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Research paper

Effect of TiO_2Nanoliquid on the Properties of Cement Mortar

C. Prabalini[1], Z. AyshaFarsana[2], A. Sumathi[3]

P.G Student, School of Civil Engineering, SASTRA Deemed University
Assistant Professor, School of Civil Engineering, SASTRADeemed University
**Corresponding Author E-mail: [3]sumathi@civil.sastra.edu*

Abstract

Mortar/Concrete is effectively used in the construction of buildings. In the view of developing the infrastructure, it is essential to come up with new methods. Generally, the mortar which is being used has numerous pores in it and thus the strength gets reduced and the absorption increases. To reduce the durability problems nano liquid is being added. Nano liquid has the advantages of anti microbial and anti UV action. This paper deals with the nano liquid on the properties of cement mortar with two curing medium (water and saturated lime water) for 3, 7 and 28 days and the results were compared with control mortar in terms of strength and durability. Nano liquid was added in terms of 2.5ml, 5ml, and 7.5ml per kg of cement. After the completion of curing period the nano liquid is uniformly sprayed on the outer surface of the mortar cube. Since the nano liquid emits heat, the curing is made with lime to reduce the heat of hydration.

Keywords: *Ordinary Portland cement, Nano-liquid, Compressive strength, sorption coefficient*

1. Introduction

Construction industry plays a major role in improving the gross domestic product of the country. So the method of construction should be effective. The effective construction can be achieved by implementing new techniques. Nanotechnology helps in introducing new materials which are effective in nature. Nanotechnology reduces the cost of structures due to its advantages like self cleaning, self repairing concretes. Nano materials are fire resistive and anti-corrosive so they can increases the durability of the structure. More research works conducted in the field of nanotechnology as there is a large amount of scope in civil engineering. Nanotechnology has huge market potential and economic impact that will create an impact on technology and business. N. Venkat Rao et al [1]. The permeability of unmodified mortar is greater than Polymer Modified Mortar (PMM) has benefits under wet or dry curing conditions. The repeated water and air curing is the effective curing method for all the PMMs, where the unmodified cement mortar, has a prolonged water curing. In the above mentioned curing condition, water–binder ratio, has the ability to reduce permeability with increasing strength MahyuddinRamli et al [2]. Permeability and abrasion resistance in cement mortars was studied extensively and tests show that the nano liquid coated cement mortar reduces permeability and increases abrasion resistance, Kamal Gad Sharobim et al [3].On partially replacing SiO_2 nanoparticle in place of Portland cement shows increased abrasion resistance and compressive strength ShadiRiahi et al [4]. The inclusion of natural and nano-additives in the conventional mortars improved the strength at early age PiotrBrzozowski et al [5].The replacement of Palm Oil Fuel Ash increased the permeability. The addition of nano silica minimize the permeability of the sample. On mixing more amount of POFA the effect of nanosilica in the mixes increases. Nano silica densify the matrix which was observed from SEM images. In the drying shrinkage the hydration rate was not effective due to the high volume replacement NimaFarzadnia et al [6].Sorptivity of the specimen was less when compared to that of the control specimen and the micro structure of the specimen with nano liquid was more compact when compared to control specimen ParthaSarathi Deb et al. [7].Nano Silica andnano clay in wet and dry condition respectively have significant improvement on the compressive and flexural strength of high performance concrete. The addition of more amount of nano liquid reacted negatively towards the compressive and flexural strength Anwar M Mohamed [8].Nano silica improves the compressive strength and resistance to sulphate attack when compared to control mortar Saloma [9].

2. Material and Methods

2.1 Materials Used

Ordinary Portland cement grade of 53 and specific gravity of 3.1 was used conforming to IS: 12269 [10]. The maximum size of fine aggregate 4.75 mm was used and it obtained from local source. The specific gravity and fineness modulus of sand were found to be 2.71 and 2.41% respectively. Clean tap water was used for the work conforming to IS 456-2000 [11]. TiO_2nano liquid is colourless with a density of 1.01 g/cc. It has a viscosity and pH of 20mPa-s and 7.1 respectively. It has flash and fire point of 100°C. It is hydrophilic in nature because it actively repels water and moisture. It also acts as anti UV and anti-microbial agent .The performance of nano liquid on the mortar surface is illustrated in the Fig1.

