes place through micro cracks or through the pore system in the concrete matrix. The durability of concrete is to be increased to reduce concrete deterioration. To get a more sustainable building, waterproofing of concrete should be done to ensure its structure's durability, which leads to a longer lifespan (Biparva, 2015). Reinforced concrete which has pores or capillary tracts is used to construct most roofs. The number of pores can vary depending upon the installation technique. Since these pores are interconnected within the concrete the water will penetrate through such pores due to osmotic effect (Glasser, 1979). Concrete is inherently weak in tension; voids and cracks can also form due to thermal expansion, shrinkage and contraction, due to this water will seep through these voids. So to prevent the roof exposed to the weather waterproofing is required. Common places in buildings where waterproofing is required are bathrooms, basements, laundry room and roof. Rising dampness becomes a problem on the high side of a sloping property when water becomes dammed against the foundation. Waterproofing is required for balconies whether timber or concrete. The resistance to penetration of water in its liquid state is called water resistant or water proof whereas Damp proof refers to resistance to dampness or humidity.

Water becomes a real danger where it is not needed. Water rots timber, leads to collapsing of floors and balconies. Concrete is subjected to "concrete cancer" (spalling) and its most common cause is water penetration. It can be avoided by making structural concrete surfaces thoroughly waterproofed. Water can be a health hazard, too. Mould and mildew caused by water and dampness can trigger respiratory problems and allergic reactions. Research has showed a correlation between mould and depression. Mould and mildew only thrive in moist conditions, so if the house is waterproofed and moisture should not be allowed to accumulate in the structure (Shenassa, 2007). In construction, a structure or building is waterproofed with the use of coatings and membranes to protect contents as well as protecting structural integrity.

There have been technological advances in waterproofing materials over the past two decades, including advanced membrane materials as well as integral waterproofing systems. Integral waterproofing is mainly of two types: the hydrophobic and the hydrophilic systems. Hydrophobic system uses fatty acids to block pores inside the concrete, preventing the passage of water. A hydrophilic system uses a crystallization technology which works on the principle of replacing the water in the concrete by insoluble crystals. Sometimes the same materials are used to keep water in, such as pond or pool liners.

Waterproofing can be categorized as traditional and modern waterproofing techniques.

Traditional waterproofing techniques

- Brick bat coba system or lime terracing
- Bituminous treatment
- Box-type waterproofing system

ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

Modern waterproofing techniques

- Membrane method
- Integral method
- Surface coating

I. **Methods of waterproofing**

A. Traditional waterproofing techniques

1. Brick bat coba system

Brick bat coba treatment provides insulation for thermal comfort and also waterproofing for leakages.

Roof slab top should be removed by cleaning it by hard wire brush and then washing it with water. Surface should be free from impurities like oil, dust, grease etc. Expansions joints are treated as per the standard practice. All external (non structural) cracks more than 0.5 mm wide and construction joints if any, should be cut in "V" shape. Then it should be cleaned with the help of wire brush and water washed. The cracks are then filled by mortar using acrylic polymer or by polymer modified cement, with addition cement slurry mix is spread upon cleaned SSD roof surface. Over this prepared surface, 15 mm thick cement, sand mortar, 1:4 admixed, with water proofer is laid (Kaushal, 2000).

Brick bat laying:- A layer of brick bats, soaked overnight in water is laid on the above prepared surface, which have an average thickness of about 110 mm,150 mm at ridge and 70 mm near rain water pipe. There should be a gap of 15to 20 mm between the brick bats. These gaps are filled with cement sand mortar with one part cement and four part sand, admixed with water proofer. Wet gunny bags should be used to cover the surface in hot and dry weather immediately after finishing. For the next 7 days curing should be done. After the curing is done the top surface is to be finished smooth forming a 20 mm layer of cement sand mortar, 1:4, admixed with water proofer. Liquid admixtures should be mixed while mixing water. 300 mm false squares are marked on the surface. Curing is to be done by ponding (Kaushal, 2000).

Advantages

- It provides slope to the roof for better drainage.
- It is simple and easy in construction.
- Economical since locally availability of materials.

Disadvantages

- The cracks are formed due to temperature variations.
- It imposes unnecessary dead load and it's almost impossible to dismantle for repairs.

