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A Review on the Effect of Hydrophobic Agents on the Mortar and Concrete

*Rajesh Kumar Dubey**

ABSTRACT

Hydrophobic additives have been used in cement and concrete for a long time to reduce water penetration. Hydrophobic agents are chemicals added to cement to widen the angle at which water contacts the surface of the concrete. Fatty acids and their fractions have been added to cement as admixtures or phase-change agents to decrease water penetration into concrete. Alkenes, oils, fats, and other greasy substances frequently belong to the hydrophobic molecule class. By lowering water permeability, the hydrophobic component increases the concrete's longevity and visual appeal. Since the middle of the 20th century, concrete that repels water has gained a lot of popularity in design and building. The frequency of adverse reactions is decreased by the high contact angle of non-polar, lipophilic, hydrophobic substances. This article provides a summary of the studies on the use of hydrophobic substances in cement mortar and concrete.

Keywords: *Hydrophobic Agents; Penetration; Durability; Permeability.*

1.0 Introduction

Water infiltration and water pollutants like chlorides and sulphates are the main causes of concern for concrete building degradation. Reduce the amount of water that concrete structures absorb in order to stop this damage[1]. Numerous practises and state-of-the-art technology have been put in place to protect the concrete surface, according to past studies[2]. The injection of hydrophobic chemicals has proven to be the strategy for protecting concrete surfaces that does the least harm to the concrete structure. Hydrophobic chemicals have been used to treat concrete to lessen water absorption through capillaries. Because of these substances, it is now forbidden to enter any abrasive water, which has aided in drying up the inside over time.When water interacts with the cement in concrete, the bulk of damaging reactions take place. It was given hydrophobic substances to keep water out. Finally, this will make the concrete construction more resilient. Very few descriptions of the numerous treatments applied to concrete constructions are correct. [1] Some authors added polymeric fibres to the cement paste to decrease water absorption and produce hydrophobic cement as a building material[3]. The lifespan, ability to self-clean, and paint resistance of a structure have all been proven to increase with the use of hydrophobic cement[4]. When used as an addition, a hydrophobic component lowers cement paste's capillary water absorption by about 70%. The time it takes for cement pastes to cure in mixes is extended by hydrophobic additives. Hydrophobic compounds had a milder (11–17%) reduction in the chloride diffusion coefficient[5]. In several studies involving workability, strength, sorptivity, water absorption, diffusivity, permeability, and electrical conductivity, it has been asserted that hydrophobic Paper sludge ash reduced

**HOD(TPO), Department of Civil Engineering, RGPV Bhopal, MP, India (E-mail: tpo_seoni@rediffmail.com)*

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absorption and sorptivity by 85-99 percent when used as a hydrophobic agent. On mortar surfaces, the hydrophobic PSA demonstrates exceptional water repellency and self-cleaning qualities[6]. Recent studies have found that bacteria in concrete can reduce cracks and boost durability[7]-[9]. According to several authors[10][11], adding oleic acid and iminodiacetic acid as an addition to cement enhanced its mechanical and physical properties. Vegetable oils at 0.5 percent of the dry cement weight appear to be the most economical hydrophobizing agent [12]. Concrete is frequently treated with hydrophobic chemicals to make it resistant to extremes in temperature, heat, UV radiation, and acidity[13][14].

2.0 Characterization of Hydrophobic Agents

A thin hydrophobic layer can be created on the surface of concrete as well as inside of its pores and voids by substances referred to as hydrophobizing agents. The following chemicals have been used as hydrophobic agents:

- Butyl stearate (ester), Caprylic acid ($C7H15COOH$), Oleic acid ($C17H33COOH$), Capric acid ($C9H19COOH$), Stearic acid ($C17H35COOH$), etc. [15][12][16]. These are the substances that interact with the characteristics of cement when it hydrates.
- Highly fine wax emulsions are very good in lowering the hydrophobicity of cement. Wax emulsion coalesces and forms a hydrophobic coating when it comes into touch with the alkaline pore water of concrete. Air entrapment, workability, retardation, and other properties of concrete have all been discovered to be greatly impacted by emulsions formed of synthetic polymers, such Latix. Latices powder is primarily used to repair mortars, which improves the adherence of both new and old concrete. It was discovered that latice networks are stronger than wax networks.
- Silane ($SiH4$) is a chemical that is typically utilised on the surface of concrete structures that have already been erected and is hardly ever used on freshly poured concrete surfaces. It was shown that silane is more expensive than fatty and vegetable acids.
- Other substances that can be utilized as a hydrophobic agent include siloxane, calcium stearate, aluminum stearate, bitumen in finely divided form, vegetable oils, and esters.

