An Experimental Investigation on Strength and Durability Characteristics of Concrete Using Polyethylene Glycol as Self-Curing Agent

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Abstract— With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. 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 of the hardened concrete. Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. The performance of concrete depends on method of curing also. In conventional curing spraying of water/ keeping under wet condition is followed. A new technique called Self Curing (SC) which provides additional moisture in concrete for more effective hydration of cement. An attempt has been made to study the strength and durability characteristics of M20 grade concrete by partially replacing cement with polyethylene glycol as self-curing agent in percentages of 0.5 to 2.

Index Terms— Self Compacting Concrete, Self-Curing & Polyethylene Glycol

I. INTRODUCTION

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. Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete. "Self-Compacting Concrete is defined as a concrete in which it is having a passing ability, filling ability and segregation resistance along with which can flow under its own weight without any application of external energy".

The performance and durability of concrete depends on method of curing also. In conventional curing spraying of water/ keeping under wet condition is followed. A new technique called Self Curing (SC) which provides additional moisture in concrete for more effective hydration of cement. There are two major methods available for self-curing, namely, internal curing and external curing. These methods use materials which may either be added in concrete during manufacturing process or after casting the structural elements depending on the application. In the recent past, the researchers showed interest to investigate the performance of SCC and SC for various applications in civil engineering.

Ms. T. C. Yazhini carried out an experimental investigation on the characteristics of self-compacting concrete (SCC) and Self compacting-self curing concrete by partial replacement of the coarse aggregate by coconut shell, adding super absorbent polymer and coir fiber. The coarse aggregate is replaced with coconut shell by 2%, 2.5% and 3% and the coir fiber is added by 0.5%. The compressive strength for various SCSCC mixes was tested and the results are compared with the SCC. Heba A. Mohamed carried out an experimental study on self-compacting concrete with two cement content. The results show that SCC with 15% of SF gives higher values of compressive strength than those with 30% of FA and water cured specimens for 28 days give the highest values of compressive strength.

The objective of the study is to study the strength and durability characteristics of self-curing–self compacting concrete by using Polyethylene glycol (PEG) varying from 0.5% to 2.0% by weight of cement for M20 grade concrete, to improve the process of hydration in the self-compacting concrete by using self-curing agents and to reduce the effect of insufficient external curing in self-compacting concrete.

II. 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. *Viscosity Modifying Agent* - Viscosity modifying admixtures are used to stabilize the rheology of SCC. They essentially increase viscosity and thus thicken the mix to prevent segregation. This viscosity buildup comes from the association and entanglement of polymer chains of the VMA at a low shear rate, which further inhibits flow and increases viscosity. In the present study, a locally available high performance viscosity modifying agent, named "Glenium Stream 2".

G. *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.

III. METHODOLOGY

Tests on materials

i. Cement

Table 1: Physical properties of Cement

Elements	Content
Specific Gravity	3.16
Fineness Modulus	9.33%
Standard Consistency	29%
Initial Setting time	40min
Final Setting time	285min

Table 2: Chemical properties of Cement

Oxides	Percentages
Cao	62.85
SiO_2	20.98
Al_2O_3	5.42
Fe_2O_3	3.92
MgO	1.76
SO_3	2.36
Na_2O	0.28
K_2O	0.53
Loss of Ignition	1.90

Table 3: Physical properties of Manufactured Sand

Sl No	Particulars	Obtained values
1	Specific gravity	2.32
2	Fineness Modulus	4.1
3	Bulk Density	1550 kg/m^3
4	Water absorption	1%

Table 3.4: Physical properties of coarse aggregate

Sl No	Particulars	Obtained values
1	Specific gravity	2.60
2	Fineness Modulus	4.72
3	Bulk Density	1750 kg/m^3
4	Water absorption	0.31%

Table 5: Physical properties of Class F Fly ash

Sl No	Particulars	Obtained values
1	Specific gravity	2.32

Table 6: Properties of PEG 400

Sl No	Characteristics	Specifications
1	Molecular Weight	400
2	Ph	5
3	Viscosity	130mpa
4	Solubility	Water
5	Color	Colorless
6	Specific Gravity	1.12

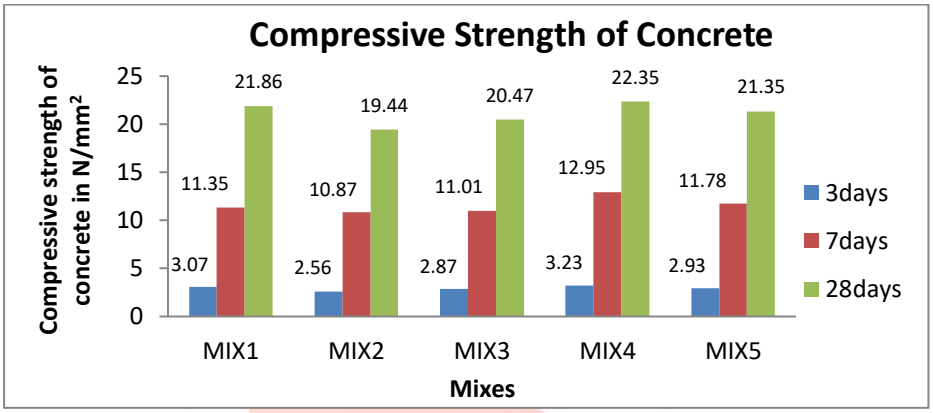
Table 7: Results of Workability Test for Various Mix

