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Influence of early water exposure on modified cementitious coating

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HIGHLIGHTS

- Comparison between crystalline cementitious coating and polymer cementitious coating.
- The effect of early exposure to water on both materials was assessed.
- Main tests includes pull-off strength and water quality.
- Water quality range was "good" to "excellent" at all curing times for both materials.
- Crystalline coating is better at preventing water ingress than the polymer coating.

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ABSTRACT

Treating concrete surfaces with cementitious coating, especially those are used as a reservoir for potable and recreational water, is increasingly gaining popularity as a safer and better alternative to conventional coating material formulated from epoxies, urethanes, acrylics and polyureas. Despite good resistance to weathering, scratches and loads, deficient curing of cementitious coating can lead to reduced performance and undesirable release of pollutants from the coating to water. In this study, the performance of a dual crystalline cementitious coating, which combines hydroscopic (water combining) and hydrophobic (water chasing) properties, for concrete protection was evaluated in an attempt to evaluate whether water affinity of the material can overcome the issue of reduced performance. The results were compared with a polymer modified cementitious coating. The influence of early exposure to water, after 24 h of curing, was assessed by coating pull-off testing and level of pollutants for the first 21-days. The water quality was found "good" to "excellent" according to World Health Organization (WHO) standard at all curing times for both materials with no surface cracking or other defects were noted. The crystalline coating needed 120–240 h for optimum curing, whilst polymeric coating needed 72. In terms of pull-off strength, the polymer coatings on the rough and smooth substrates yielded results greater than 1-MPa after 120-h curing, while crystalline coating took 240-h. However, compared to polymeric coating, the crystalline coating absorbed less water thought out the test duration, indicating that good overall performance.

1. Introduction

A layer of surface coating is an effective way of protecting and enhancing the durability of new and existing concrete structures [9,16]. The term "coating" is often used broadly to refer any liquid or semi-solid material applied to cured concrete. However, it is very difficult to choose the right type of protection material as wide range of coating is available in the market and even similar generic types can possess considerably different characteristics [1].

The most commonly used concrete coatings fall under or are hybrids of four basic polymer categories: epoxies, urethanes, acrylics and polyureas. Some of these variations may contain high amount of volatile organic compound (VOC) and if not controlled, can be potentially harmful. As an alternative, cementitious and modified cementitious based waterproofing are gaining increasing popularity as they provide better resistance against water, weathering, scratches and loads as well as blends well with concrete. In addition, cementitious coating is less susceptible to temperature, and is suitable to apply in water retaining structures like water tanks, wet rooms, swimming pools, reservoirs and as a protective system for reinforced concrete, preventing reinforcement corrosion [17,2,11,6].

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Despite the long history, cementitious protective coating often shows variable performance due to inappropriate material selection, poor application method including insufficient curing, humidity or a combination of all above [18,5,19,13,12]. Failure of coating typically manifests itself as cracking in the coating material and/or delamination of the substrate concrete, largely a consequence of non-uniform volume changes under restrained conditions. The performance of coatings also varies with the exposure conditions and failure from within the coating, i.e. between the multiple coatings that have been applied [10,4].

Reiterman and Paszderka [15] studied the effect of crystalline treatment in construction joints. In the mentioned study, authors were able to measure water absorption of treated samples at different points from the surface, and they were successful in bringing down water absorption rates in the construction joints region. In another recent research, Pazderka and Hajkova [14] studied the time it takes a crystalline coating to start performing in an efficient way. Water permeability of treated concrete was conducted at different periods from day 3 until day 28 from casting. The results showed that the extreme efficacy of waterproofing starts after 12 days from casting.

2. Research objectives

Owner and operators of water tanks and swimming pools often need to make a decision for an early commissioning of the facility to avoid disruption, economic and social consequences. This raises the possibility of inferior performance from the surface treatment and undesirable release of water pollutants. The key question raises that what should be the optimum time to open the facility without compromising the performance of coating and quality of water. Issues like coating performance, assessed by coating pull-of testing, and water quality, assessed by the level of unacceptable chemical and particulate content are key objectives of this research. The latter is referenced to World Health Authority water quality standards. The driver for this research is early delivery of facilities to the client. Two modified cementitious coating, a crystalline and a polymeric variation, were applied on concrete specimens and then submerged in water after 24 h of coating application. The dispersion of pollutants, pull off strength of coating and water absorption up to 21 days, were determined. The intensity of leachates was compared against the criteria set by WHO.

3. Experimentation

3.1. Sample preparation

A C40 concrete was chosen as this grade concrete is normally used in this type of application. In total, 24 concrete slabs (225 mm × 225 mm × 40 mm) was manufactured. The specimens were grouped into two groups (as shown in Table 1), 12 specimens with rough surface (group A) and 12 with smooth surface (group B). The rough surface was obtained by removing laitance of the slab by a needle gun. The twelve slabs from groups A & B are then divided equally for applying the polymer coating and the crystalline coating, i.e. 6A = polymer and 6A = crystalline, likewise with group B. Specimens are identified as C1A1: crystalline coating with rough surface preparation and so on.

3.2. Material description and application

Briefly, crystalline waterproofing is a non- hazardous mixture of cement, fine treated silica, sand and an active proprietary chemical mixed with water. Dual crystalline material combines hydroscopic (water combining) and hydrophobic (water chasing) properties for concrete protection. The combine action helps the coating more tolerant to internal moisture, pressure damage and defends against freeze-thaw attack. On the other hand, Polymer coating is a non-toxic waterproofing applied as liquid dispersions or as a re-dispersible powder in a dry mortar mixture. It is formed from synthetic resins, silica sands, and cement. It is worth mentioning that both materials are sensitive to temperatures lower than 5 °C, so it is better to apply them to surfaces with temperatures higher than 5 °C.

The general properties and the application method of two tested materials are shown in Table 2.

The quantity of polymer material was adjusted in the small area of coverage required; 1/5th water was mixed with approximately 2.5 kg polymer powder, as per manufacturer's instruction. The substrate was cleaned thoroughly and then wet with distilled water for approximately two hours' prior the application of material. The slurry was then applied by a brush to a thickness in the range 0.5 mm–1.0 mm is achieved. The second coat was applied after 24 h to achieve a total thickness of approximately 2 mm. The material was applied within 20 min to avoid setting and precaution was taken to avoid contamination. A ratio to 3:1 crystalline powder and distilled water were used to make the mixture to make 2 mm coat for six slabs. The preparation and application process was similar to polymer coating. The coated slabs are shown in Figs. 1a and 1b, where all the surfaces of the slabs are treated with the polymer and crystalline coatings.

3.3. Testing

All 24 slabs were weighted and then submerged in individual boxes filled with the same amount of water in each box. The testing sequences involved, taking out four specimens (C1A, C1B, P1A and P1B) after 24 h, measure water quality, dry up the specimen and weigh again. Finally, perform pull-off test on a specimen for coating properties. Similar sequences are followed at 72, 120, 240, 308 and 408 h.

3.4. Measurement

The effect of curing on water quality in terms of total dissolved solids (TDS) was compared against the criteria set by the World Health organisation (WHO) for drinking water [20]. TDS is a representation of the total concentration of dissolved substances in water consisting of inorganic salts and a small quantity of organic matter. The inorganic salts contain a mixture of anions and cations. Anions produce a negative charge and stem from compounds such as carbonates, nitrates, bicarbonates, chlorides and sulphates. Cations produce a positive charge, in the form of elements such

Table 1
Sample preparation.

Material	Surface finish			
	Rough		Smooth	
Crystalline (C)	6	Group A	6	Group B
Polymer (P)	6		6	