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Methods of waterproofing concrete

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Abstract

Resistance to penetration by water is necessary in all concrete structures to prevent loss of structural strength of concrete building materials, particularly due to ASR (alkali silica reaction), acid rain, sulphate attacked. It also prevents chloride penetration which can result in corrosion of the reinforced steel bars and is essential in such structures as tanks, reservoirs, vaults, subways, Floors, Conduits, Walls, basements and roofs. Concrete, as it is ordinarily made, is pervious to water, hence to secure concrete structures through which water will not penetrate some method of waterproofing the concrete must be employed. Many methods have been proposed and are being used; none of these methods is without faults, the best one of them has not yet been determined, and the evidence available as to their comparative merits is biased and conflicting. For these reasons any discussion of waterproofing for concrete is at the present time bound to be unsatisfactory. In this paper, the working methods and new techniques in waterproofing concrete is discussed.

Key words: Penetration , Concrete , Strength , Corrosion ,Waterproofing

1. Introduction

Water is essential to concrete production, placement, and curing. But once it fulfills its role in those processes, water is no longer concrete's friend. Depending on its function and the nature of its exposure, concrete can of course perform well in wet environments. As a naturally porous material, though, and one that is prone to cracking, concrete is vulnerable to water infiltration. The unfortunate results can be freeze/thaw damage and deterioration due to corrosion of embedded steel reinforcement.

Waterproof concrete has reduced capillary absorption properties as well as low permeability to water under pressure. To make concrete really waterproof- which means both preventing water passage and resisting hydrostatic pressure you can waterproof from the positive (exterior) side, negative (interior) side or from within the concrete itself (integral systems). Although the most widely used positive-side technology is sheet membrane waterproofing, its failures and limitations are also common and costly [1]. Since the 1980s, many construction projects around the globe have used integral crystalline admixtures to waterproof concrete. Integral systems block water passage from any direction by working from the inside out, making the concrete itself the water barrier.

2. Common methods of waterproofing concrete

1-2- Sheet membrane systems

One of the common methods of waterproofing concrete waterproof coating applied to the surface of the concrete and one of the important classes of waterproofing in this method aids are polymeric elastomeric sealants and waterproofing polymeric coatings.

Cold-applied polymer-modified bitumen is a sheet membrane composed of polymer materials compounded with asphalt and attached to a polyethylene sheet. The polymer is integrated with the asphalt to create a more viscous and less temperature-sensitive elastic material compared to asphalt on its own. These sheets are self-adhering and eliminate the harmful toxins typically associated with asphalt adhesion.[1] They also increase tensile strength, resistance to acidic soils, resilience, self-healing and bond ability, see Figure 1 .

Figure 1: Applying waterproofing sheet membranes

Despite such advancements, disadvantages persist. Installation can be challenging as membranes require sealing, lapping, and finishing of seams at the corners, edges and between sheets. Additionally, sheet membranes must be applied to a smooth finish without voids, honeycombs or protrusions and also the surface Prior to blasting shall be dry. As the membrane can puncture and tear during backfilling, protection boards must also be installed.

ln spite of all these drawbacks, sheet membranes have been the industry norm in waterproofing for many years they still hold the majority of the market share. Their continued use is due to impact resistance, toughness and overall durability compared to other membrane option.

2-2- Liquid-applied membranes

Liquid-applied membranes can be applied with a brush, spray, roller, trowel or squeegee, and usually contain urethane or polymeric asphalt (hot- or cold-applied) in a solvent base. These membranes are usually applied on the positive side of cured concrete and have high elastomeric properties. More recent technologies have also made negative-side applications possible [1], see Figure 2 and 3.

Figure 2: Applying waterproofing Liquid-applied membranes with brush on the roof

Figure 3: Applying waterproofing Liquid-applied membranes to the outside of a tunnel

Successful waterproofing with liquid-applied membranes depends on proper thickness and uniform application. They call for skilled, experienced labour to apply them, a clean and dry substrate which can often be a construction environment challenge a protection layer before backfilling, properly cured concrete to avoid problems with adhesion and blistering and, on horizontal applications, a subslab. Liquid-applied membranes deteriorate when exposed to UV radiation and cannot withstand foot traffic. The liquids themselves also contain toxic and hazardous volatile organic compounds (VOCs).

Although liquid-applied membranes work well on projects with multiple plane transitions, intricate geometric shapes and protrusions, they are typically only used when prefabricated sheets do not work.

3-2- Admixtures

Other method that can simplify the protective process is to make concrete with admixtures that waterproofing compound in powder form or liquid used for all types of concrete to prevent water penetration and provides concrete with long-lasting waterproofing property. For the past three decades, a new type of waterproofing has been used around the globe. These integral admixture systems are added at the batching plant or on-site and react chemically within the concrete [1]. Instead of forming a barrier on the positive or negative side of concrete, they turn the concrete itself into a water barrier. Integral concrete waterproofing systems can be densifiers, water repellents or crystalline admixtures, see Figure 4 and 5.

