Study of Properties of Self Curing Concrete using Light Weight Fine Aggregate & Polymeric Glycol-600

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Abstract— 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 concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day. Each 1m3 of concrete requires about 3m3 of water for construction, most of which is for curing. The aim of the investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agent with partial replacement of conventional fine aggregate with light weight fine aggregate and to optimise the quantity of poly ethylene glycol. Self-curing concrete of M25 grade were caste by replacing fine aggregate with 25% light weight fine aggregate whose water absorption property is high and by varying quantity of polymeric glycol by 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, and 1.4%. The optimum % of poly ethylene glycol was found as 1%. In this study, compressive strength, split tensile strength and flexural strength of self-curing concrete with varying quantity of polymeric glycol is evaluated and compared with the conventional concrete specimens.

Key words: Self Curing, Water Retention Capacity, Water Soluble Polymers, Poly Ethylene Glycol, Light Weight Aggregates

I. INTRODUCTION

A. General

Proper curing of concrete structures is important to ensure they meet their intended performance and durability requirements. In conventional construction, this is achieved through external curing, applied after mixing, placing and finishing. Internal curing (IC) is a very promising technique that can provide additional moisture in concrete for a more effective hydration of cement and reduced self-desiccation. Internal curing implies the introduction of a curing agent into concrete that will act as an internal source of water.

Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) 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 super-absorbent polymers (SAP), as these particles can absorb a very large quantity of water during concrete mixing and form large inclusions containing free water, that preventing self-desiccation during cement hydration. For optimum performance, the internal curing agent should possess high water absorption capacity and high water desorption rates.

B. Definition of Internal Curing

The ACI-308 Code states that "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." Conventionally, curing of concrete means creation of conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. In contrast, 'internal curing' is allowing for curing 'from the inside to outside' through the internal reservoirs (in the form of saturated lightweight aggregates, superabsorbent polymers, or saturated wood fibres) created. 'Internal curing' is often also referred as 'Self–curing.'

C. Need for 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 ordinary Portland cement concrete. When this water is not readily available, due to de-percolation of the capillary porosity, 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. This situation is intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water/cement (w/c) ratio and the pozzolanic mineral admixtures (fly ash, silica fume).

The empty pores created during self-desiccation induce shrinkage stresses and also influence the kinetics of cement hydration process, limiting the final degree of hydration. The strength achieved by internal curing could be more than that possible under saturated conditions. Often, especially in HPC, it is not easily possible to provide curing water from the top surface at the rate required to satisfy the ongoing chemical shrinkage, due to the extremely low permeability often achieved.

D. Mechanism of Internal Curing

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 water molecules, which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

E. Scope & Objective of Work

The main objective of the work is to develop self-curing concrete using self-curing agent and with partial replacement of natural fine aggregate with light weight fine aggregate and subjecting the concrete to indoor curing and conventional curing. The scope of the work is to study parameters like compressive strength of concrete, subjected to indoor curing and compare with them that of conventional curing. Two concrete mixes were considered for this study. Polyethylene Glycol of molecular weight 600 is used as self-curing agent in concrete. The concrete mixes with and without self-curing agent is subjected to two types of curing viz., conventional and indoor curing to study the above mentioned parameters.

II. Literature Survey

A. *Self-Curing of Concrete using Light Weight Aggregate*

The use of Self Curing Concrete ensures quality and durability of concrete. In the following, a summary of the articles and papers found in the literature, about the self-curing concrete and some of the projects carried out with this type of concrete, are presented.

Weber and Reinhardt (1997) introduced a new type of high performance concrete by replacing 25% by volume of the aggregates by pre wetted LWA which creates water storage inside the concrete, which supports continuous wet curing. The most important mechanical properties of the concrete under various curing conditions and the microstructure of the hardened cement paste were investigated. The results obtained showed that method of introducing a water reservoir can be successfully applied to obtain HPC with improved properties while being relatively insensitive to curing.

This paper concludes that concrete recorded high strength and was insensitive to inadequate curing and dryer the conditions higher is the measured compressive strength.

Basil M Joseph concluded Inference on Mechanical Properties And Workability mainly deal with compressive strength, split tensile strength & flexural strength. Firstly we are dealing with the compressive strength, as we told above we just use used four different proportions of polyethylene glycol. ie, (0%,0.5%,1%&1.5%) ,when we conducted the 7th day compressive strength it is noticed that the value just get increased by the varying proportion & then a sudden decrease in the strength as shown in the graph & we found that 1% was optimum as shown in the graph. Next we just deal with the 28th day strength and the values get increased by the proportions and we get maximum strength for 1%, & then we noticed a sudden decrease in the value for 1.5%.

Bentur et.al (2002) worked on Efficiency of lightweight aggregates for internal curing of high strength concrete to eliminate autogenous shrinkage. The application of the concept of internal curing by means of saturated lightweight aggregate was applied and shown to be effective in eliminate autogenous shrinkage. The work describes an approach to optimize the size and porosity of the lightweight aggregate to obtain effective internal curing with minimum content of such aggregate.

This paper concludes that efficiency of pumice aggregates, of size 2.36mm to 4.75mm can approach 100%. Similar pumice aggregates with finer size and smaller absorption values were less effective.

Jensen and Geiker (2004) compared two sources of internal water supply to mitigate autogenous shrinkage by IC. They are 1) replacement of a portion of the sand by partially saturated lightweight fine aggregate and 2) the addition of superabsorbent polymer particles (SAP). At equal water addition rates, the SAP system is seen to be more efficient in reducing autogenous shrinkage at later ages, most likely due to a more homogeneous distribution of the extra curing water within the three-dimensional mortar microstructure.

This paper concludes that either the use of partially saturated light weight aggregates or the addition of superabsorbent polymer materials can provide the extra curing water under sealed conditions. Autogenous shrinkage is also reduced.

Hoogeveen and Cusson (2008) carried work on Internal curing of high-performance concrete with pre-soaked fine lightweight aggregate for prevention of autogenous shrinkage cracking. Internal curing was supplied by pre-soaked fine LWA as a partial replacement to regular sand. It was found that the use of 178 kg/m3 of saturated LWA in HPC, providing 27 kg/m3 of IC water eliminated the tensile stress due to restrained autogenous shrinkage without compromising the early-age strength and elastic modulus of HPC.

This paper concludes that autogenous expansion, observed during the first day for high levels of internal curing, can significantly reduce the risk of cracking in concrete structures, as both the elastic and creep strains develop initially in compression, enabling the tensile strength to increase further before tensile stresses start to initiate later.

B. *Self-Curing of Concrete using self –Curing Agents*

Present-day self-curing concrete can be classified as an advanced construction material. As the name suggests, it does not require to be cured in water. This offers many benefits and advantages over conventional concrete. This includes an improved quality of concrete and reduction of autogenous shrinkage. The composition of Self Curing Concrete mixes includes substantial proportions of self-curing agents and saturated recycled coarse aggregate and this gives possibilities for utilization of water inside concrete. The benefit from Self Curing Concrete can be expected when there is need for reduced construction time, quicker turnaround time in precast plants, lower maintenance cost, greater performance and predictability. The use of Self Curing Concrete ensures quality and durability of concrete. In the following, a summary of the articles and papers found in the literature, about the self-curing concrete and some of the projects carried out with this type of concrete, are presented.

