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EXPERIMENTAL INVESTIGATION ON SELF CLEANING PROPERTY OF NANO TITANIUM DIOXIDE PARTICLES IN CEMENT CONCRETE

[1]Raam Aravindh.T, M.Tech Scholar
[2] J.Santhiyaa Jenifer, Assistant Professor,
Department of Civil
PRIST University, Vallam, Thanjavur, India – 613403
[1]raam.aravindh@gmail.com, [2]santhiyaajeni@gmail.com

Abstract: Mortar is a workable paste of cement, sand and water which is used to fill the irregular gaps, voids and bind the masonry units together. The cement mortar is also used in plastering of wall structures in order to give a smooth finish and protect the structure. But cement plaster possesses low strength, absorbs more water and a large number of pollutants from the atmosphere and deteriorate the structure which leads to surface cracks and damping. Thus in order to suppress these defects, cement plaster is added with nanomaterial and pozzolanic materials. The aim of this paper is to study the different strength properties of cement mortar and modified mortar. This study helps in reduction of carbon dioxide emission in the atmosphere due to the addition of ground granulated blast furnace slag and fly ash. These modified mortars when used in plastering exhibit high strength and less water absorption characteristics than conventional mortar plastering. This paper presents an approach which produces modified mortar by which the Portland cement is partially replaced with ground granulated blast furnace slag and fly ash at 10% respectively by weight of cement and also titanium dioxide is used at the optimum of 1% by weight of cement for the self-cleaning property. Various tests for different properties have been carried out and the results are compared to the conventional cement mortar.

Keywords: Mortar, Cement, Concrete, Nano Titanium Dioxide,

1. INTRODUCTION

Mortar is one of the most widely used construction material, it is usually associated with Portland cement as the main component for making cement mortar. To produce mortar, Ordinary Portland cement (OPC) is conventionally used as the primary binder. Although Portland cement production is a major contributor to CO_2 emissions and global warming is caused by the emission of greenhouse gases, such as carbon-di- oxide, to the atmosphere by human activities. These efforts embody the use of] supplementary cementing materials like fly ash, GGBS and finding various binders to cement. The by-product of burning coal, iron and steel is used as a substitute for Ordinary Portland cement to produce mortar due to the abundant availability of fly ash and GGBS.

A new building material which both cleans itself and filters pollutants out of the air around has been popping up on new infrastructure in recent months. The self-cleaning materials are a potential approach to make the city cleaner by reducing the air pollutants. Photo catalytic nanoparticles like titanium dioxide (TiO_2) with the ultra-smooth surface is fabricated with Portland cement i.e. Calcium Silicate Hydrates products (C–S–H). The residue of contaminants will be washed away by the rain due to its ultra-smooth surface and photo catalytic properties. This new type of mortar is promising to be utilized as a self-cleaning finishing material for the urban buildings.

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In this paper we have studied the behavior of TiO_2 studied when it is mixed with cement, fly ash and GGBS mortars at various ratios.

2. MATERIALS AND ITS PROPERTIES

The following materials were collected to carry out the research proposed in this paper:

1. Ordinary Portland Cement (OPC) of 53 grades is used and obtained from India Cements, Sankiri. Fine aggregate used in this study has a specific gravity of 2.65, fineness modulus of 2.78 and is confirmed to grading zone II as per IS 383:1970.
2. Class F fly ash is obtained from Thermal Power Plant, Mettur.
3. Ground granulated blast furnace slag is collected from Astrra Chemicals, Chennai.
4. Titanium dioxide is obtained from Mercury's Scientific Chemical Industries, Salem and it is in anatase form.

3. METHODOLOGY

In this proposed approach M20 grade ordinary Portland Pozzolana Cement 53 grade, epoxy and polyester resin were used. Additions of epoxy by 0.1% to 0.5% the volume of cement were added. Similarly polyester resin also added as an admixture.