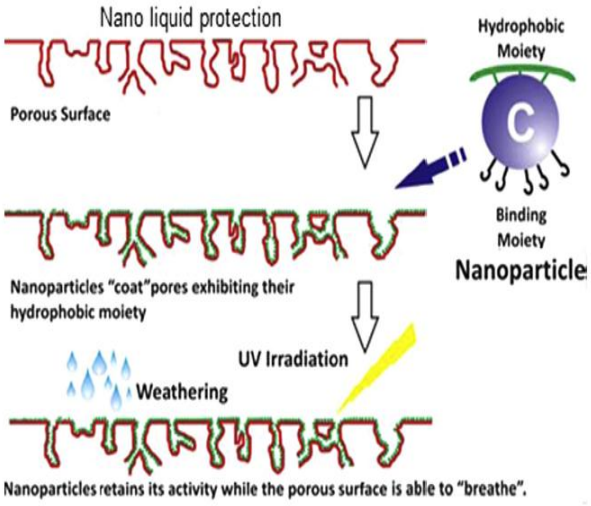


Fig. 1: Performance of nano-liquid on the mortar surface

2.2 Mix Proportions

Mortar mix ratio of 1:3 was considered for the present work. Nano TiO_2 were mixed in the fresh mix in three different dosages as 2.5 ml, 5 ml and 7.5 ml to study the compressive strength and water permeability in mortar specimens. After 28 days of normal water and saturated lime curing the specimens were coated with nano TiO_2 solution Table 1 show the details of mix proportion.

2.3 Testing Methods

Mortar cubes and cylinders were cast to determine the properties of the specimens. Three specimens were cast for each mix and for each tests, the mean values were reported. Specimens of size 70.7 x 70.7 x 70.7 mm were made as per IS 4031-6 [12] to study the compressive strength parameters under two curing media. To study the sorption, specimens of size 100 mm dia. and 50 mm height were cast and test was performed as per ASTM C1585 [13]. TABLE 1 represents the mix proportion for compressive strength.

Table 1: Mix proportion

Nano liquid Replaced(ml)	Cement (kg/m3)	Fine Aggregate (kg/m3)	Water (ml)
0	0.161	0.500	48.3
2.5	0.161	0.500	45.8
5	0.161	0.500	43.3
7.5	0.161	0.500	40.8

3. Results and Discussion

3.1 Compressive Strength Test

The effect of Nano-liquid on compressive strengths is shown in Fig 2-4respectively. The failure pattern of the specimens are depicted in Fig 5-7. Cubes were tested in each set and the average compressive strength was recorded. The mean compressive strength of the control cement mortar specimens at the age of 3 days, 7 days and 28 days of curing is 12.44 MPa, 14.3 MPa and 21.76 MPa respectively. At 28 days the strength obtained for without and with coated under water curing was found to be 19.67, 30.3, 34.3, 27.8 MPa and 21.98, 33.23, 37.5, 28.38 MPa respectively. Strength obtained for without and with coated specimens was found to be 21.76, 29.87, 37.23, 30.48 and 24.76, 32.57, 39.13, 32.58 respectively. Whereas, the average compressive strength for the 5ml nano liquid mortar specimens coated with TiO2 nanoliquid at the age of 3, 7 and 28 days of lime curing is 27.45MPa, 34.8 MPa and 40.84 MPa respectively. Among all combinations mortar with 5 ml nanoliquid under lime curing showed superior performance at all ages compared to specimens under water curing. Based on the test results 5ml nanoliquid was found to be optimum under water and saturated lime water curing at all ages.