2. Bituminous treatment

Roofing felt is a sheet material soaked with bitumen (asphalt), which is similar to tar paper, used in construction of building. The term felt is derived from historical method of making the base material. Felt is an unwoven fabric. It is produced by matting fibers under pressure. The fibers form the structure of the fabric (Whitney, 1889). For bitumen based water proofing system to be successful, the surface to be treated should be smooth, there should not be any depression or cracks, having proper slope, the surface should be bone dry and any structural defects in the roof or the parapet wall should be checked before starting the treatment.

The steps involved in laying the bitumen based surface barrier systems will be to make surface even and dry, smooth, loose dirt and remove local depressions. Dried surface is painted with bituminous primer then it is cured. Foundation coat of bitumen is applied. Lay surface barrier membrane i.e. bitumen felt. Apply another coat of bitumen and finish it using grit or coarse sand. The products are available in roll format which are pulled through huge rollers or bitumen mixes. Saturation of base product takes place in huge tanks by tar like bitumen substance, which creates a roll of water resistant but breathable material(CE's Circular No.193).

Modified bitumen is mixed with filler components such as limestone, sand, or polymers such as styrene-butadiene styrene (SBS), a rubber additive that gives more elastic benefits or atactic polypropylene (APP) that gives rigidity and tears resistance. Roll roofing is a bitumen product which is exposed to the weather. It is vulnerable to ultraviolet rays so to protect the base, mineral granules are added on the top of the felt. It also helps in decreasing the product's fire vulnerability. During manufacturing, thin, transparent film is added to the base of the felt on all torch-on products. This keeps the felt from sticking to itself when rolled up during the packaging process.

Figure 1 Flat roof under construction.
(https://en.wikipedia.org/wiki/Bituminous_waterproofing#/media/File:Flat_roof_roofing.JPG)

Advantages

- Bitumen is economical product and easily available for waterproofing.
- It provides an erosion and corrosion-free, sealed surface.

Disadvantages

- Bitumen has complex chemical composition making it difficult to identify the explicit component(s) responsible for adverse health effects which are seen in exposed workers.
- Bitumen fumes generated at work sites contains carcinogens.
- Acute irritation in workers, chronic health effects like cancer are seen.
- The exposure to extreme heat and UV radiation decreases the lifespan.

ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

3. Box-type waterproofing system

Box type waterproofing system is basically used for basements, underground ducts and swimming pools where the waterproofing has to withstand the water pressure in addition to its basic stress. In India the most commonly used method is Shahabad Box Type.

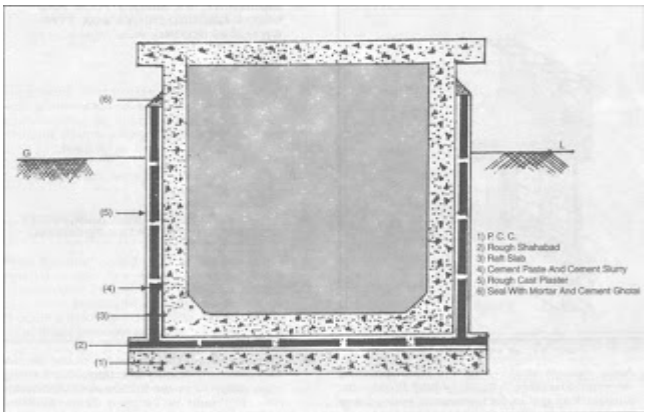

Figure 2 Box type waterproofing for basements (image source: (http://constructionduniya.blogspot.in/2012/02/waterproofing-in-basements.html)

Procedure

A base-coat in cement mortar 1:4 mixed with waterproofing compound is laid over the Raft PCC and above this rough Shahabad tiles of size 2'-0" X 2'-0" or 2'-0" X 3'-0" are fixed with minimum thickness of joints. Joints are staggered. Thickness of the Shahabad tile should be between 32mm to 40mm (1.25"-1.5"). After fixing the tiles, the joints are sealed with C.M. 1:3 and 15mm metal is pressed in the joints for enhanced strength and less shrinkage. Over this, a joint less layer of C.M. 1:3 with waterproofing compound approx. 25mm thick is applied and cured for 7 days. This layer provides a smooth layer for the raft and also protects the Shahabad tiles from getting damaged by steel bars laying and labour movement.