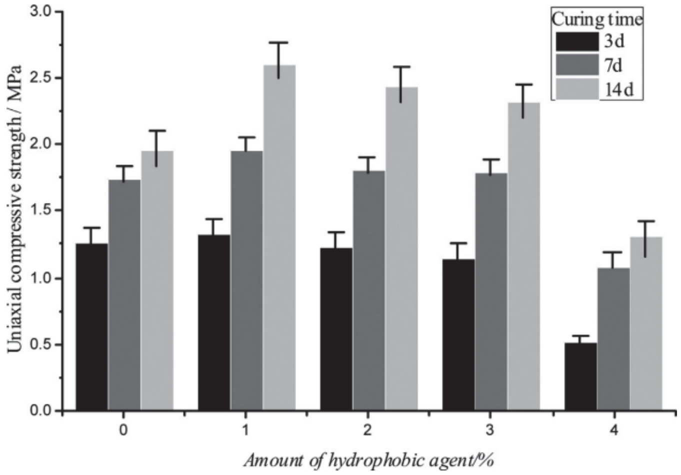
3.0 Effect of Hydrophobic Agents on Properties of Cement

The integration of a hydrophobic ingredient in cement and concrete has been documented by many authors to have a variety of different effects on the mechanical and chemical properties of cement and concrete, some of which are as follows:

3.1 Compressive strength

When the hydrophobic agent dose was 1% and the cement sand ratio of the CPB was 1:6 or 1:10, it was demonstrated that the compressive strength of the cement paste backfilled block was much higher than without it[17]. The compressive strength of cement paste-backfilled blocks with varied hydrophobic agent dosages is shown in Figure [17]. The compressive strength of hydrophobic concrete cubes increased by 75 and 81 percent, respectively, when the hydrophobic agent LYN-1 was added to cement at concentrations of 1 and 2 percent[18]. When unsaturated fatty acids and their acid fractions, such as oleic acid, linoleic acid, and linolenic acid, are used as a grinding aid in the cement industry, the compressive strength of normal concrete is significantly lowered (as shown in fig.1). The compressive strength of normal concrete increases with an increase in the length of the saturated oil chain (stearic acid, myristic acid, lauric acid)[19].

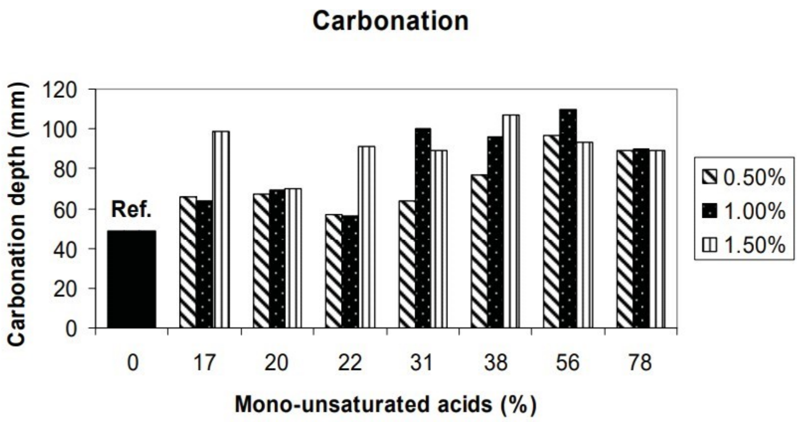
Figure 1: Effect of Hydrophobic Agent on Compressive Strength of Concrete[17]



3.2 Carbonation resistance

Carbonation depth for oil-incorporated mortar was significantly greater than that of control specimen, as found in a study conducted by Vikan and Justnes (2006) on the carbonation resistance of a 3-year-old mortar specimen that had been incorporated with vegetable oil. [12] These researchers found that the carbonation resistance of oil-incorporated mortar was significantly higher than that of control specimen. The degree to which carbonation occurs in mortar after incorporation of varying amounts of acid is depicted in Figure 2.

