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A REVIEW ON THE STUDY OF SELF CURING CONCRETE

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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).**

1. INTRODUCTION

Concrete is a versatile material of civil engineering composed of cement, fine aggregates, and coarse aggregates with or without admixture when mixed with water it hardens with time. Concrete is generally known for its strength and durability. The strength attained by concrete depends on the rate of hydration which is attained by sufficient and efficient curing. Curing of concrete is a method by which the concrete is protected against loss of moisture content, which is required for hydration and kept the concrete within the recommended temperature range. Curing of concrete is done to maintain the satisfactory moisture content i.e. to prevent the water from evaporation which is required for the hydration of cement, to avoid shrinkage cracks and maintain its physical and mechanical property of concrete. The curing of concrete increases the compressive strength; improves durability; impermeability and abrasion resistance. There are three basic ways to do it.

The first keeping the surface of concrete moist by using the pounding, sprinkling/spraying, damp sand methods. The second method is to avoid the loss of moisture from the concrete by covering the exterior surface with polythene sheeting or leaving the formwork in place. The third involves the use of spray or roller which is known as curing compounds. Nowadays new technique develops known as Self-curing. According to ACI-308 Code, "self-curing may be defined as 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". In contrast, self-curing is allowed for curing "from the inside to outside" in the form of saturated lightweight fine aggregate which acts as internal reservoirs. Self-curing is done by use of Lightweight expanded clay aggregate (LECA) or use of chemical admixtures, Such as Polyethylene glycol (PEG), Polyvinyl Alcohol (PVA), Sodium lignosulphonate, Superabsorbent polymer (SAP), Liquid paraffin wax (LPW), Solid paraffin wax (LSW), wood powder, etc shown in fig.1. In this review paper, we are going to study the strength characteristic of concrete made with optimum proportions of ingredients. The review consequences show that the physical and mechanical properties of concrete by adding different self-curing agents with different dosage limits.

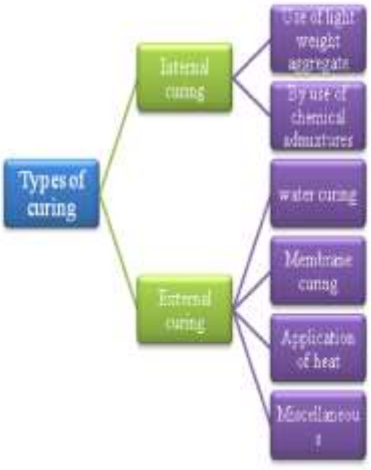

Figure 1: TYPES OF CURING

2. Mechanism of internal curing:

From the concrete surface, the evaporation of moisture takes place continuously due to the variation in the chemical potential, free energy space between the liquid and vapor phase. At the time of mixing the polymers are added in concrete which mainly from hydrogen bond between the water molecules and helps to reduce the chemical potential of the molecules due to this the vapor pressure reduces and the rate of evaporation from the exterior surface reduced.

3. Scope:

The primary aspire of this research is to study the past work done upon the self-curing concrete by using various techniques and different self-curing admixtures.

4. LITERATURE REVIEW:

4.1. Review based on compressive strength:

The compression strength of concrete may be defined as the capability of the concrete to resist loads that tend to compress it.

4.1.1. By adding of mineral admixtures:

There are many mineral admixtures which help to increase the compressive strength of concrete. While cement is relatively replaced with metakaolin there is a significant increase in the strength of concrete. The maximum value was obtained for a 20% replacement of cement by metakaolin [1]. Fly ash of around 15 percent exhibited greater strength under self-curing conditions [10]. The considerable upgrading in all the concrete properties due to the addition of 15% of silica fume. Fly ash replacement level of 20% can be considered in view of the economy and durability of concrete in the long run [19]. The 15% silica fume by weight of cement as an additional mineral used in concrete mixed gives as higher strength [20]. Pond ash a by-product of the coal power plant, the use of pond-ash in concrete which is waste product reduces the number of resources. As the pond ash act as cement alternate, the 30% pond ash gives the higher compressive strength [4]. The combination of silica fume with limestone powder as a mineral admixture in the properties of self-compacting concrete is analyzed and finds that the maximum 8% of limestone grind among 30% silica fume 14% quarry dust and clinkers are used as a mineral admixture without affecting the self-compact ability of concrete. Silica fume is used to improve the mechanical properties of self-compacting concrete (SCC), while limestone powder along with quarry dust affected the properties of self-compacting concrete (SCC) adversely [22]. Table 1 and fig 2 shows the different percentage of admixture used in self curing concrete.

Table 1: Percentage of Mineral admixture used in a self-curing concrete.