Raft is cast and RCC retaining walls are erected over this plastered base. Shahabad tiles are fixed from outside to the vertical retaining walls. All four corners of a Shahabad tile is applied with cement paste and it is pressed firmly on the RCC wall in line and level. At a time only a height of 1m is fixed. Total height above the ground level is taken as 1'-6". Joints are then sealed in C.M. 1:2 (Pointing). The Shahabad dado is then grouted using cement slurry with waterproofing compound and cured for 7 days. After curing, a joint less waterproofing plaster coat is applied and cured. Thickness of this treatment is around 65mm to 75mm. This entire process forms a box around the structure and does not allow any water to seep through or leak from the basement (Pawar, 2014).

Advantages

- It gives protection to basement at very reasonable cost.
- Doesn't require special equipment
- Materials are easily available

Disadvantages

- Joints should be grouted properly to avoid leakages.
- Installation time is more
- labour intensive work.

B. Modern waterproofing techniques

1. Sheet membranes:

Any imperfections in the substrate or background are covered by sheeting membrane. Some of sheet membranes available are:

a) Semi-rigid asbestos asphalt sheeting
b) Butyl rubber sheeting
c) Torch-on sheeting consist of layers of polypropylene bitumen modified
d) Bitumen/polyethylene sheets
e) Butyl rubber sheeting
f) Multilayer bituminous paper system with gravel topping for protection.
g) Metal sheets in the form of copper, lead or stainless steel flashing or trays.
h) Chloro sulphanated rubber (Hypalon)
i) PVC Polyvinylchloride
j) Neoprene rubber
k) Ethylene propylene Diene Monomer(E.P.D.M.)

The sheeting membranes can be applied as fully bonded or unbonded to the substrate. Sheet membranes must be overlapped about 100mm wide to each other by heat welding or adhesives. Weakest point in the system is the seams. Two persons are needed to apply the sheet. One of the people lay the sheet and smoothens while other put off the paper.

Advantages

- Its main advantage is their consistent thickness.
- It provides insulating properties and high resistant to all forces with good elongation.

Disadvantages

- It suffers from temperature stability, poor exposure resistance and little recovery from deformation.
- Severe bubbling occurs developing stresses onto the adhesive leading to eventual adhesion fracture if proper venting is not applied to water logged substrate.
- The cost of the labour and material is high.

2. Surface coating/liquid membrane

The liquid applied membrane provides a homogeneous layer with no laps, fully bonded, continuous seam-free layer which is a major advantage over sheeting membranes.

Some of the liquid membranes available are:

a) Two components polyurethane tar modified
b) Single pack moisture curing polyurethane
c) Polyester resin two parts reinforced with fibreglass matt
d) Two components tar epoxies modified
e) Water based epoxy two part for hydrostatic pressure situations
f) Acrylic co-polymer water based single part
g) Flexible epoxy resin two parts
h) Bitumen latex modified single pack

doi : 10.17950/ijer/v5i1/008

ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

i) Acrylic co-polymer cement modified two components
j) Mastic asphalt

Application of liquid membrane is done by roller, spray or trowel. Rubbery coat in formed on the wall. Liquid membrane is directly applied on the surface after its preparation. The surface should be prepared by filling voids and making it smooth.

Advantages

- Liquid coatings have low cost and excellent elongation property.
- Speed of work is faster than other methods.
- They are easy to apply, semi-flexible, seamless, and U.V. resistant.
- Ease of maintenance and repair and economical.
- It also has a ability to breathe.
- ghadgean@gmail.comInconsistency in coverage is the major disadvantage of liquid membrane
- Skilled supervision with more precautions is necessary to maintain the uniformity in thickness.

3. Integral method

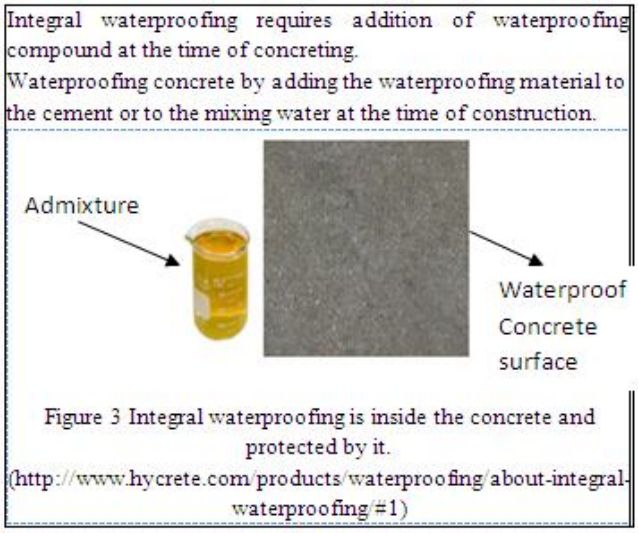

Figure 3 Integral waterproofing is inside the concrete and protected by it. (http://www.hycrete.com/products/waterproofing/about-integral-waterproofing/#1)

Concrete is a water loving material that sucks up moisture, integral waterproofing solutions work by blocking water from being able to get into concrete. Different integral waterproofing admixtures vary in terms of health and safety, performance and warranty.

