International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

Effect of Fly Ash and Nano Titanium Dioxide on Compressive Strength of Concrete

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Abstract - *The partial replacement of cement by mineral admixtures in concrete has been increasing interest in construction industry. The use of Fly ash in concrete reduces the compressive strength of concrete at early ages. To compensate such loss various nanomaterial are used which not only use to compensate the strength at early ages however, also improves the durability properties of the concrete. Nano materials are like Titanium dioxide that have photocatalytic properties which protects the environment from numerous harmful gases like NO_2, SO_2 and also controls and enhance the various other properties of materials, including hydration, performance and degradation process. This research paper concern with the use of Nano-titanium dioxide and fly ash in concrete to improve the compressive strength of concrete. This paper represents the effect on compressive strength of concrete by partially replacing a cement with fly ash (0%, 10%, 20%, 30%) and nano titanium dioxide (0%. 1%, 1.5%, 2%).*

Key Words: **Nanotechnology, concrete, compressive strength, Fly ash, Nano titanium dioxide.**

1. INTRODUCTION

Cement is most useful material in construction. During its production, it releases huge amount of carbon dioxide and also results in increase of construction cost. To overcome this, new efforts were made to partly replace a cement with mineral admixtures which helps to lower the total mix cost and also results in reduction of environmental damages. The most accepted mineral aggregates used in concrete mixture are fly ash and silica fumes. Fly ash enhance the durability properties of concrete, environmental friendly and is also economical than cement. However, use of fly ash in concrete in huge quantity results in loss of compressive strength of concrete at early ages due to slow rate reaction. For this reasons, the usefulness of nano titanium dioxide in concrete results in compensation of loss of strength at early ages in concrete.

Addition of nano materials during mixing of concrete leads to upgradation and control a portion of the properties of the material that includes hydration, performance, and deprivation process. Due to very small size (15nm) of Nano TiO_2 it reduces the setting time and also improves the strength of concrete at early ages. The objective of this research work is to do the comparative study between the conventional concrete and concrete containing fly ash and nano TiO_2 to find out the compressive strength of concrete.

1.1 LITERATURE REVIEW

Bertrand Ruot [4] study the photocatylytic behavior of cement paste and mortar by adding different proportion of titanium dioxide. Results obtained from experimental work were compared to get difference between cement paste and mortar. It has been seen that quantity of TiO_2 greater than 1% and up to 5% exhibits good photocatylytic properties in cement paste rather than mortar.

Nazari [5] studied the effect of GGBS and TiO_2 observed on strength and water absorption of self-compacting concrete. The results shows that after replacing a cement up to 45% of GGBS and up to 4% of TiO_2 shows considerable increase in compressive strength, split tensile strength, and flexural strength of concrete. The results shows nanoparticle up to proportion 4% results in increment in compressive strength of self-compacting concrete.

Wankhede P.R. and Fulari V.A. [6] Behavior of fly ash on compressive strength of concrete is studied. Results shows that excessive use of fly ash in concrete reduces the compressive strength of concrete. Maximum compressive strength is obtained at 10% and 20% fly ash and at 30% compressive strength get reduces.

Reshma [7] They investigated primarily the performance of concrete in construction site with combination of partial replacement of Nano silica and FA to determine the compressive strength, split tensile strength, flexural strength and young modulus of elasticity. Results were also compared with conventional concrete. Subsequently FA and nano silica was utilized as replacement with controlled concrete of M20 grade. In the present study, the cement was replaced with 20% and 30% of FA and Nano silica 1.5%, 3% and 4.5% by weight and the test was done on M20 grade. Hence from the tests directed it had been concluded that the concrete prepared with 20% FA and 3% nano silica combination have improved properties compared with controlled concrete.

2. MATERIAL AND MIXTURES

2.1 MATERIALS

Cement: OPC 43 grade cement was used for preparation of test samples. Various properties of cement are discussed in Table 1 and Table 2

Table 1 Ordinary Portland cement: physical properties

S. No.	Properties	Values
1.	Standard consistency (%)	28.5
2.	Fineness (%)	2.1
3.	Initial setting time (minutes)	62
4.	Final setting time (minutes)	615
5.	Compressive Strength (N/mm^2)	3 days – 25.2 7 days – 34.3 28 days –45.6

Table 2 Ordinary Portland cement: chemical composition

S. No.	Chemical constituent	Content (%)
1.	Cao	45.8
2.	SiO_2	32.4
3.	Al_2O_3	6.80
4.	Fe_2O_3	4.05
5.	MgO	1.20
6.	SO_2	1.95
7.	Loss on ignition	6.10

Fine aggregates: fine aggregates were obtained by crushing natural stone in crusher. The fineness modulus of sand was obtained as 2.85 and its water absorption and specific gravity were 0.06% and 2.64 respectively. The sand used in concrete was of good quality as specified in IS: 383-1970.

