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Study on the Strength Characteristics of Concrete by Partial Replacement of Cement with Fly Ash and Addition of Sodium Silicate

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Abstract

The basic material used for construction in Concrete is generally made of primary binding material which is cement, fine aggregate, coarse aggregate and water. Solid waste management is one of the most important techniques in today's global manufacturing scenario. This paper an attempt was made of utilizing the waste in an efficient manner for constructive purpose under eco-friendly environmental conditions. Fly ash is a by-product obtained from burnt coal in thermal power plant. In order to conserve the natural resources, fly ash is added to 20%, 30% and 40% with respect to the weight of cement. Ordinary Portland cement of 53 grade was selected. The concrete cubes, cylinders and beams were casted to determine the compressive, split tensile and flexural strength of concrete. In order to increase the strength of concrete Sodium Silicate is added by 0%, 5% and 10% with respect to the weight of cement. By adding Sodium Silicate, the content of calcium hydroxide in the concrete structures decreases whereas the content of the calcium silicate hydrate (C–S–H gel) in the concrete structures increases compared with the untreated concrete structures. Sodium silicate-based concrete sealers are essentially surface hydrophilic agents because the expansive and insoluble C–S–H gels partially fill the micro-pores, micro-voids and micro cracks in the concrete structure thus increasing the density of concrete. In this paper it is found that by adding sodium silicate to concrete by 5% and 10% the strength of fly ash concrete increases by 5% to 10% when compared with conventional concrete.

Keywords: -Sodium silicate, Fly ash, concrete sealers

INTRODUCTION

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant. Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs. Thus in order to consume this waste product the fly ash as replacement for cement by 20%, 30% and 40%. To increase the strength of concrete Sodium Silicate is added with 0%, 5%, 10% and 15% to the weight of cement. By the addition of Sodium Silicate, the content of calcium hydroxide in the concrete structures decreases whereas the content of the calcium silicate hydrate (C–S–H gel) in the concrete structures increases compared with the conventional concrete structures. Sodium silicate-based concrete sealers are essentially surface hydrophilic agents because the expansive and insoluble C–S–H gels partially fill the micro-pores, micro-voids and micro cracks in the concrete structure to form smaller micro-pores, micro-voids and micro-cracks and improve the compactness and water permeability of the concrete.

EXPERIMENTAL INVESTIGATION

In this research fly ash and sodium silicate are the material used in the manufacture of concrete. The experimental investigation consists of casting and testing of cubes, cylinders and prisms. The grade of concrete is used in this paper is M25 and M30.The mix design is done by IS10262. After 28days all the cubes, cylinder and prisms were tested.

FLY ASH

Fly ash is generated in thermal power plants with an imperative blow on environmental and living organism. The use of fly ash in concrete can reduce the consumption of natural resources and also diminishes the effect of pollutant in environment. In recent studies, many researchers found that the use of additional cementitious materials like fly ash in concrete is economical and reliable. Fly ash is one of the residues generated in the combustion of coal. Fly ash includes substantial amounts of silica (silicon dioxide, SiO2) (both amorphous and crystalline) and lime (calcium oxide, (CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits. The difference between fly ash and Portland cement becomes apparent under a microscope. Fly ash particles are almost totally spherical shape.

Figure 1 Fly ash

Table 1. Properties of Fly ash

Sl. No	Properties of Fly ash	Test Results
1	Specific gravity	2.2%
2	Bulk Density	1.1%
3	Plasticity	Lower or plastic
4	Porosity	30-65%
5	Lime reactivity	1-8Mpa

SODIUM SILICATE

Sodium silicate is a glassy gel material that reduces the permeability of the concrete. Sodium Silicate is the common name for the compounds. A well-known member of this series is sodium metasilicate, Na2Sio3. Also known as water glass or liquid glass. Sodium silicate reacts with calcium hydroxide in cement to produces C-S-H gel, which increases the density and strength of fly ash concrete. This C-S-H gel blocks all micro pores and cracks in concrete to improve its resistance to chloride attack.