Jensen et.al (2001) described a new concept for the prevention of self-desiccation in hardening of cement-based materials. The concept consists of using fine, superabsorbent polymer (SAP) particles as a concrete admixture. The SAP will absorb water and form macro inclusions, which essentially consist of nothing but free water. This leads to water entrainment, i.e. the formation of water-filled macro pore inclusions in the fresh concrete. Consequently, the pore structure is actively designed to control self-desiccation. In his work, self-desiccation and water entrainment are described and discussed. The description is based on a reinterpretation of Powers' model for the phase distribution of a hydrating cement paste.

This paper concludes that by means of water entrainment it is possible to avoid self-desiccation without impairing strength and durability.

Roland et.al (2002) worked on internal curing composition for concrete which includes a glycol and a wax. The invention of Roland was based on the observation that a combination of a wax and a glycol, when added to concrete, enables internal curing of concrete which in many respects is equal to or superior to traditional forms of curing concrete.

The invention provides for the first time an internal curing composition which, when added to concrete or other cementitious mixes meets the required standards of curing as per Australian Standard AS 3799. A preferred internal curing composition according to the invention includes a paraffin wax and a Poly Ethylene Glycol (PEG) of Molecular Weight about 200. The preferred glycol to wax ratio is 1:3 to 1:12.

Wen (2008) worked self-curing agent containing poly-acrylic acid which has strong capability of absorbing moisture from atmosphere and providing water required for curing concrete and also contains polyvalent alcohol, selected from the group consisting of PEG, PG, DPG etc. His works are carried out at RH of 50% ~ 85%. A Self Curing Concrete is provided to absorb water from moisture from air to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete. According to the invention, high-performance self-curing agent about 0.1~5 wt % of cement weight of the concrete is added to the concrete during mixing. The self-curing agent can absorb moisture from atmosphere and then release it to concrete. The self-curing concrete means that no curing is required for concrete, or even no external supplied water is required after placing. The properties of the self-cured concrete of the invention are at least comparable to even better than those of concrete with traditional curing.

The above paper concludes that self-curing agent absorbs moisture from air and then releases it into the concrete, thereby achieving self-curing without external curing method after placing. The self-curing agent is added to the concrete such that a 10% compressive strength is increased than that of concrete without curing.

Dieb (2007) investigated on water retention of concrete using water-soluble polymeric glycol as self-curing agent. Concrete weight loss and internal relative humidity measurements with time were carried out, in order to evaluate the water retention of self-curing concrete. Non-evaporable water at different ages was measured to evaluate the hydration. Water transport through concrete is evaluated by measuring absorption%, permeable voids%,. The water transport through self-curing concrete is evaluated with age. The effect of the concrete mix proportions on the performance of self-curing concrete were investigated, such as, cement content and water/cement ratio.

This paper concludes that water retention for concrete mixes incorporating self-curing agent is higher and suffered less desiccation compared to conventional concrete mixes. Water sorptivity, and water permeability values for self-curing concrete decreased with age indicating lower permeable pores.

Lura (2003) worked on autogenously deformation of cementitious materials and internal curing as a means to reduce early-age shrinkage and self-induced stresses. The main aim of his study was to reach a better comprehension of autogenous shrinkage in order to be able to model it and possibly reduce it. Once the important role of self-desiccation shrinkage in autogenous shrinkage is shown, the benefices of avoiding self-desiccation through internal curing become apparent.

The above paper concludes that incorporation of wet LWA in the mix produced early-age expansion in place of shrinkage. Early-age expansion was strongly dependent on the degree of saturation of the LWA and to a lesser extent on their particle size, being larger for smaller LWA.

Geetha (2006) compares the strength and durability properties of different grades of concrete when added with polymeric materials without any external curing for the concrete. The of concrete used were M20, M30, M40. Of the above tests conducted, the strength as well as the durability property holds good for the cubes with palak green with one day curing and without external curing.

The above paper concludes that the strength as well as durability property hold good for cubes with palak green with one day curing and without external curing. While comparing the internal curing with that of external curing, the cost of internal curing proves to be cheaper when compared with that of external curing.

C. Critical review

From above literatures it can be summarized that super absorbent polymer or light weight aggregates can be used for self-curing. The combined use of super absorbent polymer and light weight aggregate was not covered in the literature. In this work super absorbent polymer and light weight fine aggregate are used together for self-curing.

III. SELF-CURING CONCRETE

A. General

Self-curing concrete is that concrete in which there is no need for external curing. self-curing is also known as internal curing. Internal curing (IC) is a very promising technique that can provide additional moisture in concrete for a more effective hydration of cement and reduced self-desiccation. Internal curing implies the introduction of a curing agent into concrete that will act as an internal source of water.

B. Advantages of Internal Curing

Internal curing (IC) is a method to provide water to hydrate all the cement, accomplishing what the mixing water alone cannot do. In low w/c ratio mixes (under 0.43 and increasingly those below 0.40) absorptive lightweight aggregate, replacing some of the coarse aggregates, provides water that is desorbed into the mortar fraction (paste) to be used as additional curing water. The cement, not hydrated by low amount of mixing water, will have more water available to it.

- IC provides water to keep the relative humidity (RH) high, keeping self-desiccation from occurring.
- IC eliminates largely autogenous shrinkage.
- IC maintains strength of mortar/concrete at during the early age (12 to 72 hrs.) above the level of internally & externally induced strains.

- IC can make up for some of the deficiencies of external curing, both human related (critical period when curing is required the first 12 to 72 hours) and hydration related (because hydration products clog the passageways needed for the fluid curing water to travel to the cement particles thirsting for water).
- Following factors establish the dynamics of water movement to the unhydrated cement particles:
- Thirst for water by the hydrating cement particles is very intense
- Capillary action of the pores in the concrete is very strong, and
- Fluidity of water in the properly distributed particles of LWA (fine) is very fluid.

1) Concrete Deficiencies that Internal Curing can address

- The benefit from IC can be expected when
- Cracking of concrete provides passageways resulting in deterioration of reinforcing steel,
- Low early-age strength is a problem,
- Permeability or durability must be improved,
- Rheology of concrete mixture, modulus of elasticity of the finished product or durability of high fly-ash concretes are considerations.

Need for reduced construction time, quicker turnaround time in precast plants, lower maintenance cost, greater performance and predictability.

