Experimental Study on Strength and Durability Characteristics for Fly ash-Stearic Acid Mixture in Developing Water Proofing Concrete by Taguchi approach

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Abstract— With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is the most widely consumed material in the world, after water. Placing the fresh concrete requires skilled operatives using slow, heavy, noisy, expensive, energy-consuming and often dangerous mechanical vibration to ensure adequate compaction to obtain the full strength and durability of the hardened concrete.

Keywords: Water Proofing Concrete, Taguchi Approach

I. INTRODUCTION

Concrete is the most widely consumed material in the world, after water. With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is a composite construction material. It is mainly composed of cement (usually Portland cement), aggregate (coarse aggregate made of gravel, crushed stone and fine aggregate as sand) water and other chemical agents to get desired properties. The adverse development in the field of concrete has led to the development of light weight concrete with good characteristics. There is also a possibility of usage of some other materials for the replacement of cement. This reduces usage of cement and ultimately reduces the emission of CO2 during the manufacturing of cement.

According to Schutter and Audenaert (2004), though concrete is a rigid and porous material, the networks of interconnected pores interact with the environment. As a result, it becomes susceptible to ingress of water and other aggressive fluids. Permeation of water and other aggressive fluids in concrete can result in degradation and other aesthetic problems. Consequently, these affect the service life of concrete structures. A number of research studies were undertaken to extend the service life of concrete infrastructures using various waterproofing agents which can be an external membrane, external coating or integral (added with cement at the time of mixing) one.

Water proofing compound added to the concrete will have water repellent property which restricts the entry of moisture into it. But for the promotion of hydration process in development of concrete strength, there is a need of alternate material like Poly Ethylene Glycol (PEG) as superabsorbent polymers which can absorb, hold and supply water as required by the concrete at different stages.

In the present work, an attempt has been made to study the strength and durability characteristics of PEG and fly ash treated with fatty acid mixture in developing waterproof concrete.

Pradip Manjrekar and Rathi (2006) [1] carried out some studies on waterproofing admixtures on concrete structures. In his paper he said that the super-plasticizers generally work by giving better dispersion of cement and simultaneously reducing the surface tension of the water or aqueous phase. This results into better wetting and proper hydration at lesser water requirements. It was concluded that the addition of admixtures can offset various errors, increasing the possibility of producing concrete up to specifications. He also says that the waterproofing admixtures are pour filling and porosity reducing materials.

Asthana et al (2003) [2] analyzed about the problems and solutions for waterproofing in building. This paper says that one of the chronic problems in the construction industry is obtaining a defect free work, avoiding ingress of moisture in the buildings. If such seepage is allowed to continue, then unhygienic conditions will prevail and also the building may deteriorate to the extent that ultimately it becomes uninhabitable. In many cases the durability of the structure itself is seriously affected. Ingress of water or dampness or atmospheric pollution in the RCC structures results in corrosion of steel and spalling of concrete.

Punit kumar Jha (2015) [3] studied about the water proofing chemical & the strength and durability of concrete. In his study he used water proofing compound for which specimens prepared and tested for permeable, flexural, compressive strength and observations on the porosities after 28 days curing.

Dhir et al. (1994) [4] focused on achieving optimum cure of concrete without the need for applying external curing methods. The chemical ability to reduce evaporation from solution and to improve water retention in OPC was measured by weight loss. Initial surface absorption and compressive strength tests were made to determine surface permeability and strength development. The scanning electron microscope was used to determine the influence of admixtures on cement paste microstructure.

II. OBJECTIVES

1) To develop a water proofing concrete by adding Fly ash –Stearic acid mixture by using Taguchi approach
2) To ascertain the strength characteristics of M20 grade water proof concrete
3) To determine the durability characteristics of M20 grade water proof concrete

4) To optimize the relative amount of ingredients in making the water proofing concrete as cost effective by using statistical analysis
5) To determine the influence of each parameter on performance value of water proof concrete

III. MATERIALS

A. Cement:

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. In this project OPC 43 grade cement is used for the study

B. Fly Ash:

Fly ash is the notorious waste product of coal based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind. Researchers have proposed few ways of reusing fly ash for variety of application. One of the most common reuse of fly ash is in cement concrete.

