EXPERIMENTAL INVESTIGATION ON THE EFFECT OF TiO_2 PARTICLES ON MORTARS

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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 thesis is at making and studying the different strength properties of cement mortar and modified mortar. Also, 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. In the present study, to produce modified mortar 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.*

Key Words: **mortar, plastering, fly ash, ground granulated blast furnace slag, titanium dioxide, self-cleaning.**

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.

Photocatalytic 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 photocatalytic properties. This new type of mortar is promising to be utilized as a self-cleaning finishing material for the urban buildings.

In this project the behaviour of Tio_2 is studied when it is mixed with cement, fly ash and GGBS mortars at various ratios.

2. SIGNIFICANCE

This paper aims to reduce the usage of OPC and to improve the usage of the other by-products such as GGBS and fly ash which in turn helps in reducing the CO_2 emission and imparts high strength to the mortar. Titanium dioxide being photocatalyst in nature helps in cleaning the surface from dirt and pollution. In this paper, the behaviour of modified mortar is compared with that of conventional mortar.

3. MATERIALS AND ITS PROPERTIES

In this present experimental work 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.

In this work class F fly ash is obtained from Thermal Power Plant, Mettur.

In this paper, ground granulated blast furnace slag is collected from Astrra Chemicals, Chennai.

Titanium dioxide used in this work is obtained from Mercury's Scientific Chemical Industries, Salem and it is in anatase form.

4. CASTING AND CURING OF SPECIMENS

The fresh mortar was cast into moulds immediately after mixing. Seven different mixes were developed in this study. For each mix, a cube of $100mm^3$ was cast to study the workability, strength, water absorption and density of mortar. After casting, all the specimens were kept at curing till the date of testing. The mix proportions are shown in table - 1.

Table -1: Proportions of adding cementitious materials

SNO	MIX ID	BINDER %			
		CEMENT %	FLYASH %	GGBS %	TiO_2 %
1.	Mix 1	100	-	-	-
2.	Mix 2	100	-	-	0.5
3.	Mix 3	100	-	-	1
4.	Mix 4	100	-	-	1.5
5.	Mix 5	80	10	10	0.5
6.	Mix 6	80	10	10	1
7.	Mix 7	80	10	10	1.5

5. TESTING OF SPECIMENS

The specimens were tested as per IS 516:1959 and strength were calculated for 7 and 28 days. Also, the workability and water absorption tests were conducted and results were tabulated. Fig -1 shows the image of flow table test and fig -2 shows the image of compressive strength test.

Fig -1: Flow table test of mortar

Fig -2: Compressive strength test of mortar

6. RESULTS AND DISCUSSION

6.1 WORKABILITY TEST

From the table - 2, it can be observed that the workability of modified mortar is higher than the conventional mortar. The results show that mix 5 has maximum workability. Chart - 1 represents the workability of mortar.

Table -2: Flow table test results

S.NO	MIX ID	FLOW VALUE %
1.	Mix 1	47.36
2.	Mix 2	48.38
3.	Mix 3	41.66
4.	Mix 4	36.27
5.	Mix 5	55.28
6.	Mix 6	50.81
7.	Mix 7	43.76

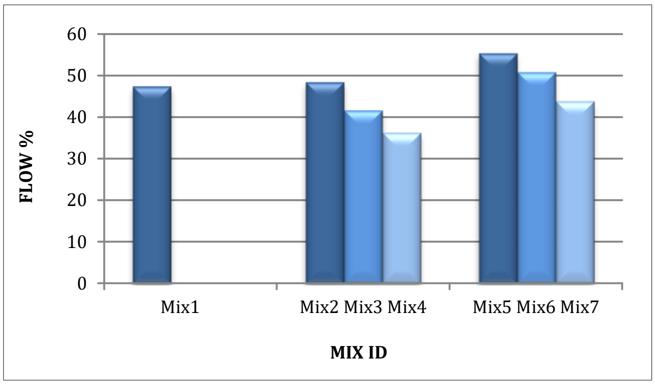

Chart -1: Workability of mortar

6.2 COMPRESSIVE STRENGTH TEST

From the table - 3, it can be observed that the compressive strength of mortar increases with the addition of fly ash, GGBS and titanium dioxide. The results show that the maximum compressive strength was obtained at mix 5. Chart - 2 shows the compressive strength at 7 & 28 days.