MIX ID	Workability Parameters		
	Slump	*V-funnel*	*J-ring*

MIX 1	630	10.5	8.7
MIX 2	645	9.3	7.95
MIX 3	650	9.7	7.8
MIX 4	680	8.5	7.2
MIX 5	628	10.1	8.3

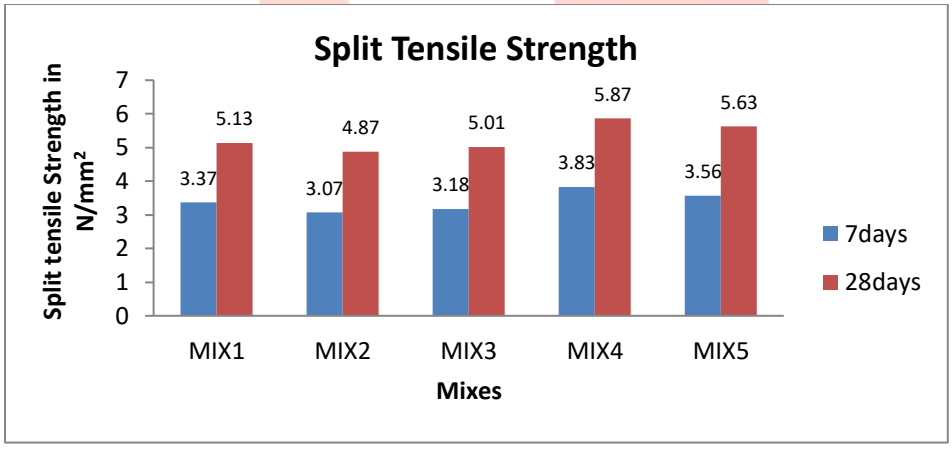
***MIX 1:** Self compacting concrete with 0% PEG
***MIX 2:** Self compacting concrete with 0.5% PEG
***MIX 3:** Self compacting concrete with 1% PEG
***MIX 4:** Self compacting concrete with 1.5% PEG
***MIX 5:** Self compacting concrete with 2% PEG

IV. RESULTS AND DISCUSSIONS



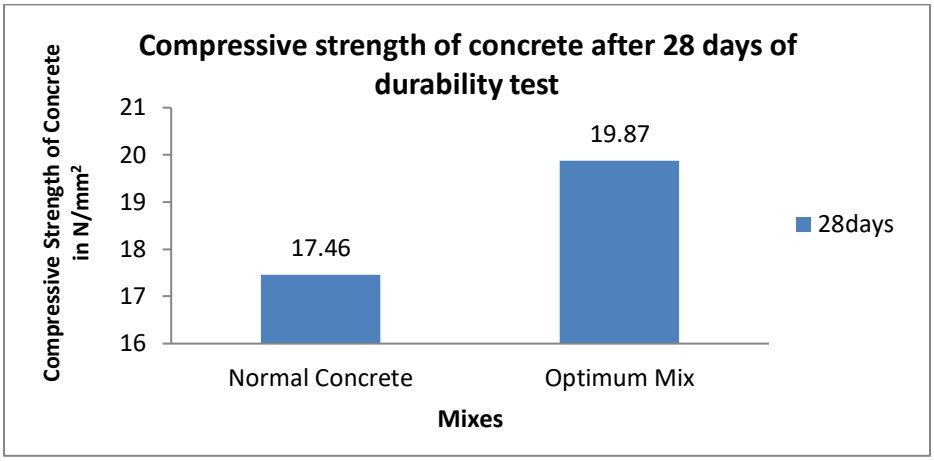
Graph1: Shows the variation of compressive strength of concrete for various mixes after 28days of curing.

The above graph shows that the compressive strength of concrete with 1.5%PEG by weight of cement is 1.02 times than compared to that of normal concrete after 28days of curing.



Graph2: Shows the variation of split tensile strength of concrete for various mixes after 28days of curing.

The above graph shows that the split tensile strength of concrete with 1.5%PEG by weight of cement is 1.14 times than compared to that of normal concrete after 28days of curing.



Graph3: Shows the variation of compressive strength of concrete for various mixes after 28days of durability test.

The above graph shows that the compressive strength of Normal Concrete and Optimum Mix (Concrete with 1.5%PEG by weight of cement) was reduced by 20.12% and 11.09% when subjected to acid test for 28days.

V. CONCLUSION

1. The optimum dosage of the self-curing admixture PEG 400 is found to be 1.5% by weight of cementitious material for M 20 concrete.
2. The fresh properties of SCC yield satisfactory results as per EFNARC and can be used in structural components.
3. The compressive and split tensile strength of Self curing-self compacting concrete is found to be 1.02 & 1.14 times higher than that of self compacting concrete with conventional curing.
4. The usage of industrial wastes such as fly ash and M sand in Self curing-Self compacting concrete helps in reducing the demand for conventional concrete materials and making the concrete eco-friendly.

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