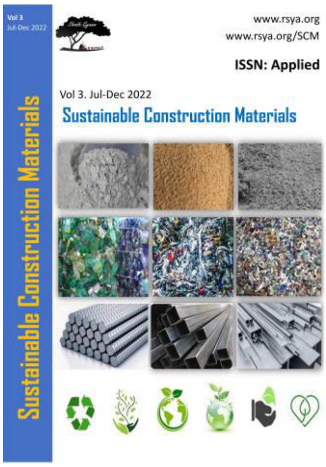

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Examining the Impact of Hydrophobic Agents on Mortar and Concrete

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Abstract. For a very long period, cement and concrete have used hydrophobic additives to lessen water penetration. Chemicals called hydrophobic agents are added to cement to increase the angle at which water hits the concrete's surface. To reduce water penetration into concrete, fatty acids and their fractions have been added to cement as admixtures or phase-change agents. Alkenes, oils, fats, and other greasy materials commonly fall under the category of hydrophobic molecules. The hydrophobic element lengthens the lifespan and aesthetic attractiveness of the concrete by reducing water permeability. Since the middle of the 20th century, water-repellent concrete has become very common in architecture and design. The non-polar, lipophilic, hydrophobic chemicals' large contact angles reduce the incidence of unfavourable interactions. The investigations on the use of hydrophobic materials in cement mortar and concrete are summarised in this article.

Keywords: Hydrophobic agents; penetration; durability; permeability

Introduction

The main reasons for concern regarding the deterioration of concrete buildings are water infiltration and water pollutants like chlorides and sulphates. 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 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].

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 ($C_7H_{15}COOH$), Oleic acid ($C_{17}H_{33}COOH$), Capric acid ($C_9H_{19}COOH$), Stearic acid ($C_{17}H_{35}COOH$), 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 (SiH_4) 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.

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:

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].

Carbonation Resistance

According to a study by Vikan and Justnes (2006) on the carbonation resistance of a 3-year-old mortar specimen that had been integrated with vegetable oil, the carbonation depth for oil-included mortar was noticeably higher than that of the control specimen. [12] Researchers discovered that mortar with oil inclusions had much higher carbonation resistance than control specimens. Figure 2 illustrates how much carbonation happens in mortar when various amounts of acid are added.

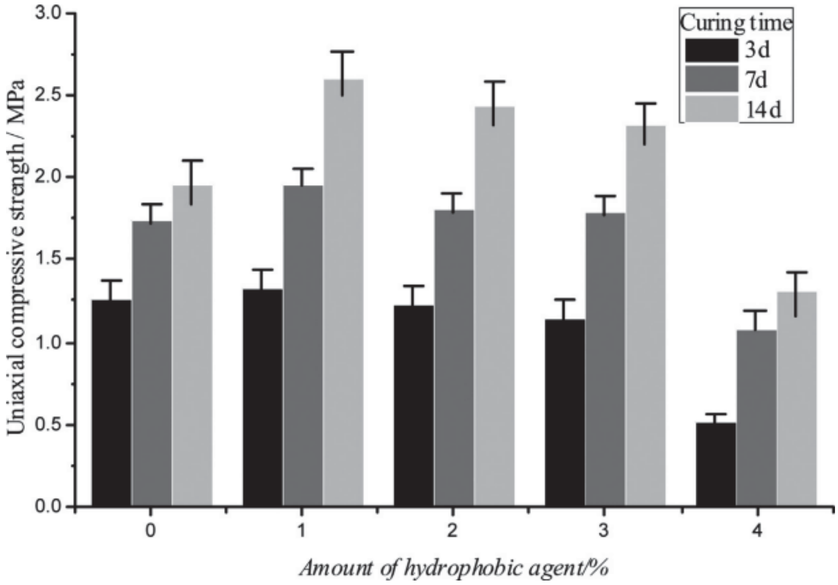

Fig. 1 Effect of hydrophobic agent on compressive strength of concrete [17]

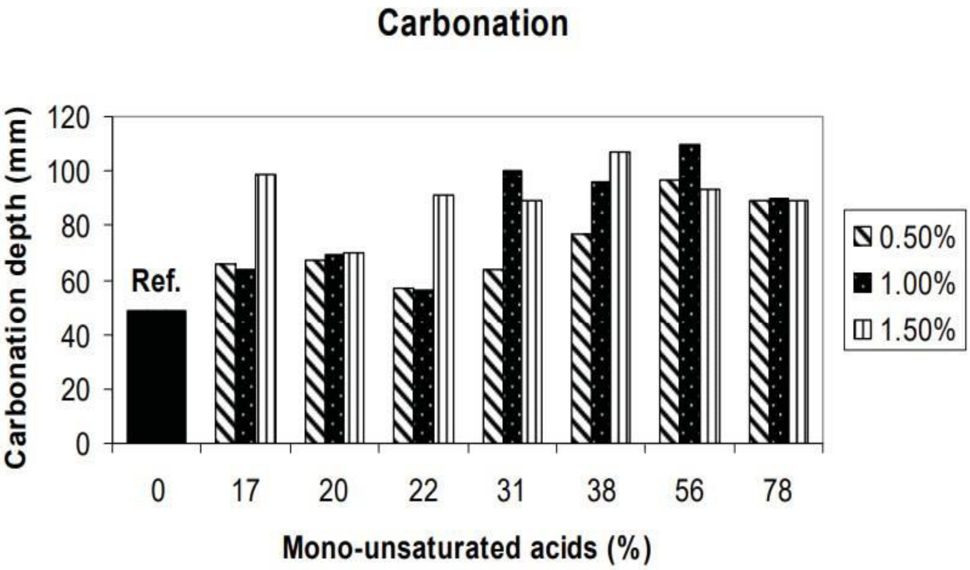

Fig. 2 Carbonation depth of mortar with different amount of acid[12]

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 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].