2) Improvements to Concrete Due to Internal Curing

- Reduces autogenous cracking
- Largely eliminates autogenous shrinkage
- Reduces permeability
- Protects reinforcing steel
- Increases mortar strength
- Increases early age strength sufficient to withstand strain
- Provides greater durability
- Higher early age (say 3 day) flexural strength
- Higher early age (say 3 day) compressive strength
- Lower turnaround time
- Improved rheology
- Greater utilization of cement
- Lower maintenance
- Use of higher levels of fly ash
- Higher modulus of elasticity
- Greater curing predictability
- Higher performance
- Does not adversely affect finishability
- Does not adversely affect pumpability
- Reduces effect of insufficient external curing.

3) Distribution of Internal Water Reservoirs for Curing

The transport distance of water within the concrete is limited by de-percolation of the capillary pores in low w/c ratio pastes. With water-reservoirs well distributed within the matrix, shorter distances have to be covered by the curing water and the efficiency of the internal-curing process is consequently improved. The concept of internal curing was established, based on dispersion of very small, saturated LWA throughout the concrete, which serve as tiny reservoirs with sufficient water to compensate for self-desiccation. The spacing between the LWA particles is conveniently small so that the water travels smaller distances to counteract self-desiccation. The amount of water in the LWA can therefore be minimized, thus economizing on the content of the LWA.

4) Usefulness of Internal Curing for Early Age Cracking

The IC can influence the 'Early- Age Cracking Contributors' which are mainly thermal effects and autogenous shrinkage. During initial ages of concrete, hydration heat can raise concrete temperature significantly (causing expansion), subsequent thermal contraction during cooling can lead to early-age (global or local) cracking if restrained (globally or locally). Another prominent effect would be autogenous shrinkage, especially in concretes with lower water-binder ratios where sufficient curing water cannot be supplied externally, the chemical shrinkage accompanying the hydration reactions will lead to self-desiccation and significant autogenous shrinkage.

C. Mechanism of Internal Curing

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 water molecules, which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

D. Chemicals to Achieve Self -Curing

Some specific water-soluble chemicals added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing.' The chemicals should have abilities to reduce evaporation from the solution and to improve water retention in ordinary Portland cement matrix.

1) Super- Absorbent Polymer (SAP) for Internal Curing

In Fig.3.1 superabsorbent polymers are swell able substances, which can absorb many times their own weight of liquids by forming a gel. The absorbed liquid is not released even under pressure. The picture shows a dry, collapsed and a swollen suspension polymerized SAP particle.

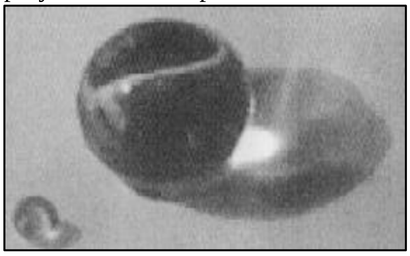

Fig. 3.1: Superabsorbent Polymer

The common SAPs are added at rate of 0–0.6% weight of cement. They are Acrylamide/acrylic acid copolymers. SAPs are a group of polymeric materials that have the ability to absorb a significant amount of liquid from the surroundings and to retain the liquid within their structure without dissolving. SAPs are principally used for absorbing water and aqueous solutions. SAPs can be produced with water absorption of up to 5000 times their own weight.

However, in dilute salt solutions, the absorbency of commercially produced SAPs is around 50 g/g. They can be produced by either solution or suspension polymerization, and the particles may be prepared in different sizes and shapes including spherical shapes. Commercially important SAPs are covalently cross-linked poly-acrylates and copolymerized poly-acrylamides/poly-acrylates. Because of their ionic nature and interconnected structure, they can absorb large quantities of water without dissolving. From a chemical point of view, all the water inside a SAP can essentially be considered as bulk water. SAPs exist in two distinct phase states, collapsed and swollen.

E. Method for Providing Moisture for Self-Curing

Water/moisture required for internal curing can be supplied by incorporation of saturated-surface dry (SSD) lightweight aggregates (LWA).

1) Water in LWA for Internal Curing

About 67% of the water absorbed in the LWA can get transported to a self-desiccating paste. Some water remains always in the LWA in the high relative humidity (RH) range and it becomes useful when the overall RH in concrete is significantly reduced. The water retained in LWA in air-dry condition may not be enough to prevent autogenous shrinkage whose magnitude, however, may be reduced significantly. The fine lightweight aggregate, in saturated condition, produce a more uniform distribution of the water needed for curing throughout the microstructure.

F. Lightweight Aggregates

Light Weight Aggregate Concrete (LWAC) is not a new invention in concrete technology. It has been known since ancient times, so it is possible to find a good number of references in connection with the use of LWAC. It was made using natural aggregates of volcanic origin such as pumice, scoria, etc.

Concrete is mostly known as a grey material with good mechanical strength, but heavy and cold. It is generally understood that concrete is not necessarily just heavy, sharp-edged grey blocks. It can acquire any shape, color, density, and strength. The low density of pumice aggregates results in weight reduction of the structures and the foundations, and also provides considerable saving in regarding thermal insulation.

The low density of the material results in high thermal insulation for buildings and, in some instances, the thickness of roofs and walls can be reduced. Where there is no reduction in thickness, a higher degree of thermal insulation will be achieved. The density is mostly controlled by the type of aggregate used. The strength is also partially dependent upon the type of aggregates used for making the concrete.

1) Advantages & Advances in Light Weight Aggregates

Usage of Lightweight Aggregates can deliver real advantages in terms of production techniques, reduced fixings, logistics and crane requirements, and by combining both coarse and fine LWA, benefits can be further increased.

Advances in admixture technology and tailored aggregate gradings have resulted in the availability of a wider range of concretes made using secondary aggregates, and offer greater selection for architects, engineers and contractors. Pumpable and self-compacting concrete made with secondary Lightweight Aggregates, both coarse and fine, can be produced with oven-dry densities in the region of 1,450kg/m3 and strengths in excess of 40N/mm2. As a result of such developments, even greater weight reductions of around 35% can be achieved by combining coarse and fine LWA. This lighter-weight concrete offers opportunities for efficient working and innovative designs that would not be feasible with traditional concrete.

G. Types of Light Weight Aggregates

Lightweight aggregates can originate from natural resources or they can be man-made. The major natural source is the volcanic material. Man-made or synthetic, aggregates are produced by a thermal process in factories.

1) Volcanic Origin

When lava from a volcano cools down, it produces a spongy well-sintered mass. Since there is an abrupt cooling of the molten mass, the material freezes. With a sudden cooling of the molten magma, there is no crystallization, and the material acquires a glassy structure, a process similar to the production of the glass known as obsidian.

It can be called a super cooled liquid, which has no crystalline phase. It is highly amorphous and has a glassy structure. Lava is a boiling melt which may contain air and gases, and when it cools down, it freezes to a spongy porous mass. In other words, it produces lightweight material that is porous and reactive. This type of material is known as volcanic aggregates, or pumice or scoria aggregates. The aggregates are produced by mechanical handling of lava, i.e., crushing, sieving, and grinding.