Table -3: Compressive strength test results

S.NO	MIX ID	COMPRESSIVE STRENGTH (N/mm^2)	
		7-days	28-days
1.	Mix 1	4.37	7.23
2.	Mix 2	4.63	6.76
3.	Mix 3	3.98	6.28
4.	Mix 4	3.71	7.66
5.	Mix 5	5.26	8.26
6.	Mix 6	4.94	7.81
7.	Mix 7	4.78	6.92

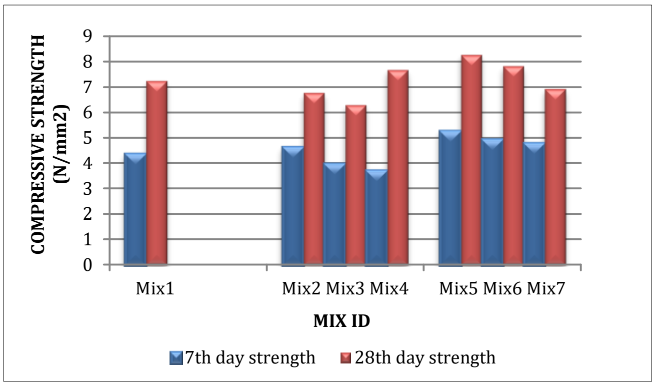

Chart -2: Compressive strength of mortar at 7 & 28 days

6.3 WATER ABSORPTION TEST

From the table 4, it can be seen that the water absorption of modified mortar decreases with the increase in the percentage of titanium dioxide. The results show that the maximum resistance to water absorption was obtained at mix 7. Chart - 3 represents the water absorption of mortar specimens.

Table -4: Water absorption test results

S.NO	MIX ID	WATER ABSORPTION %
1.	Mix 1	4.76
2.	Mix 2	3.21
3.	Mix 3	3.10
4.	Mix 4	3.32
5.	Mix 5	2.24
6.	Mix 6	2.12
7.	Mix 7	2.01

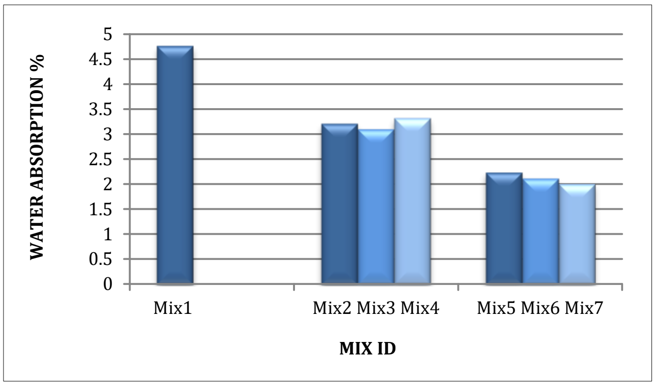

Chart -3: Water absorption of mortar

6.4 WEIGHT DENSITY TEST

From the table 5, it is observed that due to the addition of fly ash & GGBS maximum density was obtained at mix 7. Chart - 4 represents the weight density of mortar.

Table -5: Weight density test results

S.NO	MIX ID	WEIGHT DENSITY (Kg/m³)
1.	Mix 1	2013
2.	Mix 2	2035
3.	Mix 3	2051
4.	Mix 4	2127
5.	Mix 5	2077
6.	Mix 6	2143
7.	Mix 7	2220

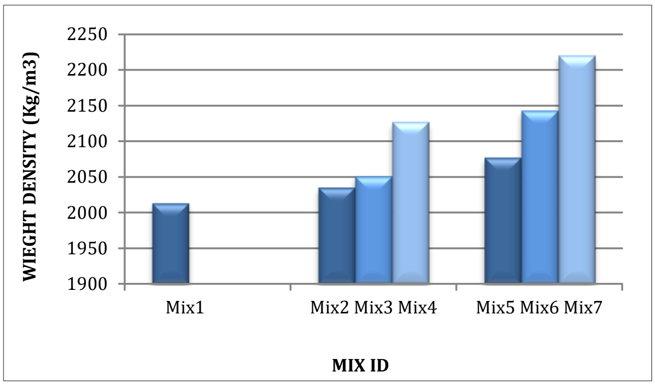

Chart -4: Weight density of mortar

7. CONCLUSIONS

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% TiO_2 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% TiO_2, 10% fly ash & GGBS gives better flow, strength and density with less water absorption characteristics than conventional mortars.

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