Categories of integral waterproofing

3.1 **Hydrophilic system /**Crystalline

Crystalline technology is the major class of integral waterproofing. They react with calcium hydroxide and other products of cement hydration and form non soluble crystals that plug and fill the pores and micro cracks in the presence of water. It works even after years.

The most common method of using crystalline products is by adding it to the mix at the batch plant. There are many more ways it can be used.

Crystalline admixtures have the feature of self-healing which seals crack automatically up to half millimeter and is reactive for life time. It can be used on large concrete pours to waterproof the cold joints with no additional treatment as it is durable up to 200psi. It can be used in any project subjected to hydraulic pressure as it can withstand hydraulic pressure up to 460.This admixture has been used for more than thirty years.

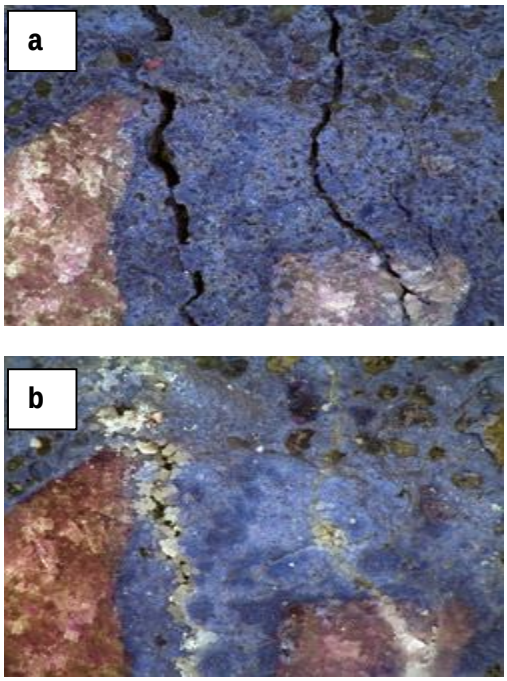

Figure 4 a) Blue-dyed concrete sample occurring shrinkage cracks b) treated with the admixture's nanocrystals. (http://www.waterproofmag.com/back_issues/201004/integral.php)

3.2 **Hydrophobic Admixtures**

It gives superior performance as compared to densifying admixtures. They absorb less than 1 % of water hence reduces the amount of water a dry concrete absorbs, and protects water ingress when concrete is wet. Even, it gives protection of water ingress from hydrostatic pressure. Water-Based Hydrophobic Permeability Reducing and Pore Blocking Admixture. Hycrete admixtures stop water from getting in through capillaries by forming barriers in the concrete matrix. They also protect steel against corrosion by coating it.

3.3 **Densifiers**

Densifiers reduce the concrete's permeability. They are not suitable where drying and rewetting may occur and works best when the concrete is permanently saturated. Industrial by-products like slag, fly ash and silica fume are used in concrete mixes. Slag is a by-product of steel manufacture, Fly ash comes from electricity production using coal as a fuel and silica fume comes from silicon manufacture. They are used in concrete mixes to fill in gaps to reduce permeability. They are all ground very fine before mixing.

Advantages

- Faster construction

doi : 10.17950/ijer/v5i1/008

ISSN:2319-6890(online),2347-5013(print)
8 & 9 Jan 2016

- Reduced cost
- Ease of application
- It reduces risk with a performance warranty
- Greener construction
- Common, non-branded materials, easily available
- Reduces permeability

Disadvantages

- Cracks larger than half a millimeter will not be treated.
- Transition, penetrations and Joints will need attention as well.
- Do not directly protect against corrosion
- A contractor may need to provide an adequate drainage system to avoid buildup of water through the life of structure in some instances, such as basements of single family homes.
- Requires adequate quality control.