2) Organic Aggregates

a) Palm Oil Shells:

The use of agricultural waste as aggregates for the production of building materials has several practical and economic advantages. The palm oil industry which is important in many countries, such as Malaysia, Indonesia, and Nigeria, produces a large amount of waste which can be utilized in the production of building materials. Palm oil shells are produced in large quantities by the oil mills and can be used as aggregates in the production of Light Weight Concrete.

3) Synthetic Aggregates

Synthetic aggregates are produced by thermal treatment of the materials which have expansive properties. These materials can be divided in three groups

- Natural materials, such as perlite, vermiculite, clay, shale, and slate.
- Industrial products, such as glass.
- Industrial by-products, like fly ash, expanded slag cinder, bed ash, etc.

The most common types of lightweight aggregates produced from expansive clays are known as Leca and Liapor. Those made from fly ash are known as Lytag, etc. The bulk density of the aggregates varies greatly depending upon the raw materials and the process used for their manufacture.

H. Production of Light Weight Aggregates & its Properties

Lightweight aggregate (LWA) can be divided in two categories:

1) Those occurring naturally and are ready to use only with mechanical treatment, i.e., crushing and sieving.
2) Those produced by thermal treatment from either naturally occurring materials or from industrial by-products, waste materials, etc.

The properties of LWAC are related to the properties of the aggregates used for producing them. This, in turn, depends upon the type of material and the process used for producing them. Generally, the strength and the density of concrete are considered when designing a structure. Specifically in the case of LWA, there is a vast variation in the density, so there will be a vast variation in the strength of the LWAC.

1) Industrial Kilns

a) Rotary Kiln

A rotary kiln used for manufacturing LWA is similar to the one used for manufacturing Portland cement. It consists of a long cylinder lined with refractory bricks and capable of rotating about its longitudinal axis, which is inclined at an angle of 5° to the horizontal (Fig. 2.1). The length of the kiln depends upon the composition of the raw material to be processed and is usually thirty to sixty meters. The prepared raw material is fed into the kiln at the higher end, while firing takes place at the lower end. As the material moves to the heating zone, the temperature of the particles gradually increases and expansion takes place. Material is then discharged into a rotary cooler, where it is cooled by blowing cold air.

b) Vertical Shaft Kiln

In this process, the prepared raw material is fed into a vertical shaft kiln in batches. A hot jet of flue gases, entering at the center of the base of the combustion chamber, lifts the material upwards until the force of the upward jet is dispersed sufficiently to become less than the force of gravity.

Material falls down and rolls to the foot of the combustion chamber, which is in the shape of a funnel, where the flue gas again forces it upwards. This process is repeated a number of times over a period of about one minute for each batch.

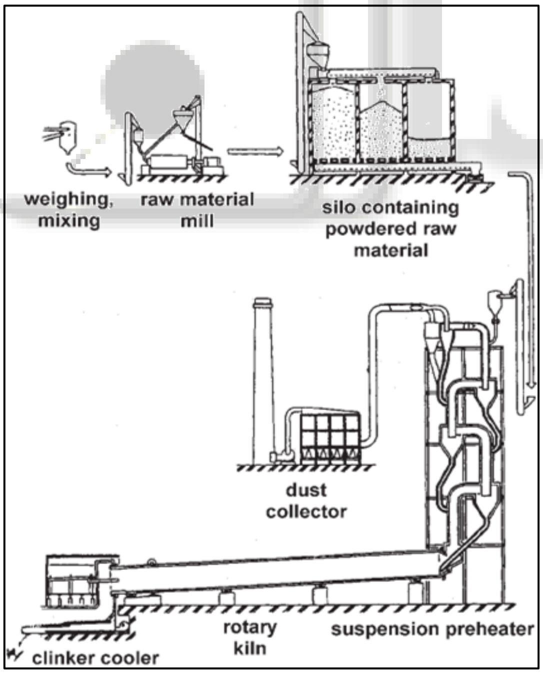

Fig. 3.2: Rotary Kiln for Producing Lightweight Aggregates

I. Polyethylene Glycol

Polyethylene glycol is a condensation polymers of ethylene oxide and water with the general formula H (OCH2CH2) nOH, where n is the average number of repeating ox ethylene groups typically from 4 to about 180. The low molecular weight members from n=2 to n=4 are diethylene glycol, diethylene glycol and tetra ethylene glycol respectively, which are produced as pure compounds. The low molecular weight compounds up to 700 are colorless, odorless viscous liquids with a freezing point from -10° C (di-ethylene glycol), while polymerized compounds with higher molecular weight than 1,000 are wax like solids with melting point up to 67° C for n 180.

The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble. It is soluble also in many organic solvents including aromatic hydrocarbons (not aliphatic). Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and non-irritating and is used in a variety of pharmaceuticals and in medications as a solvent, dispensing agent, ointment and suppository bases, vehicle, and tablet excipient.

They are used to make emulsifying agents and detergents, and as plasticizers, humectants, and water-soluble textile lubricants. The wide range of chain lengths provides identical physical and chemical properties for the proper application selections directly or indirectly in the field of;

- Alkyd and polyester resin preparation to enhance water dispersability and water-based coatings
- Brightening effect and adhesion enhance in electroplating and electroplating process
- Cleaners, detergents and soaps with low volatility and low toxicity solvent properties
- Coupling agent, humectants, solvent and lubricant in cosmetics and personal care bases
- Dimensional stabilizer in wood working operations
- Dye carrier in paints and inks
- Heat transfer fluid formulation and defoamer formulations
- Low volatile, water soluble and noncorrosive lubricant without staining residue in food and package process
- Plasticizer to increase lubricity and to impart a humectants property in ceramic mass, adhesives and binders
- Soldering fluxes with good spreading property

J. Monitoring of Self-Curing Concrete

This can be done by:

- Measuring weight-loss
- X-Ray powder diffraction
- X-Ray micro chromatography
- Thermogravimetry (TGA) measurements
- Initial surface absorption tests (ISAT)
- Compressive strength
- Scanning electron microscope (SEM)
- Change internal RH with time
- Water permeability
- NMR spectroscopy

Hence it is found that light weight fine aggregate and polymeric glycol helps in the self-curing of concrete. In this project, light weight fine aggregate and poly ethylene glycol is used and its properties are compared to control concrete. Also the optimum quantity of poly ethylene glycol is found out.

IV. EXPERIMENTAL PROGRAMME

A. General

The experimental program was designed to investigate the properties of self-curing of concrete using polyethylene glycol-600 (peg) with 25% replacement of natural aggregate with light weight fine aggregate (lwfa) for two grades of concrete M25 mix.

B. Materials Used

Materials used in this investigation are:

- 53 Grade Ordinary Portland cement (OPC)
- Fine Aggregate (Natural Fine Aggregate and Light Weight Fine Aggregate)
- Coarse Aggregate
- Polyethylene Glycol-600 (PEG)
- Water

1) Cement

Cement used in the investigation was 53 Grade ordinary Portland cement confirming IS: 12269: 1987. The cement used for experiments was obtained from a single consignment and of same grade and same source. After procuring the cement, it was stored properly.