C. Water:

Combining water with a cementitious material forms a cement paste by the process of hydration. Impure water used to make concrete can cause problems when in setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete, to form a solid mass.

D. Manufactured Sand:

With the world wide decline in the availability of construction sands along with the environmental pressures to reduce extraction of sand from rivers, the use of manufactured sand as a replacement is increasing. With the ban on sand mining implemented by different states, and with the increasing demand for river sand for construction works, many civil engineers have expressed the need to promote use of manufactured sand in the construction industry. “Manufactured sand is crushed fine aggregate produced from a source material and designed for use in concrete or for other specific products”. Only source materials with suitable strength, durability and shape characteristics should be used.

E. GleniumB233:

GLENIUM B233 is an admixture of new generation modified poly carboxylic ether. The product has been primarily developed for the applications in high performance concrete where the highest durability and performance is required. It is a free chloride and low alkali.

F. Polyethylene Glycol:

The condensed polymer of ethylene oxide and water is polyethylene glycol. PEG 400 is used in this study where 400 is the molecular weight. It has general formula H (OCH2CH2) nOH. They are soluble in water. It is nontoxic, odourless, non-volatile and non-irritating. It has wide variety of uses in medicine.

IV. METHODOLOGY

Specific Gravity	3.0
Fineness	9.33%
Standard Consistency	31%
Initial Setting Time	25min
Final Setting Time	285min

Table 1: Test Results for OPC43 Grade Cement

1) *Physical Properties*

Specific Gravity	2.2
Specific surface (cm^2 /g)	2680
Color	Dark Grey

Table 2: Test Results for Class F Fly Ash

2) *Chemical Properties*

Calcium oxide (CaO)	4.74
Silicon oxides (SiO_2)	46.80
Aluminium oxide (Al_2O_3)	23.89
Iron oxide (Fe_2O_3)	15.77
Magnesium oxide (MgO)	0.9
Sulphur oxide (SO_3)	1.18
Sodium oxide (Na_2O)	0.62
Potassium oxide (K_2O)	0.11
Loss on ignition (LOI)	2.36

Chemical Formula	$C_{2n}H_{4n+2}O_{n+1}$
Density	1.27 g/mL at 25 °C

Table 3: Physical properties of PEG

Specific Gravity	2.65
Fineness Modulus	4.2
Bulk Density	1550kg/m^3

Table 4: Test Results for Fine Aggregates

Specific Gravity	2.78
Fineness Modulus	4.04
Bulk Density	1340kg/m^3

Table 5: Test Results for Coarse Aggregates

Variable	Water to powder Ratio	Packing factor	Fly Ash	PEG
1	0.40	0	0	0%
2	0.45	20%	0.5%	0.5%
3	0.50	40%	1.0%	1.0%

Table 6: Parameters for Study

Sl. No	Cement	Fly ash	Water	FA	CA	PEG	Stearic Acid
1	425.73	0.00	293.16	604.06	1114.33	0.00	0.00
2	374.65	93.66	288.16	565.96	1089.56	1.87	0.47
3	280.98	187.32	286.51	556.28	1070.92	2.81	1.87
4	383.16	0.00	295.32	616.92	1138.06	1.92	0.00
5	337.18	84.30	291.87	596.40	1100.20	3.37	0.00
6	252.89	168.59	290.37	587.45	1083.69	0.00	0.84

7	348.33	0.00	297.09	627.44	1157.47	3.48	0.00
8	306.53	76.63	295.18	624.81	1104.94	0.00	0.77
9	229.90	153.26	293.79	616.46	1090.17	2.30	0.00