Metakaolin	20%
Fly ash	15%
Silica Fume	15%
Pond ash	30%
Limestone	8%
Quarry dust	30%
Clinkers	14%

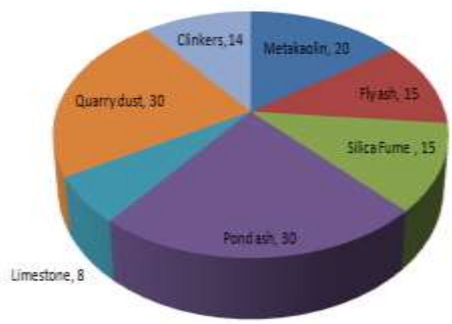

Figure 2: Maximum Percentage of Mineral admixture used in the concrete.

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4.1.2. By use of different self-curing admixture:

Polyethylene Glycol 600 and PEG 400 as a self-curing admixture for the concrete grade of M20. It was found that the maximum compression strength is obtained by the use of 1% of PEG600 and PEG400 [1],[19], and [21]. For the M40 grade of concrete, the compressive strength increased by the use of 0.5% of PEG400 and 0.24% of PVA. But after 28 days 0.5% PEG+0.24% PVA gives more strength [2],[19],[21].For M25 grade of concrete 1.5% of PEG-4000,1% of PEG6000,0.25% of PVA, super absorbed polymer (SAP) 0.25%,PEG-200 1% and polyethylene alcohol (PEA) 1% gives the maximum compressive strength [3],[13],[17].For M30 grade of concrete super absorbed polymer (SAP) 0.6%, PVA 0.5% and sodium polyacrylate 0.3% provides maximum compressive strength[4],[11],[17]. From the tests conducted at 3,7,28 and 90 days with a different ratio from 0% as a control concrete and 1%,2%, 3%, 5% and 10% by adding the baby diaper polymer. From the result, it has been obtained that, 1% of diapers polymers have the optimum result [5].Design mix (1:2.2:4) the optimum dosage when using PEG400 is 4%, for PAM 0.01%. When mixing the two chemical curing agents used as 1.0%PEG400+0.01%PAM, the mechanical properties of SC concrete significantly improved compared to using each of PEG400 or PAM individually at all ages [7]. For M40 grade of concrete PEG 600 2% and lightweight fine aggregate (LECA), 20% provides maximum compressive strength [9]. For Dolomite type of aggregate 0.25% of PEG400, for crushed concrete aggregate/recycled aggregate 0.25% of PEG400 and for a crushed red brick aggregate 0.5% of PEG is the optimum dosage and the compressive strength increased 14.1%, 12%, and 1.75%, respectively[12]. By use of sodium lignosulphonate, the compressive strength of concrete increased at the rate of 6.25% by use of 0.5% of sodium- lignosulphonate as compare with normal concrete of grade M20 with same water-cement proportion (0.5) for normal and self-curing concrete. [14]. Cement contents of (300,400,500) kg/m^3 and water-cement proportion of 0.0, 0.3, 0.4 and 0.5%. In all the cases, either 2% polyethylene-glycol (Ch) or pre-soaked lightweight aggregate (Leca) of 15% be the most favorable proportion compared with the other ratios from (1–3% ch.) or (10–20%leca), respectively [20],[18].

Table ii: Compressive strength of concrete with different grades and different admixtures.

	M20	M25	M30	M40
PEG200	-	0.25%	-	-
PEG400	1%	-	-	0.5%
PEG600	1%	-	-	2.0%
PEG4000	-	1.5%	0.5%	-
PEG6000	-	1%	-	-
PVA	-	0.25%	0.5%	0.24%
PEA	-	1%	-	-
SAP	-	0.25%	0.6%	0.3%
sodium polyacrylate	-	-	0.3%	-
Sodium lignosulphonate	0.5%	-	-	-
LECA	-	-	-	20%

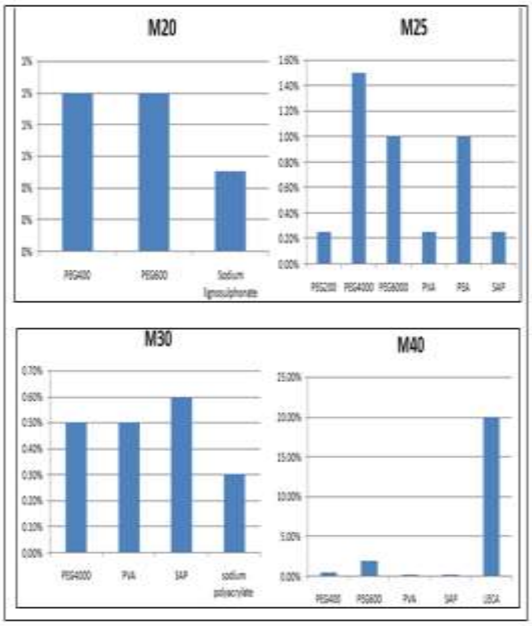

Figure 3: The optimum dosage of different admixtures in a different grade of concrete for compressive strength.