Coarse aggregates: coarse aggregates were obtained by crushing natural stone of desired grading for concrete work. The fineness modulus of coarse aggregate was 2.65 and water absorption was 0.016% and crushing and impact values were 19.5% and 165 respectively. The size of coarse aggregate has graded to nominal 20mm as per IS: 383-1970.

Fly ash: was obtained from thermal power plant. This fly ash is classified as class F fly ash which has specific gravity of 2.2. Fly ash sample is shown in figure 1.

Figure 1 Fly ash

Nano titanium dioxide: the average size of nano TiO_2 used in this work is 15nm. Sample of nano TiO_2 is shown in figure 2 and Table 3 tabulates the properties of nano-Tio_2.

Figure 2 Titanium dioxide

Table 3 Properties of Nano –Tio_2

S. No.	Properties	Values
1.	Particle size	15nm
2.	pH	6.6
3.	Appearance	white powder
4.	purity	>99.9%
5.	stability	complete stable
6.	Reactivity	Non-reactive

2.2 Proportion of mixture for compressive strength test

For compressive strength, various material combination with different proportion were taken into account. Specimens were prepared in cubes of size 150mm*150mm*150mm with design mix 1:1.5:2 (cement: sand: aggregate) and water cement ratio to be kept as 0.5 as per IS: 456-2000.

For preparing a concrete samples. Cement is partially replaced with fly ash in proportion with 0%, 10%, 20%, 30% and nano TiO_2 in proportion with 0%, 1%, 1.5%,

2% and then samples were kept in water for period of 28 days for curing. After 28 days, samples were taken out from water and tested for compressive strength under compression testing machine. The test outcomes of compressive strength of ordinary samples and prospective of using fly ash and nano titanium dioxide by partial replacement of cement in concrete has been studied.

3. RESULTS AND DISCUSSION

Compressive strength of concrete when cement is replaced with nano TiO_2 in proportion with 0%, 1%, 1.5%, 2% at 28 days are shown in Figure 2.

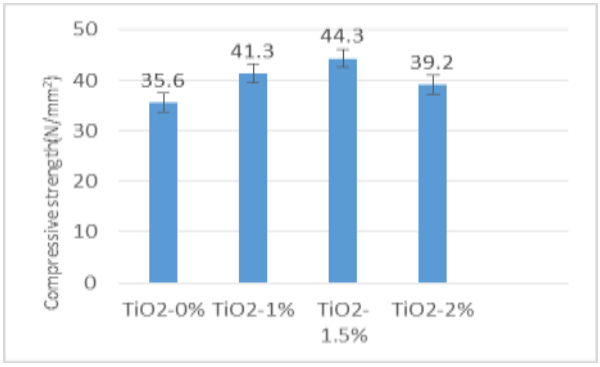

Fig.2 Compressive strength at 28 days replacement with nano TiO_2

From the experimental study, when cement is replaced with 1.5% of nano TiO_2 it shows maximum strength (44.3 N/mm^2) after 28 days of curing period. There is 24.4 percentage increase in compressive strength at 1.5% cement replacement.

Compressive strength of concrete when cement is replaced with 10% of fly ash with varying proportion of nano TiO_2 (0%, 1%, 1.5%, 2%) at 28 days are shown in Figure 3.