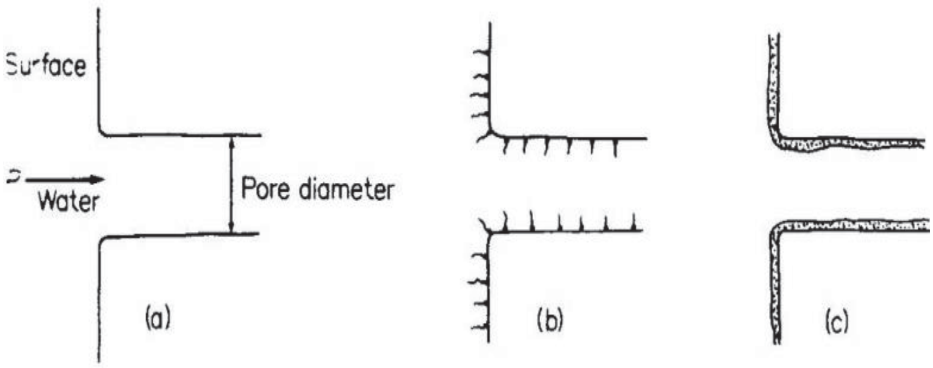

Fig.3 (a) Capillary pore without hydrophobic agent[12]

(b) Lined with molecular agent

(c) Lined with a emulsion layer

Water absorption

When silica-based organic and inorganic hybrid composites, such as Poly-methyl hydrosiloxane / nanosilica (PMHS/NS), were applied for surface treatment on hardened cement, the capillary water absorption of the mortar specimen was significantly reduced to 5.4 percent of the value as that of ordinary mortar specimen. After being treated with various hydrophobic agents for six months, Figure 2 shows the capillary water absorption of mortar samples. The capillary water absorption rate of mortar specimens has been significantly reduced by the use of hybrid agents. The water absorption rate for the NS and PMS-treated samples was decreased to 66.25 and 71.3 percent after 390 minutes of soaking, compared to 89.69, 80, 85, and 87.5 percent for the H1.2, H0.95, H0.7, and H0.6 samples. Another advantage of adding oil to cement is that cement mortar and concrete specimen samples absorb less water (as shown in fig. 4). How much of a reduction in water uptake happens depends on how much oil or hydrophobic component is used in cement [20].

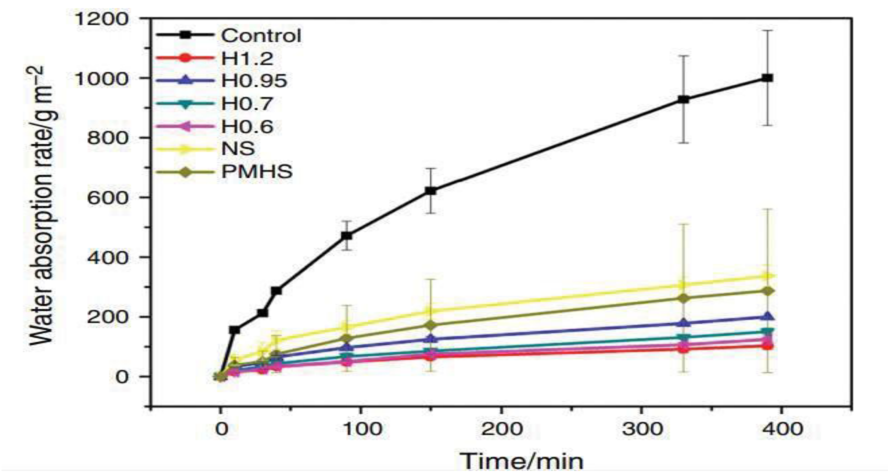

Fig. 4 Water absorption rate of mortar having different types of hydrophobic agent[20]

Conclusion

The capillary water absorption of mortar and the chloride diffusion coefficient were both decreased by the addition of hydrophobic agents, depending on the quantity added to the cement and concrete. But this was only a partial reduction. In cement and concrete, the inclusion of a hydrophobic component results in a surface that is resistant to low temperatures, ultraviolet light, alkalies, and acids. They improve both the impermeability and the water-proofing performance under normal circumstances. Concrete has hydrophobic materials that act as a barrier that prevents carbonation and chloride ions from penetrating. The length of time the concrete is allowed to cure directly relates to the quantity of hydrophobic agent required to reach the appropriate degree of compressive strength. The density and shrinkage of the concrete were little impacted by the addition of a hydrophobic additive. After being treated with a hydrophobic chemical, the sorptivity of the concrete has been greatly reduced because of the high contact angle between water and concrete. As a result, it is possible to draw the conclusion that adding a hydrophobic substance to cement and concrete increases the concrete's durability.

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