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An Experimental Study on Mechanical and Durable Properties of Self Curing Concrete by Using Polyethylene Glycol 600 and Light Weight Fine Aggregate

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Abstract- In the present day's concrete is one of the most rapidly used construction materials in civil engineering due to its high-quality durability and its strength. The durability and strength of concrete will be fulfilled only if it is properly cured. For curing of the concrete large amount of water is required so, in recent year's new technique developed known as self-curing in which cure of concrete done by itself by retaining moisture content in the concrete. This paper represents the methods of self-curing concrete and past work done so far in this area. It was found that various chemical admixtures such as (PEG), (PEA), (PVA), (SAP), etc and naturally available material like lightweight aggregate, light expanded clay, wood powder, etc. were used as a self-curing agent. Hence this paper focuses on chemicals used, physical and mechanical properties such as (Compression strength; Tensile strength; workability; durability) of self-curing concrete. Literature reviewed shows the different techniques used for self-curing concrete. Keywords— self-curing concrete; mechanical properties; physical properties; lightweight aggregate (LWA), (PEG), (PEA), (PVA), (SAP).

Keywords- Sustainability, Polyethylene glycol, Ceramic, Brick, Self-curing concrete, Durability

I. INTRODUCTION

Today concrete is the most widely used construction material due to its good compressive strength and durability. Self-curing concrete is basically a concrete which is cable of flowing in to the formwork. Concrete is a very strong and flexible moldable construction material. It consists of cement, sand, and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

Curing of concrete is defined as providing adequate moisture, temperature and time to allow the concrete to achieve the desired properties for its intended use. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying, shrinkage and cracking. Curing temperature is one of

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the major factors that affect the strength development rate. In addition to the normal concrete mix, some additional compounds in proper dosage and materials such as fly ash are used to increase the durability and strength of concrete mix. Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%. Proper curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, cement paste and aggregates.

Concrete has been the most versatile material used in the construction industry. It is the second most consumed material in the world due to its high compressive strength and durability, which is the mixture of cement, fine aggregate, coarse aggregate and water needs curing to achieve required strength. When cement is added to water, hydration reaction takes place and this hydration process is necessary for hardening of concrete.

Curing is the process to avoid moisture content deficiency from concrete during the hydration process. Effect from curing has a strong influence on the properties of hardened concrete such as it will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing. If water is not provided then shrinkage of concrete takes place which results in cracking. Furthermore, unexpected shrinkage and temperature cracks can reduce the strength, durability, and serviceability of the concrete.

Practically good curing of concrete is not achievable in many cases due to unavailability of suitable quality of water and many other practical difficulties. During the last two decades, concrete technology has been undergoing rapid Improvements. With conventional ingredients it is possible to design reasonably good fast track concrete mixture using admixtures. Internally cured concrete can be achieved by adding Self Curing Agents.

1. Methods of Self-Curing

Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses Poly Ethylene Glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention.

2. Significance of Self-Curing

When the mineral admixtures react completely in a blended cement system, their demand for curing water (External or Internal) can be much greater than that in a conventional Portland pozzolanic cement concrete. When this water is not readily available, significant autogenous deformation and (early age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste leaving to a reduction in its internal relative humidity and also to shrinkage which cause cracking, internal warping and external deflection.

Concrete is the widely used construction material due to its ability to cast into required shape and size. The most important aspect in usage of concrete is the development of desired strength which mainly depends on hydration of cement mortar. Curing allows continuous hydration of cement and consequently continuous gain in the strength. Curing of concrete can be done in several methods, among them external and internal curing has gained popularity so far. Self-curing or internal curing is a technique that can be employed to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. According to the ACI 308 committee, ''internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water''. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in concrete construction in the new millennium. Results proved that the concrete with polyethylene-glycol as self-curing agent, attained higher values of mechanical properties than with other type of curing agents.

3. Principal and Mechanism of Self Curing

An exposed surface suffers from continuous evaporation ofmoisture due to the difference in chemical potentials between the vapour and liquid phases. Also when the mineral admixtures react completely in a blended cement system, their demand for curing water can be much greaterthan that in a conventional ordinary portland cement concrete. When this water is not readily available, significant autogenous deformation and cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading toa reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking.

It is not possible to provide curing by external supply of water from top surface at the rate required to satisfy the ongoing chemical shrinkage. The polymers added in the mixmainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure [5]. The usage of polyethyleneglycol reduces the evaporation of water from the surface of the concrete and thereby providing water retention PEO) or polyoxyethylene (POE), depending on its molecular weight. It is a condensation polymer of ethylene oxide and water. The structure of PEG is commonly expressed as H(OCH2CH2)nOH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180.Polyethylene glycols are available in average molecular weight ranging from 200 to 8000.The low molecular weight compounds up to 700 are colour less, odorless and viscous compounds with a freezing point from -10oC (di-ehylene glycol),while polymerized compounds with high molecularweight more than 1000 are wax like solids with melting point up to 67oC. One common feature of PEG appears to be the water-soluble nature. Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and nonirritatingand is used in a variety of pharmaceuticals.

II. MECHANISM OF SELF-CURING

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials between the vapours and the liquids phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecule which in turn reduces the vapours pressure thus reducing the rate of evaporation from the surface.
Mechanism and Significance of Self Curing Concrete
Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (Free energy) between the vapour and liquid phases.

The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, significant autogenous deformation and (early-age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking.

III. NEED AND SCOPE OF STUDY

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However good curing is not always practical in many cases. The aim of this investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agents. The use of self curing admixture curing admixtures is very important from the point of view that the water resources are getting valuable every day.