II. Comparison between different waterproofing systems

Different conventional and modern waterproofing systems are compared on the basis of economy, ease of application and durability (Table 1). It can be reported that most of the conventional methods are economical and time consuming with low durability. Brick bat coba and bituminous treatment are cheaper than other waterproofing techniques; however, their durability is less and thus frequent repairs are required. Brick bat coba, surface coating and integral method are easy to use whereas other methods possesses some difficulty in installation. Membrane method and Integral method are durable for longer span than other waterproofing techniques, although their cost is high but durability is the major advantage. Integral waterproofing is found to be best method to meet the quality requirements and moderate economy and hence can be suitably applied.

Table 1Comparison of different types of waterproofing methods

Type of waterproofing	Cost	Ease of use	durability
Brick bat coba	low	easy	>15
Bituminous treatment	low	moderate	>10
Box type	medium	difficult	>10
Membrane method	high	moderate	>20
Surface coating	medium	easy	>10
Integral method	medium	easy	life of structure

III. Conclusions

Waterproofing is a very important tool to fight leakages and dampness. Conventional methods were widely used in the past but possessed various disadvantages as brick bat coba forms cracks due to temperature variations, imposes unnecessary load and almost impossible to dismantle for repairs. Similarly, bitumen is mostly produced from crude oil and is not regarded as a sustainable building product. Inflammability, low resistance against ultraviolet and also causes health issues. Box type waterproofing system is used for basement repairs where joints should be grouted properly or else the leakage would be from the joints. It is a labour intensive method and requires more time for installation. Due to all these disadvantages modern waterproofing techniques are used. Membrane method and surface coating are relatively costly but gives better protection from leakages and better durability. Among the modern system, integral waterproofing is found to be the best technique for waterproofing as it is economic, easy to apply and gives lifelong protection. But it also has some drawbacks as it is not feasible for cracks greater than half a millimeter. In India, still old techniques are followed due to simplicity and lack of knowledge about the new technologies. As integral waterproofing gives a protection for the intended lifespan of the structure at reasonable cost, it possesses a high scope for research in this field. Therefore, it is necessary to train the professional with advanced waterproofing system and increasing the awareness about same.

Acknowledgement

The financial support received from Sardar Patel College of Engineering, Mumbai under TEQUIP II to publish this work is duly acknowledged.

References

i. ASTM D3393-Standard Specification for Coated Fabrics.
ii. Biparva, A. (2015). Integral Crystalline Waterproofing. *STRUCTURE, 52*.
iii. Booth,R., Roberts K. (2014). "The Uses and Performance Requirements of Steep-Slope Roof Underlays in North America and the United Kingdom", *Proceedings of the North American Conference on Roofing Technology*, p. 112-118.
iv. Craig, S. (2010). "Understanding Integral Waterproofing", *waterproof magazine* http://www.hycrete.com/wp-content/uploads/Waterproof-Magazine-Integral-Waterproofing-April2010.pdf.
v. Foster, B. E. (1950). Use of Admixtures as Integral Waterproofing and Damp proofing Materials. *ACI Journal*, *22*(1), 46-52.
vi. Glasser, L. D. (1979). Osmotic pressure and the swelling of gels. *Cement and Concrete Research*, *9*(4), 515-517.
vii. Hariharan, G., Jain, S.P.S. (1998), Water Proofing of Building & Structures,CE'sCircular No.193, http://www.ser.indianrailways.gov.in/uploads/files/1303281777301-CEC-193.pdf,.
viii. Kaushal.K. (2000). "Waterproofing of Buildings", *NBM & CR*, pp. 50-55.
ix. Kubal, M. T. (2000). "Construction waterproofing handbook",*McGraw-Hill Professional Publishing.*
x. Pawar, A. (2014). "Session 2 water proofing", *slideshare*, pp 15-20.
xi. Perkins, P. (2002). "Repair, protection and waterproofing of concrete structures". *CRC Press*.
xii. Shenassa, E. D., Daskalakis, C., Liebhaber, A., Braubach, M., and Brown, M. (2007). Dampness and mold in the home and depression: an examination of mold-related illness and perceived control of one's home as possible depression pathways. *American Journal of Public Health*, *97*(10), 1893-1899.
xiii. Whitney, William Dwight. "Felt" def. 1-2. *The Century dictionary; an encyclopedic lexicon of the English language*, vol. 3. New York: The Century Co., 188991. 132.