Sl. No	Particulars		Test Results	Requirements as per IS:12269-1987 (reaffirmed 2004)
1	Specific gravity		3.15	-
2	Normal consistency		30%	-
3	Initial setting time		39 min	Not less than 30 min
4	Final setting time		283 min	Not more than 600 min
5	Compressive Strength	3 day	30.2 Mpa	Not less than 27 MPa
6		7 day	39.2 Mpa	Not less than 37 MPa
7		28 day	54.3Mpa	Not less than 53 MPa

Table 4.1: Properties of Cement

Sieve size (mm)	% passing recommended by is :383	Weight retained (g)	Cumulative weight retained	%weight retained	% finer
10	100	-	-	-	100
4.75	90-100	12	12	1.2	98.8
2.36	75-100	37	49	4.9	95.1
1.18	55-90	171	220	22	78
0.60	35-59	353	573	57.3	42.7
0.30	8-30	365	938	93.8	6.2
0.15	0-10	48	986	98.6	1.4
Pan		14	000	100	0

Table 4.2 : Proportions of Different Size Fractions of Sand

2) Fine Aggregate

The fine aggregate conforming to zone -2 according to IS: 383 were used. The specific gravity of the sand used was 2.67. The sand obtained was sieved as per IS sieves (i.e. 4.75mm, 2.36 mm, 1.18 mm, 600 µ, 300 µ, and 150µ). The Details of particle size distribution and grading are given in table 4.2

Sl. No	Description	Test results
1	Fineness modulus (IS:383-1970)	2.1
2	Specific Gravity (IS:2386(Part-III)-1963)	2.67
3	Bulk density(IS:2386(Part-III)-1963)	1590 kg/m3
4	Water absorption	1.3%

Table 4.3: Properties of Natural Fine Aggregate

3) Light Weight Fine Aggregate

The fine aggregate conforming to zone - II according to IS: 383 were used. The specific gravity of the sand used was 2.34. The sand obtained was sieved as per IS sieves (i.e. 4.75mm, 2.36 mm, 1.18 mm, 600 µ, 300 µ, and 150µ). The Details of particle size distribution and grading are given in table4.4.

Sl. No	Description	Test results
1	Specific Gravity (IS:2386(Part-III)-1963)	2.34
2	Bulk density(IS:2386(Part-III)-1963)	1323 kg/m3
3	Water absorption	5.25%

Table 4.4 : Properties of Light Weight Aggregate

4) Coarse Aggregate

Crushed granite used as coarse aggregate. The coarse aggregate according to IS: 383 were used. Maximum coarse aggregate size used 20 mm. The Details of particle size distribution and grading are given in table 4.5.Properties of coarse aggregate as shown in table 4.6.

Sieve size(mm)	Weight retained (g)	Cumulative Weight retained g)	Cumulative% weight retained	% finer
20	0	0	0	100
12.5	175	175	8.75	91.25
10	1020	1195	59.75	40.25
4.75	785	1980	99	1
2.36	20	2000	100	0

Table 4.5 : Proportions of Different Size Fractions of Coarse Aggregates

Sl. No	Description	Test results
1	Specific Gravity (IS:2386(Part-III)-1963)	2.81
2	Bulk density(IS:2386(Part-III)-1963)	1542kg/m3
3	Impact Strength	23.7%
4	Crushing strength	25.2%

Table4.6 : Properties of Coarse Aggregates

5) Polyethylene Glycol-600

Polyethylene glycol is a condensation polymers of ethylene oxide and water with the general formula H (OCH2CH2) nOH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble. Specifications of PEG-600 are listed in table 4.7.

Fig. 4.1: Polyethylene Glycol-600 Solutions

Polyethylene glycol-600	
Molecular weight	600 g/mol
Appearance	Clear liquid
Moisture	0.2% max
Ph	5 – 7
Specific gravity	1.12 - 1.13

Table 4.7: Specifications of Polyethylene Glycol-600

a) Advantages of Polyethylene Glycol

- It is useful and saves water
- Less water in concerete makes the concerete durable
- Compressive strength variation will be less

6) Water

Potable water was used in the experimental work for both mixing and curing purposes.

C. Mix Design

Mix design was done according to IS: 10262 – 2009 for M25 mix. Trial mix was done and considerable values were obtained. The water-cement ratio used in the design is 0.43. From table 5 of IS: 456 – 2000.

1) Mix Design Calculation

According to IS Code 10262-2009, the Design Mix Procedure is Carried Out:

1) Step 1: Target Mean Strength of the Mix Proportion is carried out as Fallows,

For M25 grade of concrete:

- F1ck= Fck + 1.65S,
- F1ck=Target Mean Compressive Strength of concrete@28days,
- Fck= Compressive Strength of Concrete,
- S=Standard Deviation,
- For M20-M25 Grade of Concrete Standard Deviation = 4Mpa.

2) Step 2: Selection of Water Cement Ratio from table5 of IS456-2000,

- W/C =0.43,
- Maximum water Content per m3 of Concrete for Nominal Maximum size of aggregate:
- For 20mm Nominal Maximum size of aggregate the Maximum water Content is 186kg.

3) Step 3: Calculation of Cement Content:

- Water-Cement ratio is =0.43,
- Cement Content = 186/0.43 = 432.55,

4) Step 4: Proportioning of Volume of Coarse aggregate content table 3 of IS 10262-2009:

- Volume of Coarse aggregate content corresponding to 20mm size of aggregate of ZoneIII,
- Volume of Coarse aggregate content = 0.64m3,
- Volume of Coarse aggregate content = 1 – 0.64,
- = 0.36 m3,

5) Step 5: Calculation regarding to Mix Design Volume of Concrete (a) = 1 m3,

2) Calculation of Cement Content

Water-cement ratio = 0.43

WATER (l)	CEMENT(kg)	FINE AGGREGATE (kg)	COARSE AGGREGATE (kg)
186	432.55	570.30	1217.50

Table 4.8: Mix Design

Cement content = 186/0.43 = 432.55 kg/CuM

Volume of Cement (b) = $[\frac{\text{Mass of cement}}{\text{specific gravity of cement}}] * [\frac{1}{1000}]$,

= $[455.32/3.15*\frac{1}{1000}]$ = 0.137 m3.

Volume of Water (c) = $[\frac{\text{Mass of cement}}{\text{specific gravity of water}}] * [\frac{1}{1000}]$,

= 0.186 m3.

Volume of all in aggregate (d) = [a- (b + c)],

= [1- (0.137 + 0.186)] = 0.677 m3.

Mass of Coarse aggregate = d * Volume of coarse aggregate * Specific gravity*1000,

= 0.677 * 2.81 * 0.64 * 1000,

= 1217.50 kg/m3.

Mass of Fine aggregate = d * Volume of fine aggregate * Specific gravity*1000,

= 0.677 *2.34 * 0.36 *1000,

= 570.30 kg/m3.