Table 7: Mix proportions

V. RESULTS & DISCUSSIONS

MIX ID	3days	7days	28days
NC	4.47	10.79	26.32
MIX 1	5.67	10.06	25.79
MIX 2	6.81	11.54	29.59
MIX 3	6.41	11.95	29.14
MIX 4	5.58	10.10	26.58
MIX 5	6.42	11.73	27.93
MIX 6	6.59	11.17	28.65
MIX 7	5.50	9.94	26.17
MIX 8	5.54	11.90	27.68
MIX 9	6.52	11.62	28.33

Table 8: Compressive strength (in N/mm^2) for Design mixes after 3days, 7days & 28days of curing

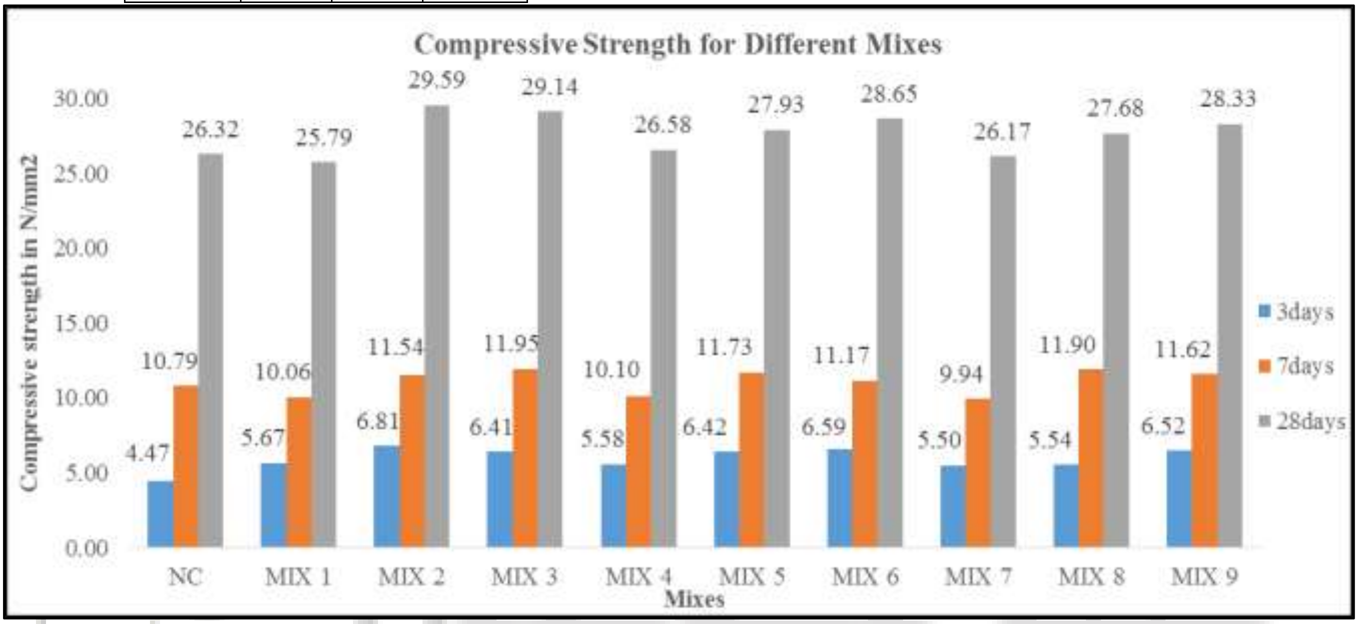

Fig. 1: Shows the compressive strength values for different mix proportions after 3, 7 & 28days of curing

VI. CONCLUSIONS

- Mineral admixture like Fly ash will reduce the carbon foot-print in manufacturing process of concrete.
- Addition of PEG into the concrete, promotes high rate of hydration which speed up the development of strength in concrete.
- Compressive strength is 12.42% more than that of normal concrete for an optimum mix having 20% replacement of fly ash by weight of cement, 0.5% of PEG by weight of cement and 0.5% of stearic acid by weight of fly ash for a w/c of 0.45
- The percentage loss in compressive strength for optimum mix was observed to be less than compared to normal concrete for both acid and alkalinity test.

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