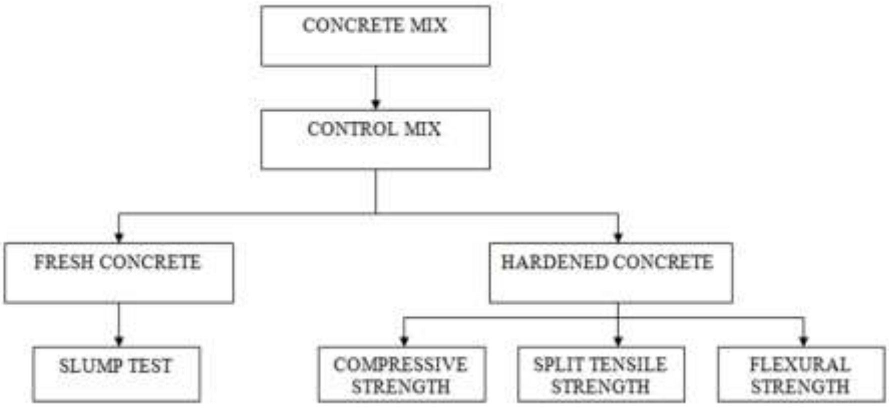

Fig.1 Cement mixture methodology

4. ANALYSIS OF MATERIAL PROPERTIES

Table 1 Dry Bulk of Coarse Aggregate Unit Volume Of Concrete As By Aci 211.1-91

Maximum size of Aggregates	**Bulk volume of dry rodded coarse aggregate unit volume of concrete for fineness modulus sand**			
F.M	2.40	2.60	2.80	3.00
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
70	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

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For all the mix proportions, the following specimens were cast.

1. Cube [150x150x150mm]
2. Cylinder [150mm dia and 300mm height]

After 28 days, the compressive strength of concrete, and split tensile strength were conducted. Fig.1 shows the methodology of cement mixture.

Table-2 Relation between Water / Cement ratio and average compressive strength of Concrete, according to aci 211.1-91

Average compressive strength at 28 days MPa	**Effective water/cement ratio (by mass)**	
	Non-air entrained concrete	**Air-entrained concrete**
45	0.38	-
40	0.43	-
35	0.48	0.40
30	0.55	0.46
25	0.62	0.53
20	0.70	0.61
15	0.80	0.71

Table-3 Requirements of aci 318-89 for w/c ratio and strength for special exposure conditions

SI.NO	**Exposure condition**	**Maximum water cement ratio, normal density aggregate concrete**	**Minimum design strength, low density aggregate concrete MPa**
1	Concrete intended to be watertight a. exposed to fresh water b. exposed to brackish or sea water	0.5 0.45	25 30
2	Concrete exposed to freezing and thawing in a moist condition a. kerbs, gutters, guard rails or thin sections b. other elements c. in presence of de-icing chemicals	0.45 0.50 0.45	30 25 30
3	For corrosion protection of reinforced concrete exposed to de-icing salts, brackish water, sea water or spray from these	0.40	33

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	sources.		

Table-4 Approximate requirements for mixing water and air content for different workability and nomlal maximum size of aggregates to aci 211.1-91

Workability or Aircontent	Water content, Kg/m of concrete for indicated maximum Aggregate size in mm							
	10	12.5	20	25	40	50	70	150
Non – air entrained concrete								
Slump 30 – 50mm 80 –100mm 150-180mm Approximate entrapped air content percent	 205 225 240 3	 200 215 230 2.5	 185 200 210 2	 180 195 205 1.5	 160 175 185 1	 155 170 180 0.5	 145 160 170 0.3	 125 140 - 0.2
Air entrained concrete								
Slump 30 – 50mm 80 –100mm 150-180mm Recommended average total air content percent mild exposure	 180 200 215 4.5 6.0	 175 190 205 5.5 7.0	 165 180 190 3.5 5.0	 160 175 185 3.0 4.5	 145 160 170 2.5 4.5	 140 155 165 2.0 4.0	 135 150 160 1.5 3.5	 12 0 13 - -

Table-5 First estimate of density (unit weight) of fresh concrete as given by aci 211.1-91

Maximum size of aggregate[mm]	**First estimate of density (unit weight) of fresh concrete [kg/m]**	
	Non – air entrained	**Air entrained**
10	2285	2190
12.5	2315	2235
20	2355	2280
25	2375	2315
40	2420	2355
50	2445	2375
70	2465	2400
150	2505	2435

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Table 6. Replacement of sand for different days of curing