Then the total Quantity is:

Cement = 432.55 kg/m3,

Coarse aggregate = 1217.50 kg/m3,

Fine aggregate = 570.30 kg/m3,

W/C ratio = 0.43,

Water = 186 litres.

432.55: 570.30:1217.5 kg/m3.

1:1.32:2.8

3) Mix Proportion

1:1.32:2.80

Trial mixes were made to obtain economical mix satisfying workability and strength requirement and details of final mix is arrived.

4) Mix Design for Self-Curing Concrete

Fine aggregates was replaced by light weight fine aggregates by 25% and adding poly ethylene glycol in varying 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, and 1.4%.

D. Geometric Details

Sl.No	Specimen	Size(mm)	% of light weightfine aggregate	% of polymeric glycol	Noof specimen
1	Cube	150x150x150	0	0	12
			0.2	25	12
			0.4	25	12
			0.6	25	12
			0.8	25	12
			1.0	25	12
			1.2	25	12
			1.4	25	12
2Cylinder	Diameter-150	Height-300	0	0	9
			0.2	25	9
			0.4	25	9
			0.6	25	9
			0.8	25	9
			1.0	25	9
			1.2	25	9
			1.4	25	9

Table4.9 Geometric Details of Specimen

Sl.No	Specimen	Size(mm)	% of light weight fine aggregate	% of polymeric glycol	No of specimen
3	Prism	100x100x500	0	0	9
			0.2	25	9
			0.4	25	9
			0.6	25	9
			0.8	25	9
			1.0	25	9
			1.2	25	9
			1.4	25	9

Table 4.10: Geometric Details of Specimen

1) Cubes

Cubes of size 150mm x150mm x150mm is casted for determining the compressive strength. Total number of cubes caste were 96. For poly ethylene glycol of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2% and 1.4% 12 cubes were caste for each %, 3 cubes for 7 day strength, 3 cubes for 28 day strength, 3 cubes for 56 day strength and 3 cubes for 90 day strength.

2) Cylinder

Cylinder of diameter 150mm and height 300mm was casted for determining split tensile strength.72 cylinders were caste. For poly ethylene glycol of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2% and 1.4% 3 cylinders were caste for each %, 3 cylinders for 28 day strength, 3 cylinders for 56 day strength and 3 cylinders for 90 day strength.

3) Prism

Prism of size 100mmx100mmx500mm was casted for determining flexural strength.72 prisms were caste. For poly ethylene glycol of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2% and 1.4% 3 prisms were caste for each %, 3 prisms for 28 day strength, 3 prisms for 56 day strength and 3 prisms for 90 day strength.

E. Test on Fresh Concrete

Self-curing concrete is an artificial material, which is made up of cement, fine aggregate, light weight fine aggregate, coarse aggregate, water and poly ethylene glycol. In this project poly ethylene glycol of 0.0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, and 1.4%. is added and 25% of fine aggregate is replaced with light weight fine aggregate. The properties of material have been arrived by conducting laboratory tests for fresh and hardened concrete.

1) Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It does not measure all factors contributing to workability. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Slump test as per IS: 1199 – 1959 is followed.

F. Test on Hardened Concrete

1) Compressive Strength

The cube-compressive test was conducted in compression testing machine as per IS 516-1964. The compressive strength of concrete is one of the most important of concrete. The cubes were tested in compressive testing machine at the rate of 140 kg/cm2/min. and the ultimate loads were recorded.

Fig. 4.2: Compression Testing

The cube specimens are tested on Universal testing machine having a capacity of 300 tones. The bearing surface of machine is wiped off clean and loses other sand or other material removed from the surface of the specimen. The specimen is placed in machine in such a manner, load is applied to opposite sides of the cubes that as casted side of specimens, not top and bottom. The axis of the specimen is carefully aligned at the centre of loading frame.

The load applied is increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. Maximum load applied on specimen is recorded.

2) *Split Tensile Strength*

Fig. 4.3: Split Tensile Testing

Test is carried out by placing a cylinder specimen horizontally between the loading surfaces of a universal testing machine and the load is applied until failure of the cylinder along the vertical diameter. When the load is applied along the generatrixan element on the vertical diameter of the cylinder is subjected to a horizontal stress and found the split tensile strength using subsequent formula. Specimens subjected to internal and external curing tested after 28, 56, 90 days. Nine specimens tested for each mix in which two of the specimens subjected to internal and external curing.

3) *Flexural Strength of Concrete*

Flexural strength is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced concrete beams with a span three times the depth (usually 100X100x500mm). The flexural strength is expressed as "Modulus of Rupture" (MR) in N/mm2. Flexural Modulus of Rupture is about 12 to 20 percent of compressive strength. However, the best correlation for specific materials is obtained by laboratory tests. The specimens are subjected to internal and external curing tested after the 28, 56, 90 days. Nine specimens tested for each mix in which two of the specimens subjected to internal and external curing.

Fig. 4.4: Flexural Testing

V. RESULTS & DISCUSSION

A. *Results*

The result of the investigations carried out for finding out compressive strength of self-curing concrete using poly ethylene glycol in varying 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2% and 1.4% using 25% light weight aggregates are given below.

B. *Mix Proportions*

Ingredients	unit	S 1	S 2	S 3	S 4
Cement	kg/m3	432.55	432.55	432.55	432.55
Fine aggregate	kg/m3	570.30	427.72	427.72	427.72
Light weight Fine aggregate	kg/m3	0	142.58	142.58	142.58
Coarse aggregate	kg/m3	1217.50	1217.50	1217.50	1217.50
Water cement ratio	By mass	0.43	0.43	0.43	0.43
Water	l/m3	186	186	186	186
Poly ethylene glycol	%	0	0.2	0.4	0.6
Poly ethylene glycol	l/m3	0	1.029	2.058	3.089

Table 5.1: Mix Proportions

Ingredients	unit	S 5	S 6	S 7	S 8
Cement	kg/m3	432.55	432.55	432.55	432.55
Fine aggregate	kg/m3	427.72	427.72	427.72	427.72
Light weight Fine aggregate	kg/m3	142.58	142.58	142.58	142.58
Coarse aggregate	kg/m3	1217.50	1217.50	1217.50	1217.50
Water cement ratio	By mass	0.43	0.43	0.43	0.43
Water	l/m3	186	186	186	186
Poly ethylene glycol	%	0.8	1	1.2	1.4
Poly ethylene glycol	l/m3	4.117	5.15	6.175	7.20

Table 5.2: Mix Proportions

C. Fresh Concrete Test Results

1) Slump Test Results

Sl No	Series	Poly ethylene glycol %	Slump value in mm
1	S 1	0	76
2	S 2	0.2	81
3	S 3	0.4	84
4	S 4	0.6	87
5	S 5	0.8	89
6	S 6	1.0	91
7	S 7	1.2	93
8	S 8	1.4	96

Table 5.3: Slump Value

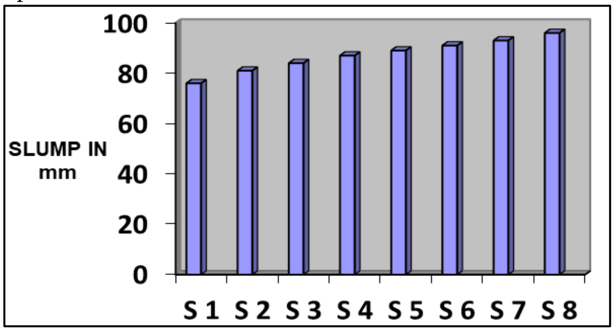

Fig. 5.1: Variation of Slump Value

From table 5.4, it is observed that with increase in % of poly ethylene glycol the slump value also increases. The self-curing concrete has more slump value compared to conventional concrete.

