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FABRICATION OF NANO-HYBRID BINDER FOR CONSTRUCTIONAL APPLICATIONS

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ABSTRACT

We have fabricated multiple nanoscale hybrid binders using TiO_2, SiO_2 and MWNTs for use in fly ash bricks. Fly Ash is a by-product at thermal power stations otherwise known as residues of fine particles that rise with flue gases. Ordinary Portland cement is selected and fly ash aggregates are prepared by incorporating the nanomaterials for hybrid binder as a composite. This is done with different ratios of nanomaterials with fly ash, gypsum, cement and water. The lower cost of these inferior materials make it an attractive alternative and adequate performance can be achieved. The compressive strength, efflorescence, water absorption and drying shrinkage strength is tested. The nanobinder provides thermal resistance and broadening the strength of the fabricated hybrid composite.

KEYWORDS: Nanotechnology, Construction, Bricks, Flyash, Tio2, Sio2, Fumed Silica, Silica, mwnt

INTRODUCTION

Coal is an important fuel in India, 565 mines are operated by Coal India and its subsidiaries. Coal-based Power plants are responsible for about 65% of the total capacity for generation of electricity. It is even higher in terms of energy supply contribution as these plants meet base load requirements. It is expected that coal-based thermal power generation will play an important role in the future since coal reserves in India are expected to last for more than 100 years [1].

Due to burning of coal, thermal power plants generate large quantities of flyash. All over the world under a quarter of the total fly ash produced is utilized [2]. However, in Germany, Belgium and Netherlands more than 95% of the total fly ash produced during 1996 was reportedly used [3]. The United Kingdom utilized around 50% fly ash during 1998 [4]. Whereas, USA and China reported utilisation levels of about 32% and 40%, respectively, during 1995 [5].

Indian coals are rich in ash content. Coal having ash content of about 40% is mostly used for thermal power generation. In 2003, 358.4 Mt of hard coal was produced. But only 407.33 Mt was utilized. India is the sixth largest generator of electricity. Fly ash can be considered as the world's fifth largest raw material resource [6]. In India about 25% of fly ash is used for production of cement, building roads and bricks [7].

Fly ash was generally released into the atmosphere in past, but due to air pollution companies are required by law to store it and dispose it off properly. Now the companies store flyash in bags and they distribute it for free to any industry which request them. The industry only has to pay for the transportation charges. Thus the bricks can be made cheaper and lighter with a very marginal increase in cost.

In this paper, we attempt to use the flyash along with nanoparticles of TiO2, SiO2, Fumed Silica, Multi-walled Carbon nanotubes and Aluminum oxide to make bricks. These bricks are then tested for their compressive strength, water absorption, efflorescence and shrinkage. These binders can be used in construction and building industry. Thus, using the waste flyash in a proper way.

MATERIAL FABRICATION PROCESS

First the sand was sieved for uniformity in size, this is important so that the particle size is uniform. It was then mixed with ordinary Portland cement and fly ash in one to one ratio. Nanomaterial of varied quantity were added to this and it is put in mixing tray. Lime and gypsum taken in required quantity and thoroughly mixed. It may be sieved again for uniform mixing, if possible. Then required quantity water of is added to the mixture and properly mixed.

Table 1: Composition of Block

Material	Mass	Weight for 50x50x50 mm Cube
Flyash/Cement(1:1)	45%	50 to 60 g
Sand	40%	40 to 50 g
Lime	10%	10 to 20 g
Gypsum	5%	5 to 6 g

The quantity of water should neither slag the mixture nor should crack the ultimate product. The mixture then is kept in the mould so that it is half filled with the help of shovel/trowel. Then it is shaken to settle the mixture properly and so that it is dispersed evenly in the mould. The rest half is also filled and the surface is laid smooth with the help of shovel. This is then covered on top. Four blocks of same nanomaterial but varying levels of concentration are made (SiO2, TiO2, and MWNTs). Two blocks of different compositions are kept for 7 days and on 7^{th} day the tests are performed. Other two blocks are kept for 28 days and then on 28^{th} day tests are performed. With Al2O3 two blocks were made. One tested on 7^{th} day which had no considerable difference in compressive strength. For control, normal bricks were also made using the same procedure without adding the nanomaterials for the purpose of comparison. The results are then compared.

EXPERIMENTAL RESULTS

Silica

The literature survey revealed that the samples having SiO2 had higher compressive strength than compared to the control sample [8].