4.1.3. Review based on tensile strength:

Tensile strength is one of the most significant properties of concrete it is the ability of a material to withstand tensile load but concrete is vulnerable in tensile. To check the tensile strength of concrete specimen we use indirect tensile methods due to the difficulty in applying uniaxial tension in the

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specimen. The specimen is checked by (1) Split-tensile strength test and (2) Flexural strength test. In split tensile strength we use a cylinder of diameter 150 and length 300mm placed in horizontally between the load plates in CTM or UTM machine. In the flexural tensile test, the beam of size 150×150×700 or 100×100×500 used depends upon the size of coarse aggregate. The maximum split tensile strength and flexural strength were obtained when 1 percent of PEG 6000 and SAP 0.4% was used for M25 grade of concrete.PEG 6000 provide more tensile strength then PEG 4000 [3],[17].For M30 grade of concrete SAP 0.5%, PVA 0.50%, pond ash 30% provide us more split tensile and flexural strength [4],[17]. Design mix 1:2.2:4 with different self-curing agents PEG400 and PAM the split tensile strength and flexure strength increased when 4% of PEG 400 and 0.01% of PAM are used. A combination of these chemicals gives us more tensile strength [7]. 20% (LECA) and 2 % polyethylene glycol combination provide as optimum split tensile strength and flexural strength for M40 grade of concrete [9]. For M30 grade of concrete 0.5% of sodium, polyacrylate is optimum for the flexural strength of concrete [11]. Recycled aggregate concrete in which dolomite, crushed concrete, crushed red brick use as an aggregate because it decreased environmental impact and save natural resources. And also, PEG 400 was used to condense the water loss from concrete. Dolomite and 0.25% of PEG, crushed concrete and 0.25% of PEG and crushed red brick with 0.5% of

Table iii: The optimum dosage of different admixture in a different grade of concrete for tensile strength

	PEG 200	PEG 400	PEG 6000	PVA	PEA		sodium lignosulphonate	sodium polyacrylate	LECA
M20	-	1%	-	-	-	-	0.5%	-	-
M25	1%	-	1%	—	1%	0.4%	-	-	-
M30	—	-	-	0.5%	-	0.5%	-	0.5%	-
M40	—	0.5%	-	-	-	-	-	—	20%

PEG used as an optimum dosage for split tensile strength and flexural strength [12]. For M25 concrete PEG 200 and PEA (poly Ethylene Alcohol), 1% provides the maximum split tensile strength among both of them PEG 200 is a good quality self-curing agent and 0.5% of SAP (super absorbed polymer) provides maximum tensile strength of concrete [13],[17] .0.5% of sodium lignosulphonate provides us more split tensile as the percentage of sodium lignosulphonate increased the tensile strength decreased [14].For M20, 1% PEG 400 and for M40, 0.5% of PEG 400 provides maximum split tensile and flexural strength of concrete [19],[21]. With different cement contented and the different water-cement proportion of 2% of PEG and 15% of the pre-soaked lightweight aggregate (LECA) is the optimum dosage for indirect tensile strength [20].

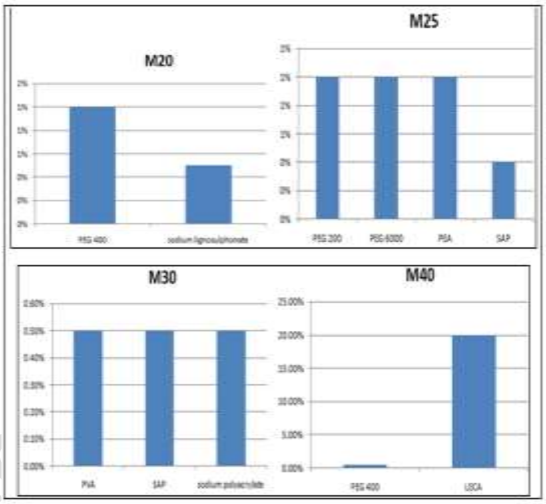

Figure 4: The optimum dosage of different admixture in a different grade of concrete for tensile strength

4.1.4. Review based on workability test:

Workability may be defined as easy by which concrete can be mixed, transport, place, compact and finish. As the percentage of polyethylene glycol (PEG) 400 and polyvinyl alcohol (PVA) increased slump also increased for M40 grade of concrete [2]. For a grade of M25 concrete, the use of self-curing agent PEG6000, PVA, SAP slump increased among all of these three SAP provides more workability [3]. As the percentage of pond ash, PAM increased workability decreased [4],[7]. If we increased the percentage of lightweight aggregate (LECA) and fly ash up to 15% slump increased [9],[10].