D. Compressive Strength Test Results at 7, 28, 56 & 90 Days

Series	Poly ethylene glycol %	Light weight fine aggregate %	Avg. compressive strength 7 days(N/mm2)	Avg. compressive strength28 days(N/mm2)	Avg. compressive strength 56 days(N/mm2)days(N/mm2)	Avg. compressive strength 90 days(N/mm2)
S 1	0	0	20.89	25.43	28.12	29.71
S 2	0.2	25	20.93	29.85	32.94	33.42
S 3	0.4	25	21.89	32.44	35.71	36.79
S 4	0.6	25	22.47	32.91	35.78	37.09
S 5	0.8	25	22.91	33.09	35.98	37.14
S 6	1	25	23.02	33.24	36.14	38.71
S 7	1.2	25	21.23	30.77	33.79	34.78
S 8	1.4	25	18.99	26.06	32.09	31.97

Table 5.4: Compressive Strength at 7, 28, 56 & 90 Days

From table 5.5, it is observed that compressive strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol. The compressive strength of self-curing concrete of 0.2%, 0.4%, 0.6%, 0.8%, 1%, and 1.2% reached design strength in 7 day, 28 day, 56 day and 90 days test. The compressive strength of self-curing concrete of 1.2% and 1.4% did not reach design strength in 7 day, 28 day, 56 day and 90 days test.

E. Split Tensile Strength Test Results at 28, 56, 90 Days

Sl No	Series	Poly ethylene glycol %	Lightweightfine aggregate %	Avg. split tensile strength 28days(N/mm2)	Avg. split tensile strength56 days(N/mm2)	Avg.split tensile strength 90 days(N/mm2)
1	S 1	0	0	3.47	3.58	3.68
2	S2	0.2	25	3.51	3.63	3.81
3	S3	0.4	25	3.62	3.71	3.94
4	S4	0.6	25	3.66	3.82	3.96
5	S5	0.8	25	3.71	3.90	3.99
6	S 6	1.0	25	3.77	4.04	4.18
7	S7	1.2	25	3.68	3.81	3.87
8	S8	1.4	25	3.56	3.79	3.72

Table 5.5: Split Tensile Strength 28, 56, 90 Days

From table5.6, it is observed that split tensile strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol. The split tensile strength of self-curing concrete reached design strength in 28, 56, 90 days test. The split tensile strength does not show large variation with change in poly ethylene glycol.

F. Flexural Strength Test Results at 28, 56, 90 Days

Series	Poly ethylene glycol %	Light weight fine aggregate %	Avg.Flexural strength28 days(N/mm2)	Avg. Flexual strength 56 days(N/mm2)	Avg. Flexual strength 90 days(N/mm2)
S 1	0	0	3.67	3.99	4.14
S2	0.1	25	3.74	4.12	4.21
S3	0.2	25	3.84	4.23	4.29
S4	0.3	25	3.93	4.41	4.42
S5	0.4	25	3.99	4.67	4.46
S 6	0.5	25	4.14	4.82	4.73
S7	0.6	25	3.97	4.61	4.44
S8	0.7	25	3.80	4.30	4.28

Table 5.6: Flexural Strength 28, 56, 90 Days

From table 5.7, it is observed that flexural strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol. The flexural tensile strength of self-curing concrete reached design strength in 28, 56, 90 days test. The split tensile strength does not show large variation with change in poly ethylene glycol.

G. Discussions

Performance of self-curing concrete with polyethylene glycol in varying 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%,and 1.4% and 25% light weight fine aggregate is compared to that of normal concrete.

1) Comparing Compressive Strength of 7 days

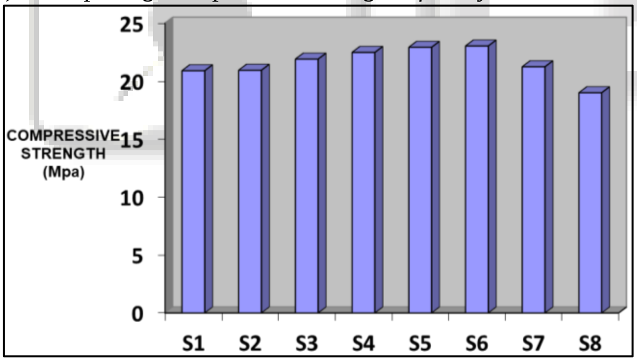

Fig. 5.2: Comparing Compressive Strength 7 Days

From table 5.4, it is observed that compressive strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

2) Comparing Compressive Strength of 28 Days

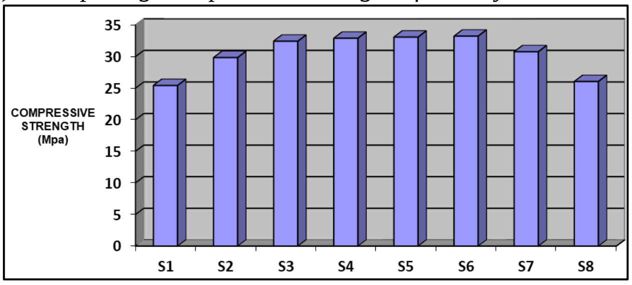

Fig. 5.3: Comparing Compressive Strength 28 Days

From table 5.4, it is observed that compressive strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol

3) Comparing Compressive Strength of 56 Days

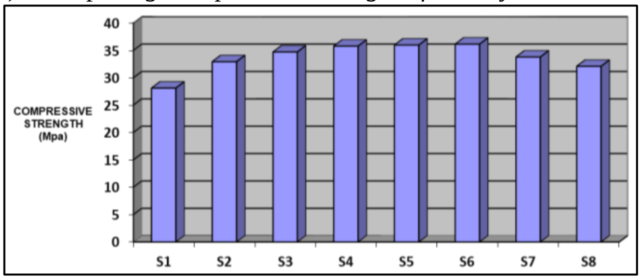

Fig. 5.4: Comparing Compressive Strength 56 Days

From table 5.4, it is observed that compressive strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol