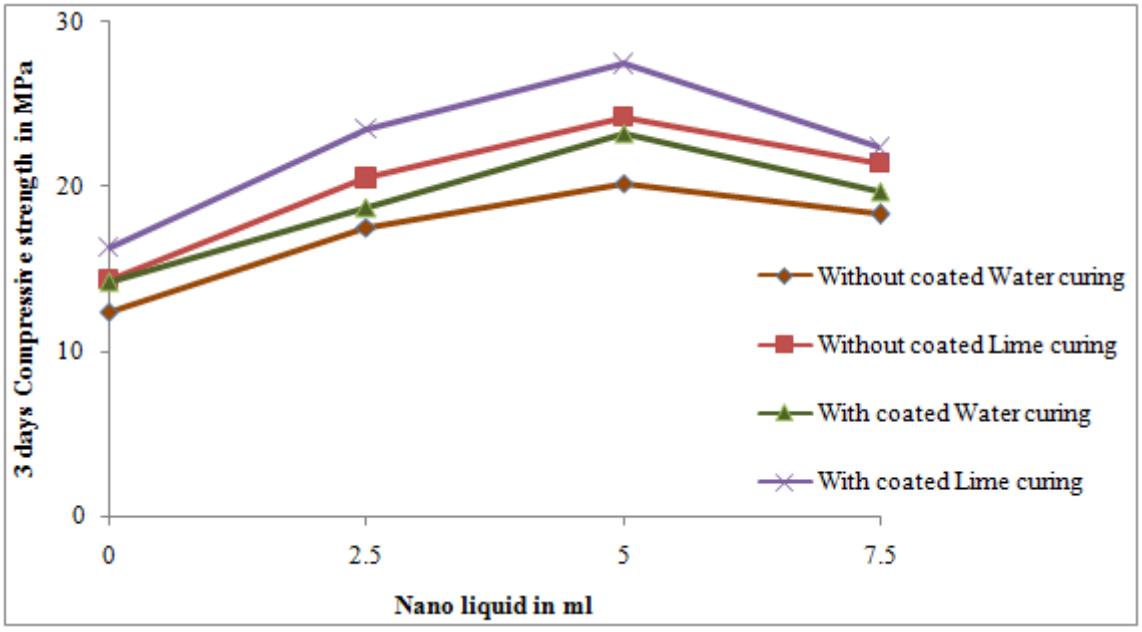


Fig. 2: 3 days compressive strength

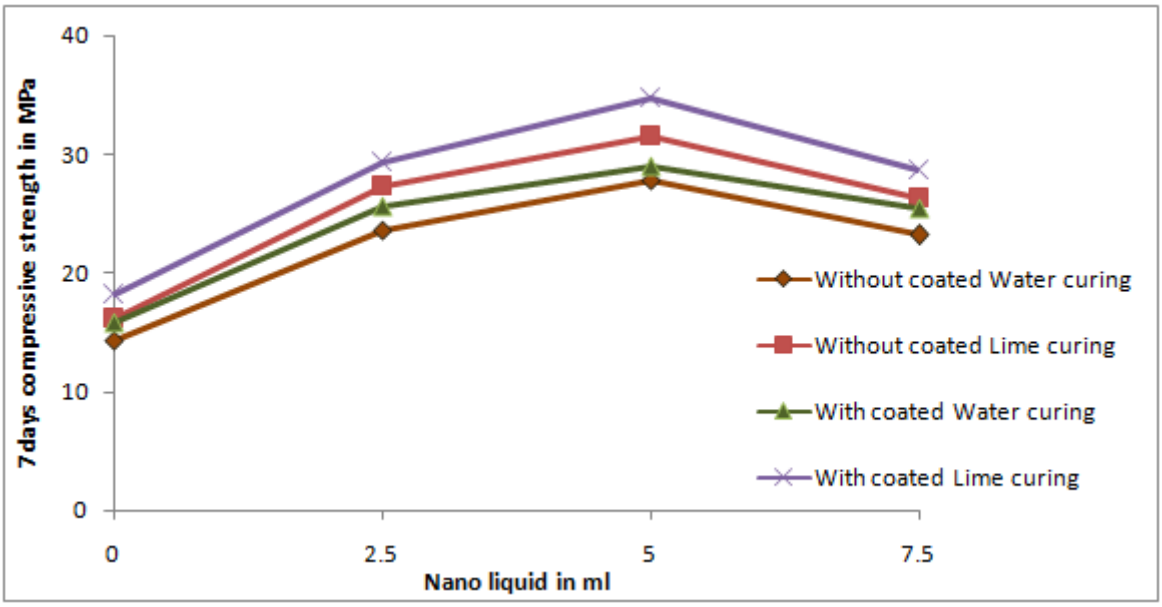


Fig. 3: 7 days compressive strength

