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A Study on Effect of Compressive Strength of Ternary Blended Concrete using Metakoline and Nano Silica

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ABSTRACT

Cement is one of the main component of the building materials, thus its demand is increasing day to day proportionately the emission of carbondioxde is also increasing. Inorder to overcome this, many alternatives are being used these days, one among them is pozzolonic cement which is made of mineral admixtures. Inorder to have a clear knowledge about the pozzolonic action a detailed study is made on the compressive strength of concrete when added with different admixtures. The admixtures used are Metakaolin and Nano silica.(NS) The control concrete is made of 15% of Metakaolin(MK) and the mixes were made by varying the percentage of Nano silica. The Nano silica is used in 0.5% and 1%. The strength are tested for 3rd ,7th and 28th day. The mixes are also tested for its water absorption at the same intervals of 3rd,7th and 28th day.

1. INTRODUCTION

Concrete is a key component in the construction industry. Cement is an essential component of concrete. Portland cement demand is rising on a daily basis. Whereas the negative impact caused by carbon dioxide emissions from cement manufacture. It is related to the usage of fossil fuels, especially those used to create power during the cement making process. As a result, in order to minimize cement use, the use of pozzolana materials as a partial alternative for cement preparation is becoming more common. The use of pozzolanas in the production of concrete is regarded effective since it allows for a reduction in cement consumption while boosting the strength and water absorption capabilities of the concrete.

Cement is one of the key ingredients of concrete, and its principal hydration product, C-S-H, has a Nano structure. The quality of C-S-H gel determines the strength and water absorption qualities of concrete. One of the most significant components in improving the microstructure of concrete is silica. As a result, substantial study has been dedicated in recent years toward the performance of pozzolana concrete.

When employed as a partially replaced ingredient for cement in concrete, metakaolin combines with $Ca(OH)_2$, one of the products of the hydration process, resulting in additive C-S-H gel and an enhancement in different strength qualities of concrete. It also lowers the permeability of hardened concrete. As a result, partially substituting Metakaolin for Portland cement not only decreases carbon dioxide emissions into the environment during cement manufacturing but also enhances the service life of structures [1-5].

The mechanical and water absorption characteristics of concrete are primarily determined by the hardened cement paste structure and the continuously growing paste-aggregate interface. Because of the increased silicon dioxide powder concentration, nano silica, a novel pozzolanic material created artificially in the form of a water emulsion of Ultra Fine Amorphous Colloidal Silica (UFACS), has better characteristics than silica fume. The use of Nano Silica can increase the impermeability and strength of concrete. The current study attempted to evaluate the combined application of Metakaolin and Nano Silica on the performance of concrete [6-12].

2. OBJECTIVE

The main aim of the study is to obtain a comparative study of concrete influenced by various mineral admixture. Various properties of M30 Grade concrete is studied with different proportion of Nano silica. The control concrete is made up of 15% of metakaolin which is replaced by cement. The other specimens are prepared by replacing cement by 0.5% and 1% of Nano Silica and its compressive and water absorption test are conducted. Then the results are compared with the controlled concrete. The test is conducted on 3rd, 7th and 28th day respectively.

3. EXPERINMENTAL INVESTIGATION

3.1 Materials

In this study, Ordinary Portland cement of grade 43 is employed in accordance with IS standards. The cement has a specific gravity of 3.15. River sand (Zone I) from a nearby river that met IS specifications was utilized. It has a fineness modulus of 2.94 and a specific gravity of 2.6 according to the pycnometer test was used. Machine Crushed Aggregate in accordance with IS 383-1970 is used as coarse aggregates. The nominal sizes of the coarse aggregate used in this study were 20mm and 12mm. The specific gravity of coarse aggregate

was found to be 2.88. Metakaolin is a refined version of kaolin that has been calcined. The kaolin clay is burnt under precisely regulated circumstances to produce amorphous alumina silicate, which is reactive in concrete. Metakaolin particle size is finer than that of cement, making it an effective pore filler substance. Table 1 displays the metakaolin properties. Nano silica is a novel pozzolanic substance in the form of a colloidal water emulsion. It looks to be significantly superior to silica fume since it contains more powdered silica and has smaller spherical particles (1-50mm). In the current experiment, cement is substituted with 1%, 2%, and 3% of Nano Silica by weight. Table 2 shows the characteristics of Nano Silica. For casting and curing concrete test specimens, portable water is employed. The water utilized is free of turbidity and impurities, which can reduce the strength of concrete.

Table 1: Properties and characteristic of Metakaolin

S.No.	Characteristics	Actual Analysis Result
1	Silicon dioxide ($Sio_{2)}$	52-55%
2	Alumina(Al_2O_3)	40-43%
3	Ferric oxide	<1
4	Bulkdensity	350gm/lit
5	Moisture	0.23%
6	Appearance	White Powder
7	PH	6.59
8	Residue on 325 Mesh	.1%
9	50% particles below	1.74 micron
10	Specific gravity	2.262

Table 2: Propoties and characteristic of Nano silica

S.No.	Characteristics	Actual Analysis Result
1	Nano solids	30-32%
2	PH	9.0-10
3	Specific Gravity	1.2-1.22
4	Texture	White Milky Liquid
5	Dispersion	Water

3.2 Concrete Mix Proportion

The impact of metakaolin, which partially substitutes cement, and the combination application of Metakaolin and Nano Silica, which partially replaces cement, on M30 grade concrete is explored in this experimental study. The design of a concrete mix of M30 grade was done in accordance with the Indian Standard code of Practice. The table below shows the various elements for one cubic metre of M30 grade concrete. Because colloidal Nano Silica is available, the amount of water necessary to make concrete is altered to account for the water available in colloidal Nano Silica. Table 3 shows the constituent quantities per cum of m30 grade concrete.

