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Characteristic Strength And Durability Of Cement Addition With Admixture Materials

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ABSTRACT :- There has been widespread use of supplementary cementitious materials as mineral admixture in concrete to enhance and modify its strength and durability characteristics. In the present work, an attempt has been made to assess the strength and durability properties of concrete made with rice husk ash, fly ash and nano-silica. The experimental investigation includes the determination of optimum dosage of superplasticizer, rice husk ash and nano-silica, compression strength test, non-destructive tests and test for obtaining chloride profile in concrete. On the basis of trial tests, concrete specimens are prepared from different mixes at w/b ratios 0.4, 0.45 and 0.50. Compressive strength test has been conducted at the ages of 28 days, 90 days and 120 days of curing for all the concrete mixes where as the non-destructive tests have been conducted at the age of 120 days. All the concrete mixes have been subjected to chloride solutions (external chloride exposure) with alternate wetting and drying cycles. Further the relationships between compressive strength and the non-destructive parameters namely rebound number and ultrasonic pulse velocity for different concrete mixes have also been obtained. Finally on the basis of observations from the results, relevant conclusions have been drawn. **Keywords:** Concrete; Rice husk ash; Nano silica; Fly ash; Compressive strength; Rebound hammer; USPV; Chloride ingress.

I INTRODUCTION

For a long time concrete has been considered to be very durable material requiring a little maintenance. The assumption is largely true, except when it is subjected to highly aggressive environment. Most of the concrete structures which are built in highly polluted industrial areas, aggressive marine environments, harmful sub-soil water in coastal areas and many other hostile conditions have performed better where other materials of construction are found to be non-durable.

Concrete

Concrete is a construction material composed of cement, coarse aggregate, fine aggregate and water. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make buildings, pavements, pipe, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures and footings for gates, fences etc.

Admixture

An admixture for concrete is defined as a material other than water, cement, aggregates and fiber that is used as an ingredient of concrete and is added to the batch immediately before or during mixing. Admixtures are used to modify properties of fresh & hardened concrete and to ensure the quality of concrete during mixing, transporting, placing & curing. There are different types of admixtures available in the market to perform various functions such as increasing the plasticity, accelerating the setting, improving the strength development, and reducing the heat of hydration .

Admixtures are generally divided into two groups:

- Chemical admixtures
- Mineral admixtures

Chemical admixture

Chemical admixtures are materials in the form of powder or liquids that are added to concrete to give it certain characteristics not obtainable with ordinary concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing. The most common types of admixtures are

- Accelerating admixtures
- Retarding admixtures
- Water reducing admixtures
- Air entraining admixtures
- Corrosion inhibitors

Super plasticizers

Super plasticizers (high-range water-reducing admixtures) are a class of plasticizers which have fewer deleterious effects when used to significantly increase the workability. Alternatively, plasticizers can be used to reduce the water content of a concrete while maintaining workability. This improves its strength and durability characteristics. The two most commonly used chemicals as superplasticizers are:

- Sulfonated melamine-formaldehyde condensates (SMF)
- Sulfonated naphthalene-formaldehyde condensates (SNF)

Mineral admixture

There are inorganic materials those have pozzolanic properties. These are very fine-grained materials that are added to improve the properties of concrete. The mineral admixtures may be natural or industrial by-products. These are added to concrete in relatively large amounts, generally in the range 10 to 50 percent by mass of the total cementitious material. Natural mineral admixtures are pumice, tuff, shale and industrial by-products are fly ash, rice husk ash, silica fume, ground granulated blast-furnace slag, nano silica etc.

Rice husk ash

A number of research works have been directed towards the utilization of waste materials in concrete. In the construction industry, the development and use of blended cements is growing rapidly. Pozzolans from industrial and agricultural by-products such as fly ash, rice husk ash and nano-silica are receiving more attention now since their uses generally improve the properties of the cement concrete, reduce the cost and the negate the detrimental effects of environmental pollutions. Though many researches have reported studies on use of fly ash in concrete, however very little work has been reported in literature regarding the use of rice husk ash and nano-silica in concrete.