4) Comparing Compressive Strength of 90 Days

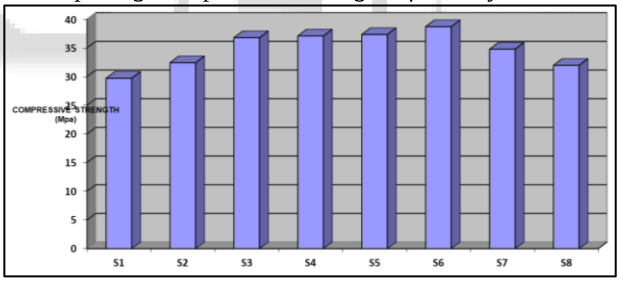

Fig. 5.4: Comparing Compressive Strength 90 Days

From table 5.4, it is observed that compressive strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol

5) Comparing Split Tensile Strength of 28 Days

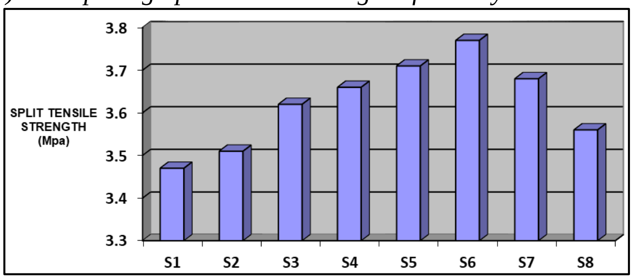

Fig. 5.5: Comparing Split Tensile Strength of 28 Days

From Fig 5.5, it is observed that split tensile strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

6) Comparing Split Tensile Strength of 56 Days

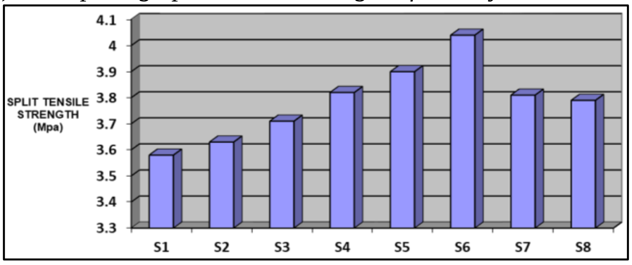

Fig. 5.6: Comparing Split Tensile Strength of 56 Days

From Fig 5.5, it is observed that split tensile strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

7) Comparing Split Tensile Strength of 90 Days

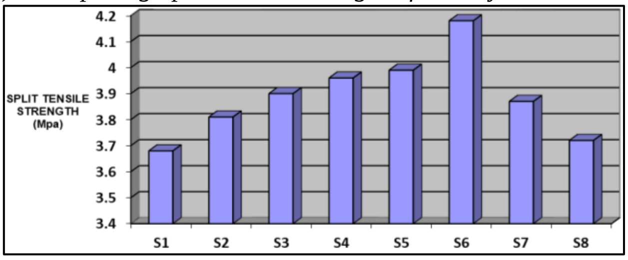

Fig. 5.7: Comparing Split Tensile Strength of 90 Days

From Fig 5.5, it is observed that split tensile strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

8) Comparing Flexural Strength of 28 Days

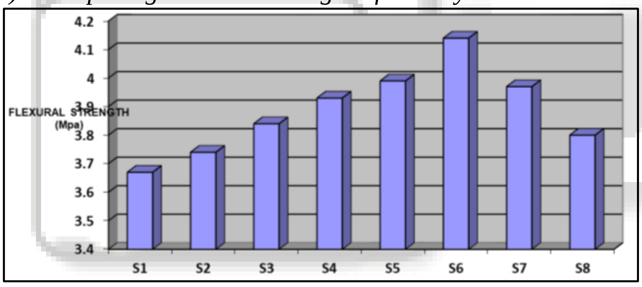

Fig. 5.8: Comparing Bending Strength of 28 Days

From table 5.6, it is observed that flexural strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

9) Comparing Flexural Strength of 56 Days

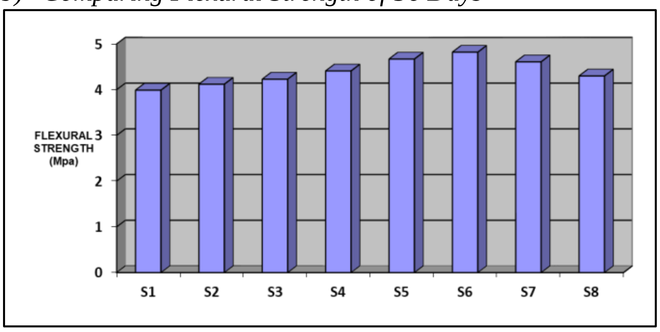

Fig. 5.9: Comparing Bending Strength of 56 Days

From table 5.6, it is observed that flexural strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

10) Comparing Flexural Strength of 90 Days

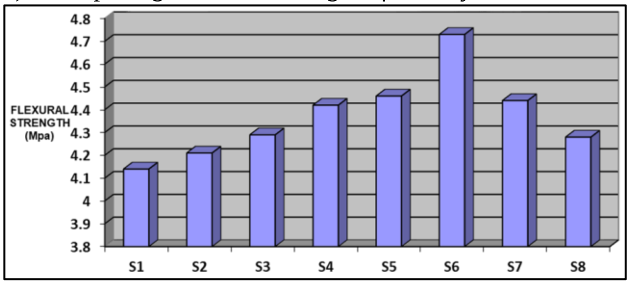

Fig. 5.10: Comparing Bending Strength of 90 Days

From table 5.6, it is observed that flexural strength increased with increase in % of poly ethylene glycol till 1% and then decrease with increase in % of poly ethylene glycol.

VI. Conclusions

In this project, the mix design for control concrete grade of M25 have been design as 1: 1: 2. Self-curing concrete is useful in water scarce areas and in places where good quality water is not available. The self-curing concrete required have been arrived from the control concrete with addition of 25% of light weight fine aggregate and poly ethylene glycol (0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, and 1.4% of cement). Compressive specimen was prepared and tested.

It is observed from the test results and the following conclusion have been drawn

- Compressive strength increased with increase in % of poly ethylene glycol till 1% and then decreased with increase in % of poly ethylene glycol.
- The optimum % of poly ethylene glycol was found to be 1% for compressive strength.
- Same as compressive strength split tensile strength increased with increase in % of poly ethylene glycol till 1% and then decreased with increase in % of poly ethylene glycol.
- Like both compressive strength and split tensile strength flexural strength increased with increase in % of poly ethylene glycol till 1% and then decreased with increase in % of poly ethylene glycol.
- The compressive strength of self-curing concrete of 0.0% 0.2%, 0.4%, 0.6%, 0.8% and 1%, reached design strength in, 7 day and 28 day, 56 day and 90 days test but the compressive strength of self-curing concrete of 1.2% and 1.4% did not reach design strength in 7,28,56,90 days.
- The flexural tensile strength and split tensile strength of self-curing concrete reached design strength in 28,56,90 days
- The fresh self-curing concrete has more slump value compared to conventional concrete.
- The slump value increased with increase in % of poly ethylene glycol.
- The compressive strength, split tensile strength and flexural strength for control concrete was higher than that of self-curing concrete.
- The self-curing concrete has 10% more strength when compared to conventional concrete.