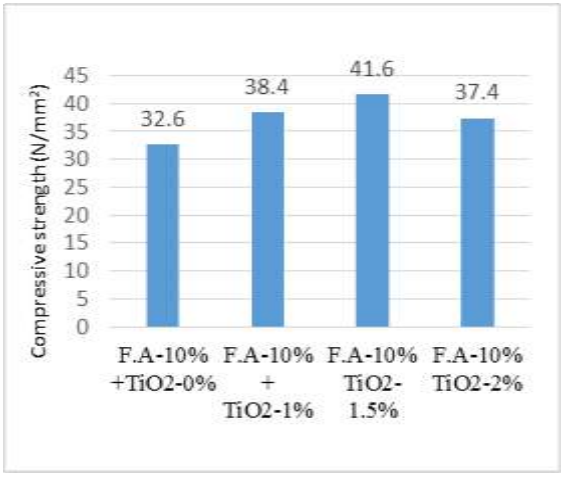

Fig.3 Compressive strength at 28 days replacement with 10% fly ash and nano TiO_2

Compressive strength of concrete at 10% replacement of cement with fly ash increases and attained maximum strength when nano titanium dioxide replaced with cement in proportion of 1.5% .The percentage increase in compressive strength is 27.6% when compared to cement replaced with only fly ash at 10%.

Compressive strength of concrete cubes when cement is replaced with 20% fly ash and with varying proportion of nano TiO_2 (0%, 1%, 1.5%, 2%) at 28 days are shown in Figure 4.

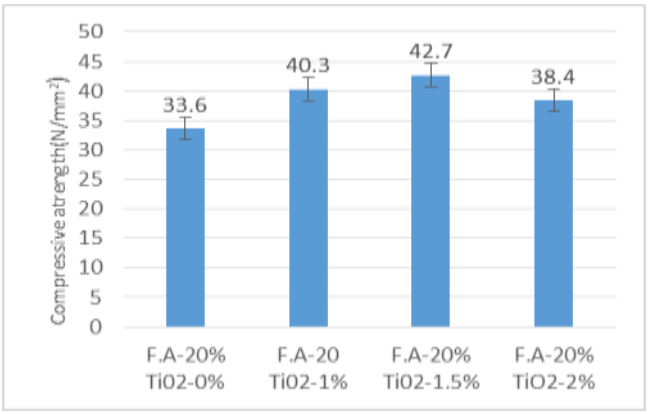

Fig.4 Compressive strength at 28 days replacement with 20% fly ash and nano TiO_2

Compressive strength of concrete at 20% replacement of cement with fly ash increases and attained maximum strength when cement is replaced with 1.5% of nano titanium dioxide. The percentage increase in compressive strength is 27.08% as compared to concrete when cement is replaced with only 20% of fly ash.

Compressive strength of concrete cubes when cement is replaced with 30% fly ash and with varying proportion of nano TiO_2 (0%, 1%, 1.5%, 2%) at 28 days are shown in Figure 5.

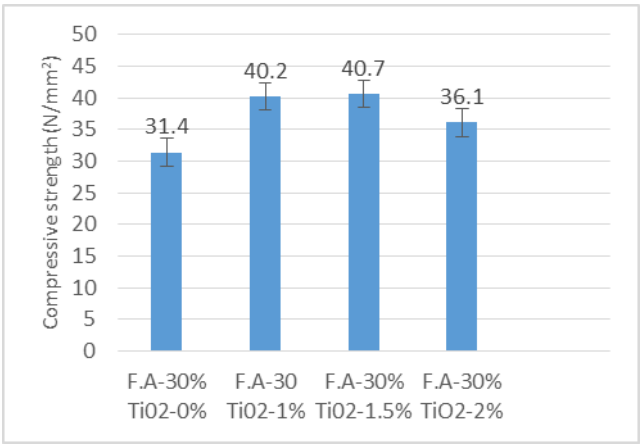

Fig.5 Compressive strength at 28 days replacement with 30% fly ash and nano TiO_2

Similarly, compressive strength of concrete at 30% replacement with fly ash with cement increases and attained maximum strength when cement is replaced with 1.5% of nano titanium dioxide. The percentage increase in compressive strength is 29.6% when compared to concrete in which cement is replaced with only 30% fly ash.

4. CONCLUSIONS

Based on experimental investigation, following conclusions were drawn:

1. Compressive strength of concrete at 28 days decreases slightly when cement is replaced with fly ash without using nano TiO_2 as compared to conventional concrete with 0% fly ash replacement.
2. However, small increment in compressive strength at 28 days without using nano TiO2is obtained using 20% fly ash of cement content.
3. Maximum Compressive strength is obtained in all cases when cement is replaced with 1.5% nano TiO_2 either fly ash is added or not.

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BIOGRAPHIES

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