Rice Husk is the outer covering of rice grains which is obtained as an agricultural residue during the milling of paddy. During milling, about 78% of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. Rice husk is burnt approximately 48 hours under controlled combustion process. The burning temperature is within the range 600 to 8500C. This husk contains about 75 % organic volatile matter and the remaining 25 % of the weight of this husk is converted into ash during the firing process. This ash is known as rice husk ash. The rice husk ash thus obtained is ground in a ball mill for 30 minutes. Its appearance colour is grey. Rice husk ash contains around 85% - 90% of amorphous silica. The particle size of rice husk ash is 25µm. It is a very fine material having surface area of the order of 50-60 m2/gm.

The most important property of rice husk ash that determines pozzolanic activity is the amorphous phase content. Rice husk ash is a highly reactive pozzolanic material, which is suitable for use in lime-pozzolan mixes and for Portland cement replacement. Its reactivity related to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific surface.

II LITERATURE REVIEW

Byung et al. investigated development of powder concrete with nano silica particles. They evaluated compressive strengths of cement mortar with various water-cementitious ratios. Five different water-cementitious ratios used were 0.23, 0.25, 0.32, 0.35, 0.48 and four contents of nano silica particles were 3%, 6%, 9%, and 12% by weight of cement. The compressive strength of cement mortar with the addition of silica fume were also evaluated at w/c ratio of 0.48 to compare the compressive strength of mortar containing nano silica particles with silica fume of different levels; 5%, 10% and 15% by weight of cement. The specific conclusions which can be drawn from this experiment are the compressive strength at age of 7 and 28 days of nano-mortar were higher than that of OPC and silica fume. The microstructure of the paste containing nano silica revealed that the formation of hydrate products was denser and Ca(OH)2 crystals were reduced.

Qing et al. studied the influence of nano silica addition on properties of hardened cement paste as compared with silica fume. They have experimentally observed that compressive strengths of hardened cement paste and bond strengths of paste–aggregate interface incorporating nano silica were higher than that incorporating silica fume, especially at early ages. They compared the results of various mix proportions i.e. by replacing cement content with 1%, 2%, 3%, 5% of nano-silica and 2%, 3%, 5% of silica fume and found that nano silica makes cement paste thicker and accelerates the cement hydration process. Nano silica gives high compressive strengths at early age than silica fume. Bond strengths of paste– aggregate interface incorporating nano-silica are higher than those of control sample and than those incorporating silica fume.

Li studied on properties of high-volume fly ash concrete incorporating nano silica. The results were compared for high-volume fly ash high-strength concrete (HFAC) versus high- volume fly ash high-strength concrete incorporating nano silica (SHFAC). There was significant increase in strength in case SHFAC as compared to the HFAC after 3 days curing. In addition there were improvements in the pore size distribution of SHFAC. Fly ash has low initial activity, but the pozzolanic activity significantly increased after incorporating a little nano-silica. Addition of nano silica to high-volume high-strength concrete leads to an increase of both short-term strength and long-term strength. SHFAC has an increase in 3-day strength of 81% with respect to HFAC, and the 2-year strength was 115.9 MPa which was higher than HFAC (108 MPa).

Ji has carried out preliminary study on the water permeability and microstructure of concrete incorporating nano-silica. A water permeability test and an environmental scanning electron micro-scope (ESEM) test were performed to investigate the durability of concrete with nano silica and the mechanism about the effect of nano silica was studied. The water permeability test showed that, for concretes of similar 28-day strength, the incorporation of nano-silica can improve the resistance to water penetration of concrete. An ESEM test reveals that the microstructure of concrete with nano silica is more uniform and compact than that of normal concrete. He has compared the results of normal concrete by replacing 20% of the weight by fly ash and 4% by nano silica. The tapered cylinders with a height of 150 mm and a diameter of 175 mm at one end and 185 mm at the other end were used to determine the water permeability of normal concrete and nano silica concrete. In the above experiment he concluded that nano silica concrete is stickier than normal concrete due to the larger specific surface area. The water permeability test shows that the nano silica concrete has better water permeability resistant behavior than the normal concrete.