According to the experimental results the compressive strength of samples with nanofumed silica with 12.5g replacement of fly ash were 8.0 N/cm^2 and 8.3 N/cm^{2}at 7 and 28 days and with 18.75g replacement of fly ash were 6.0N/cm^2 and 6.5 N/cm^2. The compressive strength of samples with silica with 6.25g replacement of fly ash were 8.2 N/cm^2 and 8.4 N/cm^2 and with 9.45g replacement of fly ash were 7.1 N/cm^2 and 7.2 N/cm^2.

The experimental results show that the compressive strengths of sample with nano-silica were all higher than those of mortars containing silica fume at 7 and 28 days. This is higher than the reported values in [8]. Overall the compressive strength of concrete increased from 10% to 15%.

Al_2O_3

There was no considerable difference in compressive strength with the sample containing alumina in any concentration. It is proposed that the nano alumina particles fill the pores at interfaces between the different mediums and create a dense interficial transition zone having very low porosity compared to control sample.

When its quantity increases, the nanoparticles tend to agglomerate thus decreasing the density of the interficial transition zone thereby decreasing the elastic modulus of the sample.

CNT

CNTs give a very high bond strength. CNTs act as bridges across cracks, distributing the force across a larger surface area, thus the Material gains the high bond strength.

Flexibility and stiffness of cementous materials can be increased by adding a low concentration of MWCNTs-Multi Walled Carbon Nano Tubes. These MWNTs tend to aggregate easily thus they were sonicated in water for an hour before adding it to the sample, thus increasing it homogeneity. It was reported by [9] that very little quantity of CNTs by weight % (1%), can lead to an increase in flexural and compressive strength

As per the experimental results obtained, addition of 1.25 g of MWNTs to the sample with replacement of fly-ash, the compressive strength were 8.9 N/cm^2 and 9.0 N/cm^2 at 7th and 28th day which is higher than the reported values.

TiO_2

A few studies have shown that nano-TiO2 can accelerate the early-age hydration of portland cement [10], improve compressive and flexural strengths [11].

As per the experimental results obtained, addition of 12.5 g of MWNTs to the sample with replacement of fly-ash, the compressive strength were 8.5 N/cm^2 and 8.7 N/cm^2 at 7th and 28th day which is higher than the reported values. Also when the concentration of TiO_2 was increased to 25 g the compressive strength of the sample remained constant at 8.0 N/cm^2

Table 2: List of Nanomaterials used and the Test Performed on the Samples

Nano-Materials Used with Approximate Weights		Efflorescence Test		Water Absorption Test (%)		Drying Shrinkage Test (%)		Compressive Strength Test (N/cm^2)	
		Day 7	Day 28	Day 7	Day 28	Day 7	Day 28	Day 7	Day 28
Nil		Yes	Yes	14	12	0.04	0.035	7.5	7.6
Al_2O_3	**6.25 g**	Yes	No	12	10	0.03	0.03	7.4	7.4
SiO_2 Fumd	**12.5 g**	Yes	No	11	8	0.045	0.035	8.0	8.3
	18.75kg							6.0	6.5
SiO_2	**6.25 g**	Yes	No	10	5	0.05	0.04	8.2	8.4
	9.45 g							7.1	7.2
TiO_2	**12.5 g**	No	No	10	7	0.02	0.02	8.5	8.7
	25 g					0.03	0.02	8.0	8.0
MWNTs	**1.25 g**	No	No	11.5	10	0.001	0.001	8.9	9.0

CONCLUSIONS

The work done in this paper shows that the waste fly-ash from power plants can be combined with nanomaterials to form bricks which have higher compressive strength, lower efflorescence, good water absorption and drying shrinkage values.

These results suggest that the addition of nanomaterials to the fly ash bricks is an effective method to increase the compressive strength of the brick. These bricks can be used in various constructional purpose. From the comparative results it can be seen that the sample has better characteristics. The study on the compressive strength revealed that the samples consisting of TiO_2, Alumina, Silica, MWCTs without any other chemical contamination. So by increasing the concentrationof the nanomaterials, the compressive strength decreases, thus optimum level of concentration is required. The results presented in this paper are better than those found in literature survey. The blocks made with these nanomaterials have UV resistance with a wide range of applications because of the nanoscale dimensions. This will reduce the use of paints on the wall. With the combination of various nanomaterials different properties can be obtained which may be better than that given in this paper. With the addition of nanomaterials the cost of the bricks\blocks will go high but later when the production of nanomaterials can be done in bulk, the cost will eventually reduce.

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