STRENGTH PERFORMANCE OF SELF CURING CONCRETE IN COMPARISON WITH CONVENTIONAL CONCRETE

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Abstract: Today concrete is most widely used construction material due to its good compressive strength and durability. The concept of several self-curing agents is to reduce water evaporation from concrete. And hence there is a need to 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. The aim of this investigation is to study the strength and durability properties of concrete using water-soluble Polyethylene Glycol as self-curing agent. The function of self-curing agent is to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to the conventionally cured concrete. As the water is becoming more scarce now-a-days there is need to implement new techniques to reduce usage of water in construction field. In this study, compressive strength, flexural strength and split tensile strength of concrete containing self-curing agent are investigated and compared with those of conventionally cured concrete. Poly Ethylene Glycol is used as a self curing agent in various percentages as 1%, 1.5% and 2% by weight of cement. M30 concrete mix is used in the study and strength properties of the specimen are determined after 7 days, 14 days and 28 days. Poly ethylene glycol 400 (PEG 400) is a super absorbent polymer which reduces the evaporation of water from the surface of concrete and also helps in water retention. In PEG 400, 400 represent the average molecular weight.

***Keywords*: PEG, Self Curing Concrete, Normal Curing Concrete, Compressive Strength, Split Tensile Strength.**

I. INTRODUCTION

1.1 Concrete:

Concrete is made of Portland cement, water, cement substitutes and aggregates. Portland cement is hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. The setting and hardening of concrete are the outcome of chemical and physical developments that take place between Portland cement and water called hydration. This hydration reaction is an exothermic reaction, which liberates large quantity of heat, and this is to be dissolute for continuing hydration process. When aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses.
Many types of concrete are available, distinguished by the proportions of the main ingredients. In this way or by substitution for the cement and aggregate phases, the finished product can be tailored to its application. Strength, density, as well as chemical and thermal resistance are variables.
Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand. Cement, most commonly Portland cement, is associated with the general term "concrete." A range of other materials can be used as the cement in concrete too. One of the most familiar of these alternative cements is such as fly ash and slag cement sometimes added as mineral admixtures pre-blended either with the cement or directly as a concrete and become a part of the binder for the aggregate.

1.2 Self Curing Concrete:

Today concrete technology has been undergoing rapid improvement. Cement concrete is an artificial building material that is obtained by mixing together cement, water and some other inert materials. Concrete has number of characteristics that can improve the sustainability performance of building of structure. For better performance and durability, proper curing of concrete is important. Curing of concrete is one major area that lacks due attention and due importance in the construction field.
Curing is the process or operation which controls the loss of moisture from concrete after it has been placed in position, or in the manufacture of concrete products, thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time, days, and even weeks, rather than hours, curing must be undertaken for some specified period of time if the concrete is to achieve its potential strength and durability. 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. Curing period will depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, that is the temperature and relative humidity of the surrounding atmosphere.

1.3 Criteria for selection of Self Curing Concrete in India:

As water becoming a scare material day-by-day, there is an urgent need to do control the water usage in making concrete and in constructions. When concrete is exposed to the environment vaporization of water takes place. The moisture loss in concrete will minimize the water cement ratio initially and this result in the incomplete hydration of the cement and this incomplete hydration of cement will reduce the quality of the concrete. Due to cement hydration chemical shrinkage occurs, empty pores are also created within the cement paste, it is leading to a decrease in its internal relative humidity and also to shrinkage which may cause early-age cracking.

In these day's many techniques are getting introduced and rapid improvement in the concrete technology is taking place. To modify property of concrete some chemical & mineral admixture are used. Self-curing is one of the techniques, which is used in water lacked and low water resource areas. Many researches are concerned to identify effective self-curing agent. Internal curing helps concrete realize its maximum potential in a simple, economical and sustainable way. Self-curing or internal curing is a system that can be utilized to give extra moisture in concrete to progressively powerful hydration of bond and to diminish the self-drying up. Internal curing refers to providing additional internal water that helps prevent early age shrinkage (reducing early age cracking), and increases hydration of cementitious materials throughout the concrete.

The mechanism of internal curing is holding the preserved water content of concrete structures within it. So concrete structures are not required any additional water for curing purpose. Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials 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.