III METHODOLOGY

Objective

From the literature review, it is found that few studies have been carried to see the effect of nano-silica and rice husk ash individually on strength and durability aspect of concrete. Further, it is observed that studies on performance of concrete made with both nano silica and rice husk ash are scanty. Keeping this in view, it was decided to carry out an experimental investigation incorporating varying dosages of nano silica, rice husk ash and also fly ash in the preparation of concrete and performing compressive strength, durability and non-destructive tests. Thus the objective of the present investigation has been formulated as follows.

- To determine the optimum dosage of super plasticizer, rice husk ash and nano silica for making concrete of required workability and strength.
- To assess the performance of concrete made with rice husk ash, nano silica and fly ash by performing compressive strength test at different ages of curing.
- To evaluate the effect of w/b ratio and curing age on compressive strength of all the concrete mixes.
- To determine the Rebound number by conducting Rebound hammer test for all the concrete mixes and to obtain the relationships between compressive strength and non- destructive parameter namely rebound number.
- To evaluate the resistance of concrete against chloride ingress by exposing the specimen to chloride environment

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with alternative wetting and drying cycles.

Sieve analysis of 20mm (MSA) coarse aggregate

Details of cubes for all concrete mixes

Sl.No.	Type of Binders	No. of Cubes
1	Control Mix	36
2	1% NS	36
3	1.5% NS	36
4	10% RHA	36
5	10% RHA - 1% NS	36
6	10% RHA - 1.5% NS	36
7	10% RHA - 20% FA	36
8	10% RHA - 20% FA - 1% NS	36
9	10% RHA - 20% FA - 1.5% NS	36
	Total	**324**

IVRESULTS AND DISCUSSION

Compressive strength values of control mix

Type of cement	Age (days)	Compressive Strength (N/mm^2)
OPC	28	27.9
	90	33.4
	120	38.3
	28	32.5
	90	35.3
	120	42.5
	28	39.0
	90	40.7
	120	44.4

Compressive strength values of 1% NS mix

Percentage replacement of Nano Silica (by mass of total binder)	Age (days)	Compressive Strength (N/mm^2)
1%	28	32.9
	90	34.5
	120	38.8
	28	33.6
	90	40.9
	120	44.4
	28	38.7
	90	48.4
	120	49.8

Compressive strength values of 1.5% NS mix

Percentage replacement of Nano Silica (by mass of total binder)	Age (days)	Compressive Strength (N/mm^2)
1.5%	28	34.8
	90	36.4
	120	37.6
	28	36.6
	90	39.6
	120	41.5

	28	44.9
	90	46.5
	120	49.9

V CONCLUSIONS AND FUTURE WORK

1.There was reduction in compressive strength with increase in dosage of super plasticizer as observed from trial tests.

2.There is no systematic variation in slump value of nano silica concrete composites, as the super plasticizer dosage increases beyond 1% by mass of total binder content.

3.On the basis of results related to compressive strength and workability obtained from trial tests, the optimum dosage of rice husk ash and nano silica have been fixed at 10% and 1 to 1.5% by mass of total binder respectively.

4.The 10% RHA mix exhibited higher compressive strength at the age of 28 days where as both 10% RHA mix and 10% RHA – 1% NS mix mostly showed higher compressive strength as compared to other mixes at the age of 90 days and 120 days.

5.The rate of pozzolanic reaction in concrete composites made with supplementary cementitious materials decreased after 90 days.

6.The 10% RHA – 1% NS mix resulted in higher values of rebound number as compared to other mixes.

7.It is concluded that there exists linear relationship between compressive strength and rebound number test.

8.The chloride ingress did not take place into all concrete mixes during the stipulated exposure period.

9.By analysing the results, it is concluded that, incorporating nano silica improved the performance of concrete. Overall, the 10% RHA – 1% NS mix performed better followed by 10% RHA mix.

Suggestion for future work

The following suggestions have been made for future investigation.

1.Chloride diffusion studies can be carried out on concrete made with rice husk ash and nano silica.

2.The performance of rice husk ash and nano silica concrete composites can be evaluated under sulphate environment.

3.The present study can be extended to concrete composites made up of other supplementary cementitious concrete materials.

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