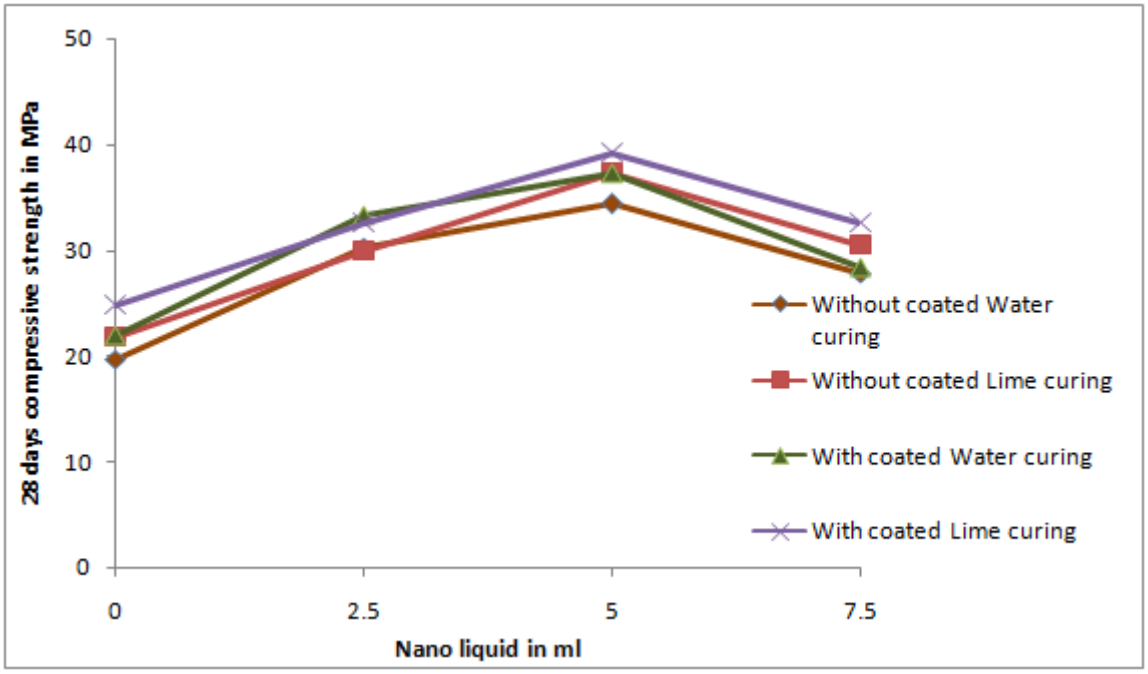
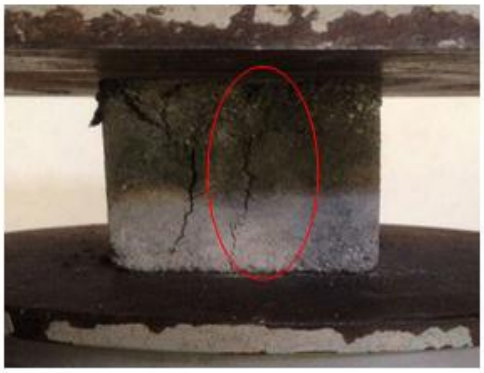


Fig. 4: 28 days compressive strength

(a) (b)