Figure 2: Carbonation Depth of Mortar with Different Amount of Acid [12]



3.3 Water contact angle

The initial water cement ratio (w/c) and cement hydration level are the two crucial variables that affect how Portland cement's pore size distribution behaves. Pore size in typical Portland concrete ranges from 0.05 to 1.0 microns (diameter). Through the capillary rise phenomena, water from outside sources reaches the concrete surface through these holes. The introduction of hydrophilizing chemicals in cement caused a layer of molecules or various particles to coalesce on the concrete surfaces, according to the literature review. Concrete's hydrophobic materials have high

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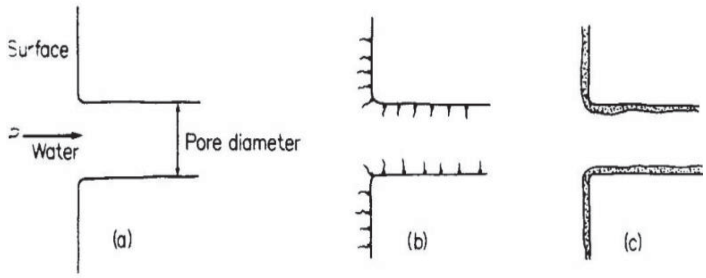
contact angles with water (as shown in Fig. 3). There are two types of wetting behavior: hydrophobic (WCA > 90°) and excessively hydrophobic (WCA > 120°) [4].

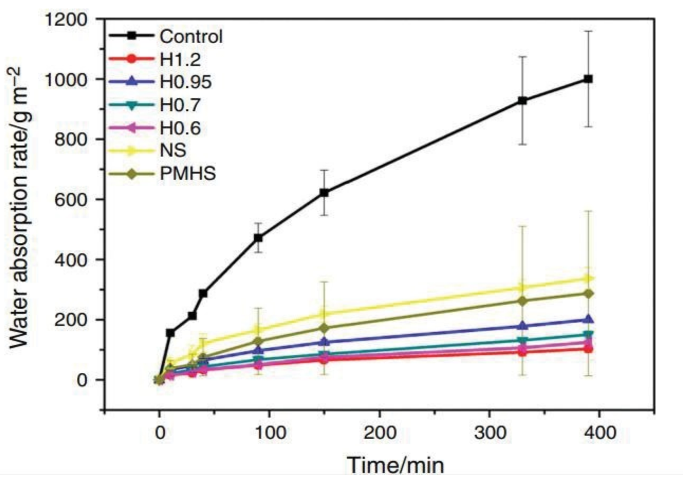
Figure 3: (a) Capillary Pore Without Hydrophobic Agent[12] (b) Lined With Molecular Agent (C) Lined With A Emulsion Layer



3.4 Water absorption

The capillary water absorption of the mortar specimen was significantly reduced to 5.4 percent of the value as that of ordinary mortar specimen when silica-based organic and inorganic hybrid composites, such as Poly-methyl hydrosiloxane / nanosilica (PMHS/NS), were applied for surface treatment on hardened cement. Figure 2 illustrates the capillary water absorption of mortar samples after six months that have been treated with various hydrophobic agents. By adding hybrid agents, the capillary water absorption rate of mortar specimens has been dramatically decreased. After 390 minutes of soaking, the water absorption rate for the NS and PMS-treated samples was reduced to 66.25 and 71.3 percent, respectively, while it was 89.69, 80, 85, and 87.5 percent for the H1.2, H0.95, H0.7, and H0.6 samples. Reduced water absorption of cement mortar and concrete specimen samples is another benefit of adding oil to cement (as shown in fig. 4). The amount of oil or hydrophobic ingredient used in cement determines how much of a reduction in water uptake occurs. [20]

Figure 4: Water Absorption Rate of Mortar Having Different Types of Hydrophobic Agent[20]



4.0 Conclusion

Depending on the amount of hydrophobic agent that was added to the cement and concrete, the capillary water absorption of mortar and the chloride diffusion coefficient were both reduced thanks to the addition of hydrophobic agents. However, this reduction was only partial. The presence of a hydrophobic ingredient in cement and concrete produces a surface that is resistant to low temperatures, ultraviolet light, alkalies, and acids. Under typical conditions, the water-proofing performance and impermeability are both improved thanks to them. The presence of hydrophobic substances in concrete creates a barrier that is resistant to the penetration of chloride ions and carbonation. The amount of hydrophobic agent needed to achieve the desired level of compressive strength in concrete is directly proportional to the amount of time the concrete is allowed to cure. The introduction of a hydrophobic agent had very little of an effect on the density of the concrete as well as its shrinkage. Because of the high contact angle between water and concrete, the sorptivity of the concrete has been significantly decreased after being treated with a hydrophobic chemical. Therefore, it is possible to conclude, as a result, that the addition of a hydrophobic ingredient to cement and concrete contributes to an increase in the durability of the concrete.

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