Table 2. Properties of Sodium silicate

Sl. No	Properties of Sodium silicate	Test Results
1	Chemical formula	Na_2SiO_3
2	Density	2.61/cm³

Figure 2. Sodium Silicate

Mechanical properties of conventional and Fly ash - sodium silicate concrete:

The Table No: 3 indicates the comparison of Mechanical properties of conventional concrete M25 and 20%, 30%, 40% replacement of cement with Fly ash, with the addition of Sodium Silicate by 0%, 5%, 10% respectively.

Table 3. Strength of concrete result in M25 grade of concrete

Mix	Compression strength at 28 Days (N/mm^2)	Split Tensile strength at 28 Days (N/mm^2)	Flexural strength at 28 Days (N/mm^2)
Conventional concrete	31.6	3.15	4.87
M25+20% Fly ash +0% Sodium silicate	29.78	3.18	4.38
M25+20% Fly ash +5% Sodium silicate	27.08	2.49	4.56
M25+20% Fly ash +10% Sodium silicate	33.25	2.21	4.77
M25+30% Fly ash +0% Sodium silicate	28.32	3.02	3.94
M25+30% Fly ash +5% Sodium silicate	25.81	2.24	4.62
M25+30% Fly ash +10% Sodium silicate	**36.69**	**3.56**	**5.18**
M25+40% Fly ash +0% Sodium silicate	27.92	2.98	3.81
M25+40% Fly ash +5% Sodium silicate	25.75	2.28	4.36
M25+40% Fly ash +10% Sodium silicate	33.29	2.12	4.97

The Table No: 4 indicates the comparison of Mechanical properties of conventional concrete M30 and 20%, 30%, 40% replacement of cement with Fly ash, with the addition of Sodium Silicate by 0%, 5%, 10% respectively.

Table 4. Strength of concrete result in M30 grade of concrete

Mix	Compression strength at 28 Days (N/mm^2)	Split Tensile strength at 28 Days (N/mm^2)	Flexural strength at 28 Days (N/mm^2)
Conventional concrete	39.9	3.46	5.04
M30+20% Fly ash +0% Sodium silicate	37.51	3.11	4.27
M30+20% Fly ash +5% Sodium silicate	34.11	3.16	4.45
M30+20% Fly ash +10% Sodium silicate	40.91	2.88	4.79
M30+30% Fly ash +0% Sodium silicate	35.91	3.61	4.20
M30+30% Fly ash +5% Sodium silicate	33.59	2.89	4.47
M30+30% Fly ash +10% Sodium silicate	**43.95**	**3.62**	**5.39**
M30+40% Fly ash +0% Sodium silicate	35.18	3.48	3.94
M30+40% Fly ash +5% Sodium silicate	32.94	2.73	4.35
M30+40% Fly ash +10% Sodium silicate	40.46	2.45	4.86

RESULT AND DISCUSSION

The obtained results from the above test shows that by replacing cement with Fly ash reduces the strength of concrete due to the decrease in the formation of the calcium-silicate-hydrate bond. After conducting compression strength, split tensile strength and flexural strength it is found that addition of fly ash and sodium silicate improve the mechanical properties strength of concrete of both the grades. Thus, in order to increase the bonding capacity of Fly ash and Sodium Silicate concrete to increases the strength of concrete up to 30% and 10% respectively for both the grades. Generally, in this research work addition of fly ash and sodium silicate increases strength of concrete by 5% to 10% compared with conventional concrete. Hence this research suggested that where ever good quality concrete required without much cost, this concrete may be recommended.

CONCLUSIONS

From the above research work the following conclusion where drawn,

1) Sodium silicate when used as surface treatment, the early age results were similar to that with concrete mixing with fly ash. But as the age goes on increasing, there was increase in strength when compared with conventional concrete.
2) Addition of Fly ash by 20% decreases the strength of concrete by 2% compared with conventional concrete.
3) When sodium silicate 10% added along with 20% of fly ash, the compression strength increases by 5% compared with conventional concrete. But the split tensile strength and flexural strength was decreases by 10% compared with conventional concrete.
4) Finally, in this research work found that, when sodium silicate 10% added along with 30% fly ash the strength of concrete increased by 5 and 10% compared with conventional concrete.

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