Fig. 5: (a) Failure pattern of 28 dayslime curing (5ml) coated
(b) Failure pattern of lime curing (5ml) non-coated



(a)

(b)

Fig. 6: Failure pattern of 28 days water curing 5ml coated (b) Failure pattern of lime curing 5ml non-coated

Fig. 7: (a) Failure pattern of 28 days water curing (b) Failure pattern of lime curing

3.2 Sorpitivity

The sorption coefficient was attained for the mixes is shown in figure 8. The results infer that the rate of absorption decreased over the course of time, and there was no significant increase in the rate of absorption after 120 minutes for almost all the samples. This is mainly due to the superior matrix in mortar with nanoliquid than the control specimen. It has also been observed that higher amount of nanoliquid content leads to considerably lower absorption, which is consistent with the superior pore structure with reduced porosity, and which is in contrast with the control concrete in which the increase in the absorption rate results in micro-cracking due to high amount of heat released at water curing compared to lime water curing.

The graph for the square root of time versus the parameter Q/A was plotted. Sorption coefficient was calculated based on the linear fit in to the graph. Figure 8 shows the rate of absorption for mixes with different dosages of nanoliquid under water and lime curing respectively. The results inferred from the graph that the sorption co-efficient of 5ml nanoliquid gives the lowest value than other mixes. This is due to fine particles of nanoliquid fill the void spaces with air bubbles, so as to reduce the permeability of concrete by locking the air spaces and so, when these air bubbles get filled, permeability of concrete is greatly reduced and mixes with nanoliquid becomes highly impervious.

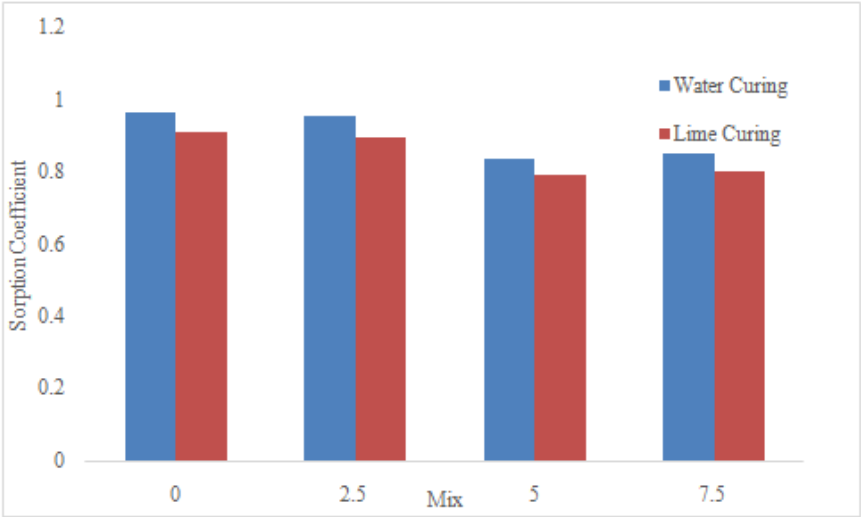


Fig. 8: Sorption coefficients for water and Lime curing

4. Conclusions

To study the effect of Nano-liquid on properties of cement mortar, an experimental program was carried out by mixing nano liquid during casting and spraying nano liquid on the surface of dry mortar after curing.

1. Nano-liquid has a remarkable improvement on strength when it is mixed and applied on hardened mortar surface, the strength attained a maximum value for 5ml nano liquid coated under lime curing when compared with water curing.
2. The percentage increase of strength in lime curing is more than water curing when compared with control specimens for 2.5 ml, 5ml and 7.5ml of nano-liquid compared to control mortar. Similarly the percentage increase of strength in non-coated mortar cubes is more when compared to coated mortar cubes.
3. Based on the strength and sopritivity results the optimum content of nano liquid was found to be 5 ml per kg of cement.
4. Among the different mortar mix under two curing media, Cement mortar with 2.5 ml and 5 ml nano liquid non - coated specimens was found to be better mix in terms of strength and reducing the permeability.

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