Mould Casted	Curing Days	Replacement of Sand		
		20%	30%	40%
Cube	7	2	2	2
	14	2	2	2
	28	2	2	2
Cylinder	7	1	1	1
	14	1	1	1
	28	1	1	1
Prism	7	1	1	1
	14	1	1	1
	28	1	1	1

Table 7. Mix Proportions

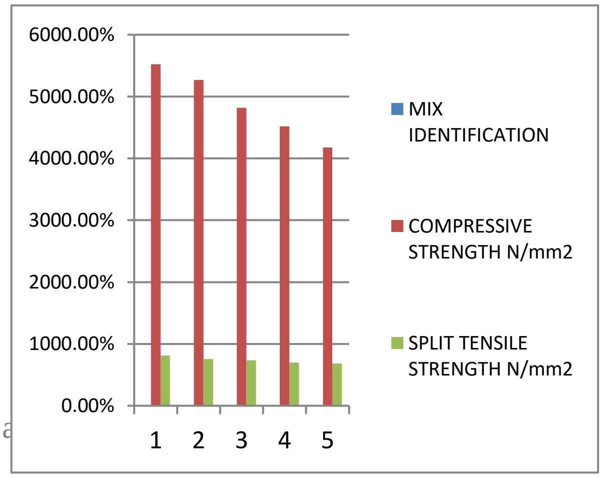
CEMENT	COARSE AGGREGATE	FINE AGGREGATE	WATER
370	808	992	185
1	1.55	2.14	0.5

Table 8. Test result for m_{20} grade concrete
(Control concrete)

Mix identification	**Compressive strength n/mm^2**	**Split tensile strength n/mm^2**
M_{20} Grade Concrete	26.09	1.96

Table 9. Epoxy Concrete comparison

Mix Identification	**Compressive strength (n/mm^2)**	**Split tensile strength (n/mm^2)**
0.1%	55.20	8.12
0.2%	52.70	7.54
0.3%	48.20	7.35
0.4%	45.20	7.00
0.5%	41.75	6.82



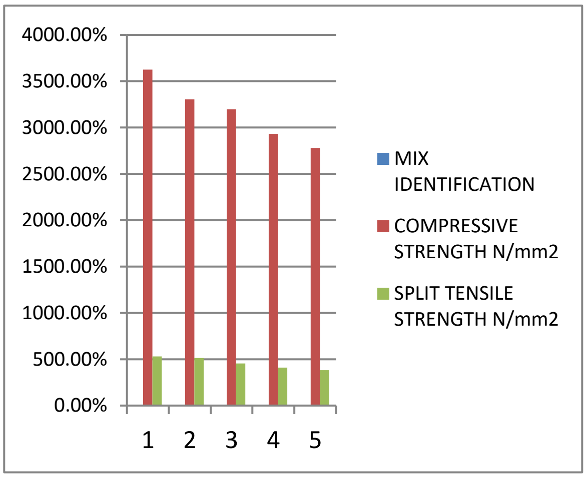


Fig -Epoxy concrete Compressive strength

Fig-Polyester resin Split tensile strength

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Table 10. Polyester Resin Concrete

Mix identification	Compressive strength (n/mm^2)	Split tensile strength (n/mm^2)
0.1%	36.25	5.32
0.2%	33.05	5.12
0.3%	31.99	4.55
0.4%	29.32	4.11
0.5%	27.82	3.83

CONCLUSION

Based on the experimental work the following conclusions are drawn: The workability of mix 5 is higher and increases by 7.92% than conventional mortar. The compressive strength test at 28 days results shows that mix 5 has 1.03% higher strength than conventional mortar. The combinations of, replacement of 10% fly ash & GGBS with 0.5% – 1.5% TiO2 addition gives compression strength not less than that of nominal mixes. Water absorption of modified mortar has greatly reduced by 2.75% than conventional mortar. Water absorption in mix 7 decreases with increase in percentage of fly ash, GGBS and titanium dioxide. Weight density of mix 7 is 1.5% higher than the density of other mixes. Thus it is concluded that a mortar mix with optimum of 1% TiO2, 10% fly ash & GGBS gives better flow, strength and density with less water absorption characteristics than conventional mortars.

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