Figure 4: Applying waterproofing admixture systems in powder at the batching plant

Figure 5: Applying waterproofing admixture systems in liquid at the batching plant

Densifiers react with the calcium hydroxide formed in hydration, creating another by-product that increases concrete density and slows water migration. They are typically not characterised as waterproofing materials or repellents because they have no ability to seal cracks and joints. Concrete under hydrostatic pressure requires additional waterproofing methods to protect it from damage and deterioration.

Water repellents are also known as 'hydrophobic'. These products typically come in liquid form and include oils, hydrocarbons, stearates or other long-chain fatty acid derivatives. Although hydrophobic systems may perform satisfactorily for damp—proofing, they are less successful at resisting liquid under hydrostatic pressure. Induced stresses cause cracking in any concrete, which creates pathways for water passage. So the effectiveness of water repellents is highly dependent on the concrete itself [1].

4-2- Crystalline admixtures

Crystalline-based systems typically come in a dry, powdered form and are hydrophilic in nature. Unlike their hydrophobic counterparts, crystalline systems actually use available water to grow crystals inside concrete, effectively closing off pathways for moisture that can damage concrete. They block water from any direction because the concrete itself becomes the water barrier. The crystalline formula contains no VOCs and can be completely recycled when demolition occurs [1].

Additionally,crystalline admixtures offer installation advantages. Unlike traditional membrane waterproofing, which tends to be labour-intensive and expensive, crystalline admixtures can be shipped in dissolvable, pulpable bags that are thrown into the concrete batch during mixing. This speeds up the construction schedule and decreases labour costs by combining steps with concrete placing, see Figure 6.

Figure 6: Applying waterproofing Crystallin admixtures with brush on the wall

Integral crystalline waterproofing systems should not be used in applications under constant movement. During the crystallisation process, crystals align in a three-dimensional array that breaks when subjected to excessive movement. Areas that require flexibility and face recurring movement- such as plaza decks or rooftops – would be better waterproofed another way.

3. Nano technology innovation in waterproof concrete

Nanotechnology is the use of very small particles of material either by themselves or by their manipulation to create new large scale materials. Nanotechnology is not a new science and it is not a new technology, it is rather an extension of the sciences and technologies that have already been in development for many years. Nanotechnology is the re-engineering of materials by controlling the matter at the atomic level [2].

The new development in science & technology has allowed using the latest nano technology to produce eco-friendly Organo-Silicon products to waterproof practically all the different kinds of building materials. The nano technology has ensured that service life of this approach will lead to life cycles beyond 20 to 30 years at very economical cost. Building materials, especially concrete are known to have water seepage, water leakages due to inherent porosity and microcracks.Waterproofing is a treatment, which isexpected to make the material impervious to water. Lots of technology and product development has taken place in various waterproofing products for the last 50 years, particularly using polymeric backboneand variety of other materials.Another serious issue waterproofing addresses is to prevent loss of structural strength of concrete building materials, particularly due to ASR (alkali silica reaction), acid rain, sulphate attacked. It also prevents chloride penetration which can result in corrosion of the reinforced steel bars [3].

1-3- Water related problems

Most of the building materials especially concrete are very porous and have surface hydroxyl groups. These hydroxyl groups attract water because of the hydrophilic nature and similarity with the structure of water. Therefore, concrete easily wet and absorb water in the pores. The size of the water molecule is 0.18 nm (i.e. 0.00018 microns).The size of the pores in most of the concrete, range from 5 to 200 nm [4]. The size of most of the pollutants like acids, chlorides & sulphates would range between1 to 2 nm.Even with the dense concrete and stones the pore size is much larger than water allowing easy entry with the hydrophilic nature of the building material.

The essential requirements waterproofing materials are:

1-1-3- Resistance it can impart to water absorption.
2-1-3- Preventing of water soluble salts, particularly chloride salts.
3-1-3- Penetration of waterproofing treatment to a measurable depth.
4-1-3- Non-staining of treated surface areas.
5-1-3- Long-term stability in an alkaline en vironment.
6-1-3- Low environmental and health risk.
7-1-3- UV stability (20+ years).

2-3- classes of waterproofing products

There are two classes of waterproofing products [3]:

1-2-3- Film Formers
2-2-3- Penetrants

1-2-3- Film Formers

The economics and the ease of application have led to widespread use of film forming water repellents. The products like acrylic paint, silicon polymers are commonly used in the world for waterproofing application.These film formers have particle size greater than 100 nm, which will not allow them to penetrate inside the pores of the building materials but form a film covering and preventing the surface from water absorption.Generally, these polymer films are hydrophobic but they need to be continuous and defect-free and also must be UV resistant. It is found that during application ensuring continuous film on rough surface is not easy which leads to weak points for film former, see Figure 7 and 8.