The benefit of self -curing admixtures is more significant in desert areas where water is not adequately available .In this study the mechanical properties of self-curing at different percentages of poly ethylene glycol will be evaluated and compared with conventional concrete specimen.

Scope of the study is to identify the effect of polyethylene glycol (PEG) on strength characteristics of self-curing concrete and also to evaluate influence of poly ethylene glycol on mechanical properties which are experimentally investigated.

1. Problem Statement

When concrete is not cured properly, its durability, strength and abrasive resistance are affected. Due to inadequate curing, concrete develops plastic shrinkage cracks, thermal cracks, along with a considerable loss in the strength of the surface layer.

When the surface of the concrete is not kept moist within the first 24 hours after the casting, the evaporation from the exposed horizontal surface results in plastic shrinkage cracks and a weak and dusty surface. An excessive temperature difference between the outer and the inner layers of the concrete results in thermal cracking due to restraint to contraction of the cooling outer layers from the warmer inner concrete. When concrete is allowed to freeze before a minimum degree of hardening is achieved after casting, the concrete gets permanently damaged due to the expansion of water within the concrete as it freezes. This results in irretrievable strength loss and makes concrete porous.

2. Justification of the Project

Today concrete is the most generally utilized development material in the world due to its strength and sturdiness properties.

To attain good strength, the curing of concrete is important so we introduce the concept of self-curing concrete rather than immersion or sprinkle curing to avoid water scarcity. It was observed that water-soluble polymers can be utilized as a self-curing agent. Polyethylene Glycol400(PEG-400) The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules of water which in turn reduces the vapor pressure, thus reducing the rate of evaporation from the surface.

IV. RESULT AND SIMULATION

1. Compressive Strength

The cube specimens were tested on compression tested machine of capacity 3000KN, bearing surface of the machine was wiped off clean and sand or other material removed from the surface of the specimen.

This specimen was placed in machine in such a manner that the load was applied to the opposite sides of the cubes as casted That is, not top and bottom.

The axis of the specimen was carefully aligned at the centre of the loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was record. FC = P/A Where, P is load, A is area.

Table 1 Compressive strength in MpA 1.

	Compressive strength in Mp			
Days	7 days	14 days	21 days	28 days
Conventional Concrete	20.76	27.15	28.74	31.94
Conventional Concrete + Flyash	7.28	9.52	10.64	11.20

Table 2 Compressive strength in MpA 2.

Percentage varying of PEG-400	Compressive a, strength in Mp			
	7 Days	14 Days	21 Days	28 Days
0%	7.54	10.38	18.73	21.96
0.5%	21.26	27.80	29.44	32.71
1.0%	22.66	29.63	31.38	34.86
1.5%	16.23	21.22	22.50	24.97
2.0%	15.49	20.26	21.45	23.83

2. Split Tensile Strength

The cylinder specimen were tested on compression testing machine of capacity 3000KN. The bearing surface of machine was wipe off clean and loses other sand or other material removed from the surface of the specimen. the load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. f split = 2P /3.14D where p = load, D = diameter of the cylinder

Fig 3 Split Tensile Strength.

Table 4 Split Tensile Strength-1.

	Split Tensile Strength in Mpa			
Days	7 days	14 days	21 days	28 days
Conventional Concrete	1.42	1.86	1.97	2.18
Conventional Concrete + Flyash	1.13	1.48	1.56	1.74

Table 5 Split Tensile Strength in MpA-2.

Percentage varying of PEG-400	Split Tensile Strength in MpA			
	7 Days	14 Days	21 Days	28 Days
0%	1.09	1.34	1.76	2.11
0.5%	1.25	1.53	1.82	2.39
1.0%	1.52	2.10	2.81	3.66
1.5%	1.41	1.74	2.23	2.81
2.0%	1.32	1.72	2.13	2.67

V. CONCLUSION & FUTURE SCOPE

1. Conclusion

- The optimum dosage of PEG-400 for maximum strengths (Compressive, Tensile) was found to be 1% for M20 grade concrete,
- The percentage of PEG-400 also gets increased slump value.
- Strength of Self-curing concrete is relatively high when compared with conventional concrete.
- It’s fully controls the water evaporation during the hydration of concrete. It gives more strength when it is compared to conventional concrete to save the water and to save the world.
- The cost requirement is also low in internal curing when compared with external curing.
- The strength and durability properties of internally cured concrete with PEG-400 gives better result compared with external cured concrete.
- Combination of partial replacement of fly ash by the 10% weight of the cement plus conventional concrete gives the less strength when it compared with conventional concrete and also conventional concrete plus flyash plus PEG-400 mix concrete.

- Self curing concrete is the answer to many problems faced due to lack of proper curing.
- The self-curing concrete improved the workability.
- To study the workability property of concrete by slump cone test with various percentage addition of PEG-400.

2. Scope for Future Work

- Further study can analysis beyond the 2% dosage of PEG-400 as self-curing agent in various concrete mix.
- Effect of natural climate factor such as sunlight, Room temperature and huminity duration self-curing on the properties may be studied.
- Use partial replacement of fly ash increases the ultimate concrete strength and durability of concrete,
- Effect of change of molecular weight of PEG's on self-curing capacity may be studied,
- Some specific water soluble chemical such as polyethylene glycol-400 is added during the mixing can reduce water evaporation from and within the set concrete make it self curing.
- Use of fly ash reduce concrete shrinkage during the curing period and also prevent the cracks in buildings.
- The scope of the work to study the effect of polyethylene glycol-400 on strength characteristics of the self-curing concrete.
- Use of fly ash reduce the amount of water required in mixture.
- In future the availability of fly ash as the replacement for cement can be used.
- To reduce the green das emission and to safe the land.
- To reduce the construction time in the project.
- Flyash increases the resistance to sulphate attack in the concrete.

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