II. LITERATURE REVIEW

Patel Manish Kumar Dahyabhai: They studied the effect of polyethylene glycol (PEG 400) on strength characteristics of Self-curing concrete. The objective was to study the mechanical characteristics of concrete such as workability, compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG from 0% to 2% by weight of cement for both M20 and M40 grades of concrete. The experimental program was designed to investigate the strength of self-curing concrete by adding poly ethylene glycol PEG400 @ 0.5%, 1%, 1.5% and 2% by weight of cement to the concrete. The plain samples were cured for 28 days in water pond and the specimens with PEG400 were cured for 28 days at room temperature by placing them in shade. Test specimen: The size of each cube is 150 x150 x 150 mm. The size of each cylinder is 150 mm in diameter and 300 mm in height. The size of each prism is 100 x100 x 400 mm. He concluded that, the optimum dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1% for M20 and 0.5% for M40 grades of concrete. Further increasing the dosage resulted in decreased strengths. As percentage of PEG400 increased, slump and compacting factor increased for both M20 and M40 grades of concrete. But, the rate of increase of slump & compaction factor for M40 concrete is less than that of M20 concrete. Strength of self-curing concrete is on par with conventional concrete.

Mohanraj A, et.al (2016) studied on "self-curing concrete incorporated with polyethylene glycol". The compressive strength of cube for Self-cured concrete is higher than of concrete cured by conventional curing method. The split tensile strength of self-cured concrete specimen is higher than that of the conventionally cured specimen. Self-cured concrete is found to have less water absorption values compared with concrete cured by other methods. Self-cured concrete thus have a fewer amount of porous.

Vishnu Kumari M aim to compare strength of M30 grade concrete achieved by conventional curing method and self-curing method. The present study involves the use of shrinkage reducing admixture polyethylene glycol in concrete which helps in self-curing and helps in better hydration and hence strength. Both PEG-400 and PEG-200 are used in the study in 0% to 2% by weight of cement. The compressive strength of concrete mix increased by 12.04% by adding 1.0% of PEG 400 and 9.18% by adding 0.5% of PEG 200 as compared to the conventional concrete. The optimum dosage of PEG400 for maximum compressive strengths was found to be 1% of weight of cement for M30 grades of concrete. The optimum dosage of PEG200 for maximum compressive strengths was found to be 0.5% of weight of cement for M30 grades of concrete.

Sreenivasa kumar A, Dr.Suresh Babu T studied the effect of admixture (PEG-200) on compressive strength, split tensile strength at one percentage for M25 mix was studied and it compared with the properties of PEA(PolyEthylene Alcohol). Also studied the mechanical characteristics of concrete such as compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG and PEA from 0% to 2% by weight of cement of M25 grade concrete. He concluded that the optimum strength values for both the self curing agents were found and among both the agents PEG-200 is a best and good self curing agent because in the durability and normal compressive strength aspects it was giving good results when compared with both conventional concrete and PolyEthylene Alcohol (PEA). It was found that Poly Ethylene Glycol-200 is a good self curing agent when compared with Poly Ethylene Alcohol.

S.M.Junaid, et al. (2015) The study involves the use of shrinkage reducing admixture polyethylene glycol (PEG-4000, 1% weight of cement) in concrete (grade ratio = 1:2.23:3.08) which helps in self-curing and in better hydration and hence strength and compared with that of conventional cured concrete. 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. 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. When concrete is cured at high temperature normally develops higher early strength than concrete produced and cured at lower temperature, but strength is generally lowered at 28 days and later stage. They concluded that, PEG-4000 was used as self-curing agent. It has been observed during testing, cubes of Normal Mix +PEG-4000

shows less crack and doesn't broke down even after throwing from almost 1m of height which is not in case of Conventional Mix alone. There is less shrinkage and good bonding observed in Normal+PEG-4000 which is not in case of Conventional Mix alone.

Mohanraj Rajendran M Studied on "self-curing concrete incorporated with polyethylene glycol". The compressive strength of cube by compression testing machine for Self-cured concrete is higher than of concrete cured by full curing and sprinkler curing. The split tensile strength of self-cured cylinder specimen is higher than that of the conventionally cured specimen. Self-cured concrete is found to have less water absorption values compared with concrete cured by other methods. Self-cured concrete thus have a fewer amount of porous. The success of the initial studies highlights the promise of additional work. In planned studies the mix design will be optimized for self-curing agent in concrete mix.