Figure 7: Film formers to create a barrier on top of substrate concrete materials

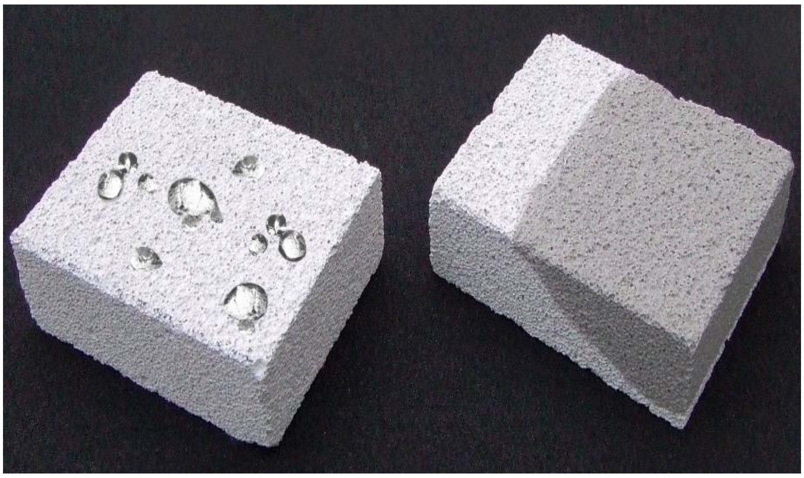

Figure 8: The difference between the ordinary and waterproof concrete by film formers on water absorption

All the typical polymer films tend to break down under UV leading to cracking of the films in 2-5 years, which leads to failure in terms of losing of hydrophobicity and water repellency.

2-2-3- Penetrants

Most penetrants are solvent based, soluble monomeric material with less than 6nm size. They easily penetrate inside the pores and subbranches of the pores.There are two types of penetrants i.e. non reactive and reactive. Nonreactive penetrants are oils and other low viscosity hydrophobic material, which coats the pore of the substrates, and provide water repellency. However, these types of materials are also biodegradable and loose hydrophobicity within a year. Additionally, these products also provide food for mold or fungus growth, see Figure 9.

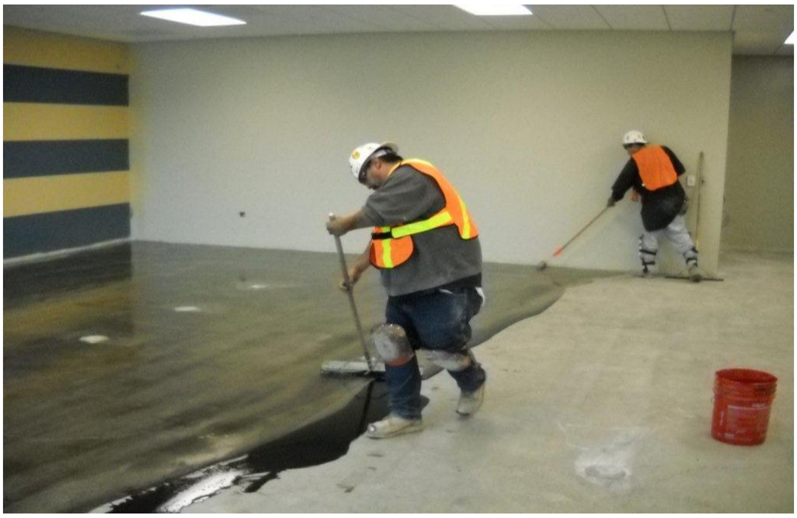

Figure 9: Applying waterproofing oil penetrants with brush on the floor

The reactive penetrants chemically react with the substrate and provide molecular level hydrophobicity to the treated surface and 3-5mm deep in the substrate. Therefore, these types of waterproofing products provide protection for a very long period. Additionally, the product is bound chemically on a molecular level to the substrate as a result; weathering (UV radiation) and natural abrasion have virtually no effect and hence very limited effect on the waterproofing characteristics.

Experimentally it has been seen that Silane based waterproofing products are desirable for long-term performance. Silanes and Silane/Siloxanes are known as new class of waterproofing products. Theseproducts are used in USA and Europe for last 30 years. However only last few years they became available in iran. The solvent based silane waterproofing compounds are proven to provide long lasting performance and are used very widely in USA and Europe [4].

The various alkyl silanes that are used for waterproofing are (i) isobutyltrialkoxysilane (ii) n-octyltrialkoxysilane. Silanes are monomeric materials. The products used for waterproofing are known as alkylalkoxysilane. Most building materials contains hydroxyl (OH) group. These OH groups can chemically react with alkoxy groups of Silane forming permanent siloxanes bonds with the substrate. The alkyl group R’ provides hydrophobicity (water repellency) to the surface. Therefore, these types of products impart water repellency by modifying surface characteristics from hydrophilic to hydrophobic.

4. Conclusion

Penetration excess water loss in concrete strength concrete structures construction due to acid rain and alkali silica reaction and sulfate attack in concrete. Also Penetration chloride, which can cause corrosion of reinforced steel rods Therefore a lot of maintenance costs against such threats need. Use concrete waterproofing solutions in addition to two or three times greater than the normal a period reduces the cost of maintenance and repair of concrete to be 30 to 40 percent. Select the appropriate key construction industry with concrete waterproofing products are available to reduce the project timeline.

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