Table 3: Quantities of Ingredient per cum of M30 Grade Concrete

Concrete	Cement (kg)	Metakaolin (kg)	Colloidal Nano Silica (kg)	Water(lit)		w/c	Fine Aggregate (kg)	Coarse Aggregate (kg)
				In Nano silica	Added water			
Control	328	58	0	0	135	0.4	728	1313
0.5%NS	326.1	58	1.9	1.3	133.7	0.4	728	1313
1%NS	324.14	58	3.86	2.66	132.34	0.4	728	1313

4. METHODOLOGY

Concrete test specimens are cubes sized 100mmx100mmx100mm were cast in order to perform compressive and water absorption tests. The compressive strength of concrete is determined by testing concrete cube specimens after 3,7,28 days of curing. At the same curing intervals, the cubes are also evaluated for water absorption capability.

5. EXPERIMENTAL RESULTS

5.1 Compressive strength

The compressive strength of M30 grade concrete was evaluated on concrete mixes with varying amounts of Nano silica and metakaolin during different curing times. Three specimens' results are used to get the average cube compressive strength. It may be concluded that the compressive strength of metakaolin-based concrete with Nano silica is greater than that of control concrete.

The variation of 3, 7, 28 days compressive strength of M30 grade concrete prepared with metakaolin and different proportion of Nano silica are shown in the table and graph below. The compressive strength of concrete increases with increases in percentage of Nano silica. This is due to availability of sufficient quantity of C-S-H gel.The test results are given in figure 1.

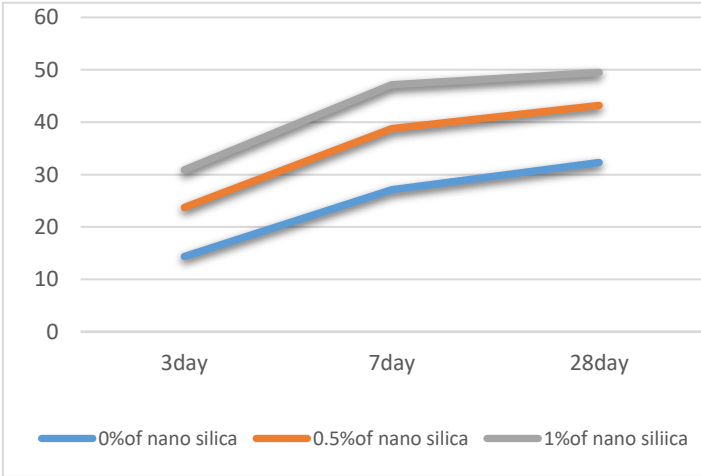

Figure 1: Variation of Compressive Strength

The 3, 7, 28 cube compressive strength of M30 grade control concrete is 14.36 N/mm^2, 27.1 N/mm^2, 33N/mm^2 respectively. Whereas the mean compressive strength is reached almost in the seventh day. Thus the concrete serves as a High Strength Concrete.

5.2 Water absoprtion

The effect of change of variation of water absorption values of cubes at the intervals of 3,7,28 days are tested. It is noted that the absorption rate decreases with increase of Nano silica. The addition of 0.5% of Nano Silica reduces the absorption rate to nearly 7%.The increase in the strength was found to be 30% by the addition of 0.5% of NS and about 50% by the use of 1% of NS. By addition of 1% of Nano silica again the rate reduces to nearly half the percentage.

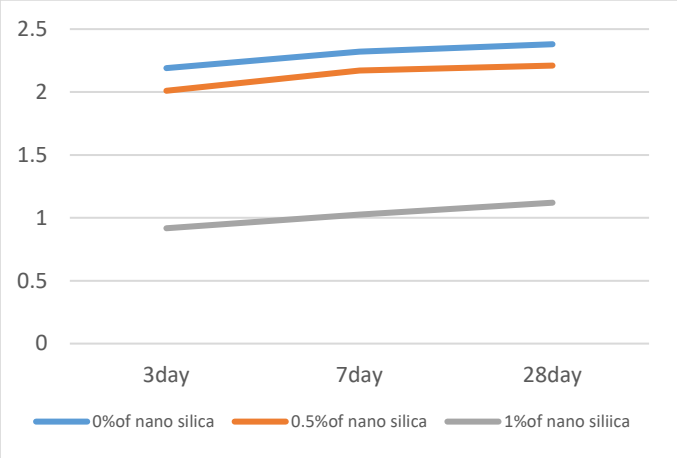

Figure 2: Variation of Water absorption

6. CONCLUSION

Controlled concrete of M30 grade is cast, and tests on standard concrete specimens are performed to determine the concrete's water absorption capacity and compressive strength. The results are then compared with concrete containing metakaolin and different proportions of Nano silica, such as 0%, 0.50%, and 1% as cement replacement. The tests were conducted on concrete specimens containing metakaolin at 15% as control concrete and its compressive strength and water absorption capacity are calculated. Also the test were conducted on the specimens containing 15% of Metakaolin and 0.5% and 1% of Nano silica. Similarly those compressive strength and water absorption capacity are compared with normal concrete, it is found that the compressive strength is found to increase in such a way that the specimen reaches its mean strength at the 7th day. The increase in the strength was found to be 30% by the addition of 0.5% of NS and about 50% by the use of 1% of NS, thus serving as the high strength concrete. Hence it can be concluded that, the various strength properties concrete can be improved by the addition of 15% of Metakaolin and 0.5% and 1% of Nano silica.

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