M. Geetha, Dr.R.Malathy (2011): In this research paper they compare the strength and durability properties of different grade concrete by using polymeric materials without use any external water. During this experimental work grade of concrete selected was M20, M30 and M40. Spinacia oleracea (palak greens) of 0.6% to 0.8% weight of cement is added as admixture to concrete while preparing concrete. Poly ethylene at 0.2% to 0.4% of cement were used as self curing agent. During experimental work split tensile strength, cylindrical compressive strength, acid resistance, sea water resistance and accelerated corrosion of concrete was observed. The strength as well as durability properties of specimens with palak green was better than other three alternatives and proved be best when compared to external curing. Also the cost of internal curing was cheaper than external curing.

The advantages of prefabricated building components are:
1. Self curing concrete uses PEG 400 as curing compound so water can be saved.
2. Strength of concrete is also increased.
3. Workability is also more is self curing concrete.
4. The early age cracking can be reduced.

III. MATERIALS USED FOR SELF CURING CONCRETE PREPARATION:

- Ordinary Portland Cement of 53 Grade cement conforming to IS: 169-1989.
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Poly Ethylene Glycol 400
- Water.

3.1 Cement:

Generally, selection criteria for cement is depend on requirement of strength and durability of concrete. The cement used in this experimental works is "53 Grade Ordinary Portland Cement". Grade-53 cement has the good quality and high durability. It is generally used for concreting of residential buildings.
Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

Table-1: Properties of Opc 53 Grade Cement

S .no.	**Characteristics**	**Value obtained Experimentally**
1	Specific Gravity	3.16
2	Normal Consistency	32%
3	Initial Setting Time	27 minutes
4	Final Setting Time	600 minutes
5	Fineness	3.2%
6	Soundness of Cement	0.2

3.2 Fine aggregate:

Fine aggregate is the natural material. The fine aggregate effectively fills all the open spaces in the middle of coarse aggregates. Therefore, it diminishes the porosity of the last mass and significantly builds its quality. The fine aggregate means the stones which are passing through the 4.57 mm sieve with specific gravity of 2.79 and water absorption is 3.5%.
Sand is naturally occurring material from rock and minerals by weathering and composed of majorly SiO_2, and calcium carbonate. The sand used throughout the experimental work was obtained from the Godavari River i.e., locally available.

Table-2: Properties Of Fine Aggregate

S .no.	Characteristics	Value obtained Experimentally
1	Fineness Modulus of fine aggregate	2.72
2	Specific gravity of fine aggregate	2.61

3.3 Coarse aggregate:

Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve are called coarse aggregate. The coarser the aggregate, more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

Coarse Aggregates are a main material of concrete. The role of aggregate is to give reinforcement in concrete. The 10mm and 20mm sized coarse aggregates are used. The water absorption capacity of it is 2%.

Table-3: Properties Of Coarse Aggregate

S .no.	Characteristics	Value obtained Experimentally
1	Fineness modulus of coarse aggregate	6.15
2	Flakiness index	39.18%
3	Elongation index	42.27%
4	Specific gravity of coarse aggregate	2.631
5	Impact test	19.3%

3.3 Polyethylene glycol-400:

Polyethylene Glycol (PEG) is a condensation polymer of ethylene oxide and water having a general formula $H-(OCH_2 - CH_2)_n-OH$, where n is the average number of repeating oxy ethylene groups typically ranging from 4 to 180 approx. The abbreviation (PEG) is defined in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble substance. PEG is non-toxic, odourless, lubricating, neutral, non-volatile and non-irritating and is used in a variety of Pharmaceutical works.

Table-4: Properties Of Peg-400

S. No.	Description	Properties
1.	MOLECULAR WEIGHT	400
2.	APPEARANCE	CLEAR FLUID
3.	MOISTURE	0.2%max.
4.	Ph	5-7
5.	SPECIFIC GRAVITY	1.12

3.4 Water:

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid, etc., in general, the water, which is fit for drinking should be used for making concrete.

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. Details of the hydration process are explored in the next section. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete or otherwise interfere with the hydration process. The role of water is important because the water to cement ratio is the most critical factor in the production of perfect concrete. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped into different forms (i.e., walls, domes, etc.). Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete.

IV. METHODOLOGY

4.1 Compressive strength of self curing concrete:

The compressive strength of concrete is carried out on a cubical specimen of size 150mm x 150mm x 150mm. And these casted cubes for tested for 7 days, 14 days and 28 days using compressive testing machine.

It is determined from the expression given below.

Compressive strength σb = P/A, in Mpa

Where, P = Maximum applied load in KN

A = Area of mould

Table-5: Compressive Strength Values

Mix	% of PEG 400 / No. of days	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M 30	Conventional concrete	23.92	30.08	38.25
	1%	23.51	29.57	37.92
	1.5%	25.04	31.81	39.76
	2%	23.63	29.72	38.11

4.2 Tensile strength of self curing concrete:

The tensile strength of concrete is carried out on a cylindrical specimen of size 150 mm diameter and 300 mm length. And these casted cylinders for tested for 7 days, 14 days and 28 days using compressive testing machine.

It is determined from the expression given below.

$$F_t = \frac{2p}{\pi DL}$$

Where, F_t = Split tensile strength in N/mm^2

p = Compressive load on the cylinder

L = Length of the cylinder

D = Diameter of the cylinder

Table-6: Tensile Strength Values

Mix	% of PEG 400 / No. of days	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M 30	Conventional concrete	1.9	2.12	2.2
	1%	2.0	2.29	2.4
	1.5%	2.1	2.35	2.45
	2%	2.02	2.26	2.35

3.4.3 Flexural strength of self curing concrete:

The flexural strength of concrete is carried out on a beams of size 100mm×100mm×500mm. And these casted cylinders for tested for 7 days, 14 days and 28 days using compressive testing machine.
It is determined from the expression given below.

$F_{cr} = \frac{3Pa}{b \times d^2}$ when a = 11.0 cm to 13.3 cm for cross section 10 cm × 10 cm

Where
P is maximum load at failure.
L is length of the span on which the specimen is supported.
b is measured width of the specimen.
d is measured depth of the specimen at the point of failure.

Table-7: Tensile Strength Values

Mix	% of PEG 400 / No. of days	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
M 30	Conventional concrete	5.39	5.99	6.21
	1%	5.55	5.79	5.88
	1.5%	6.04	6.40	6.54
	2%	4.74	5.1	5.23

V. METHODOLOGY

5.1 Compressive strength of self curing concrete:

The results of the compressive strength are represented in Table 5 and the graphical representation is shown in Fig 1.The compressive strength was found to increase up to 1.5%PEG400 and then decreased for M30 grade. The increase in compressive strength was 3.94% at1.5% of PEG 400 compared to conventional concrete for M30 grade concrete.

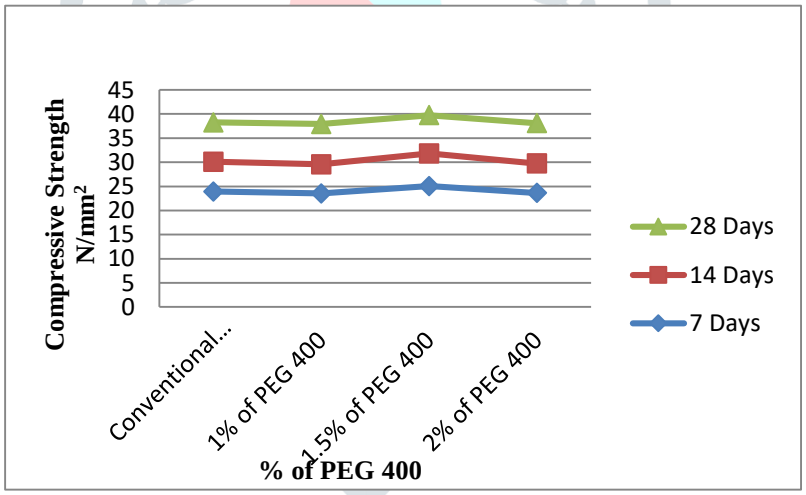

Fig.1Variation of compressive strength

5.2 Split tensile strength of self curing concrete:

The results of the split tensile strength are represented in Table 6 and the graphical representation is shown in Fig 2. The split tensile strength was found to increase up to 1.5% PEG400 and then decreased for M30 grade. The increase in split tensile strength was 11.36% at 1.5% of PEG 400 compared to conventional concrete for M30.

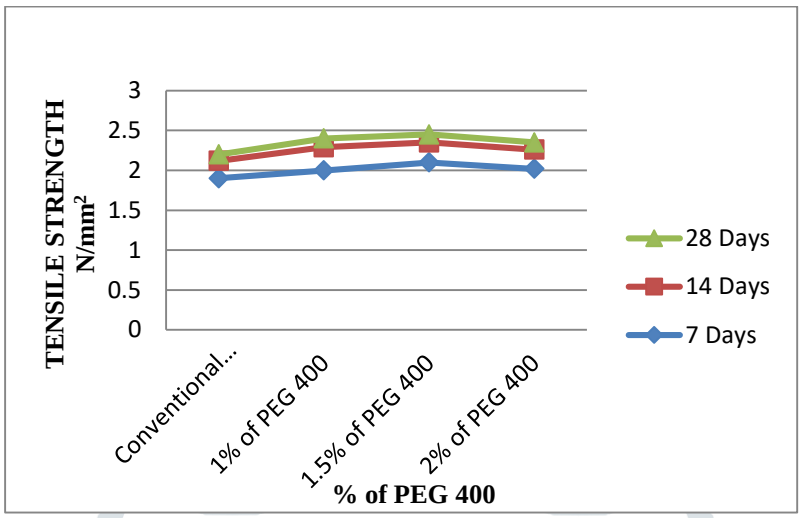

Fig.2 Variation of tensile strength

5.3 Flexural strength of self curing concrete:

The results of the flexural strength are represented in Table 7 and the graphical representation is shown in Fig 3. The flexural strength was found to increase up to 1.5% PEG400 and then decreased for M30 grade. The increase in split tensile strength was 5.31% at 1.5% of PEG 400 compared to conventional concrete for M30.

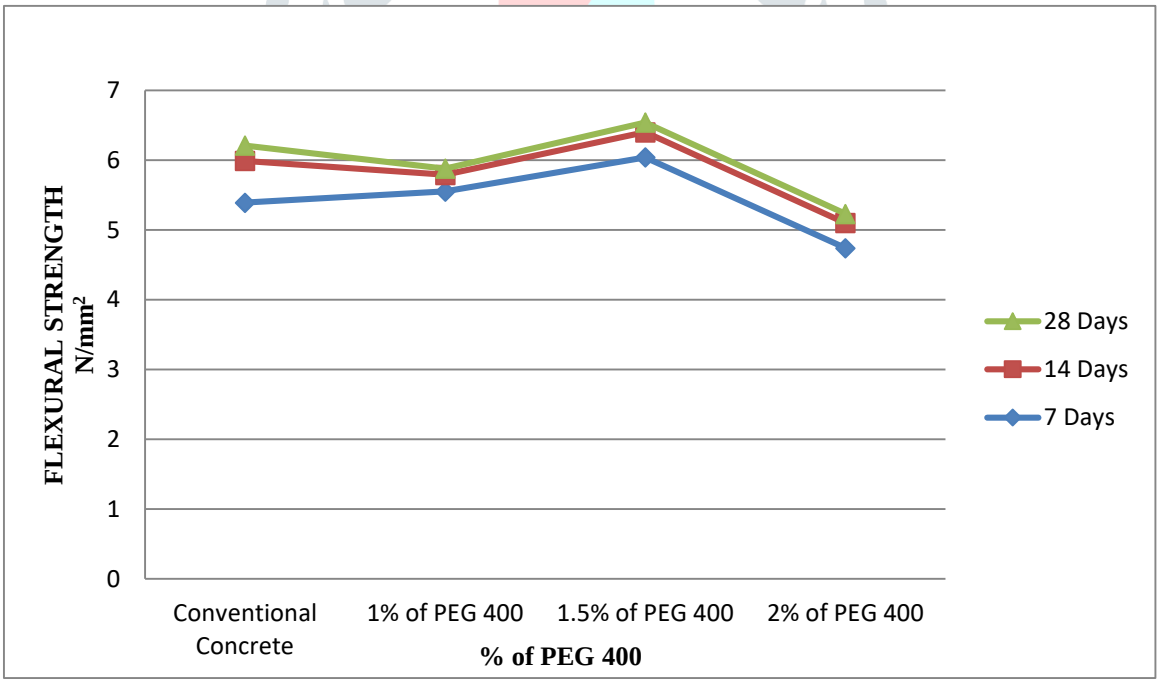

Fig.3 Variation of flexural strength

VI. CONCLUSIONS

The optimum dosage of PEG 400 for maximum compressive strength was found to be 1.5% for M30 grade of concrete. As PEG 400 increased, slump value is increased for M30 grade of concrete. From the workability test results, we observed that the self curing agent has increased the workability results. Self curing concrete is an alternative to conventional concrete in desert regions were scarcity of water is a major problem. Self curing concrete is the answer to many problems faced due to lack of proper curing. Self – Curing concrete is an alternative method to conventional concrete in desert regions where scarcity of water is a major problem.

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