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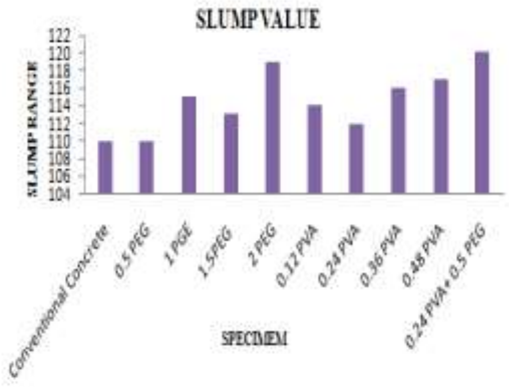

Figure 5: Graphical representation of Slump Value (K. A man and S.Parihar 2018)

4.1.5. Review based on Durability test:

The durability of concrete may be defined as the serviceable life of the structure under different environmental conditions. The durability of concrete can be tested by many durability tests. To calculate the marine effect the durability study was done by using marine water and calculated the loss of a percentage of compressive strength compared to the normal concrete. The loss of compressive strength in self-curing concrete is less as compared to the normal concrete [17, 13]. One of the other studies was carried out with or without silica fume (SF) and chemical shrinkage reducing admixture polyethylene-glycol (PEG), also lightweight expanded clay aggregate (LECA) used as a self-curing. In this cement content of 400 Kg/m^3; silica fume 15% and chemical admixture polyethylene-glycol 2% weight of cement used and also 15% (LECA) by volume of fine aggregate used water-cement proportion 0.4 were selected for this study. The specimens were cured by four regime: First specimen was set aside in air at a temperature of 25°C for 28 days; second specimen was kept in air at a temperature of 50°C for 28 days; the third specimen was exposed to carbon-dioxide of 5% for a period of 6 months, and the fourth specimen exposed to wet and dry cycles in a saline water of 8% sodium chloride for the period of 6 month. Air curing (25°C) at 28 days, self-curing concrete gives high compressive strength of (26.5, 20.6, and 8.8) percent correspondingly. In elevated temperature (50°C), after 28 days self-curing exhibits high compressive strength by about 21.6; 16.2 and 8.1 percent correspondingly. The reduction of 18.4% and 26.7% for compressive and tensile strength of normal concrete. Polyethylene-glycol 2% gives the optimum results for mechanical and physical properties in all four curing regimes [15]. The performance of self-curing concrete at higher temperature levels of about 200°C; 400°C; and 600°C for a heating period of 2h and 4h and also air and water cooling deed for compressive strength and split tensile strength of normal concrete and self-curing concrete are deliberate. Air-cooling (as a slow cooling method) is more effective compared to water cooling (as fast cooling method) at high temperatures. Water-cooling may reduce the compressive and tensile strength of about 5-25% for ordinary concrete but not effective for SCC up to 400°C. Using water-cooling is suitable for self-curing concrete up to 400oC with heating time up to 2 h but when heating duration increases to 4 h or temperature increases to 600oC the air-cooling is preferable [16].

4.1.6. Review based on self-curing self-compacting concrete:

This research is upon the self-compacting self-curing concrete by the use of polyethylene glycol (PEG4000) for different dosages of range between 0.1 to 1% by the weight of. In this study, we find water retention and the Compressive strength of self-compacting concrete (SCC) with a low water-cement proportion. Along with the addition of PEG-4000, the optimum dosage is found to be 0.1% of self-compacting concrete (SCC) with a low water-cement proportion. The maximum dosage of the polyethylene glycol (PEG-4000) was 1% and the minimum dosage 0.1% [6]. Polyethylene glycol (PEG 400 and PEG 600) were used as a self-curing agent with different dosages of 1%; 2%; 3%; 4%; and 5%; and lightweight aggregate (LECA) 1%, 2%, 3%, and 4%, was used as an interior reservoir to help in internal curing.PEG and LECA added to different types of concrete mixes (NS-SCC) and (HS-SCC). The property of self-curing self-competing concrete depends on which type of curing agent is used specially when the workability and flowability are considered. In NS-SCC, the optimum value of PEG 400 is 3% while in the case of high-strength self-curing self-compacting concrete the optimum value obtained at 2% of PEG600. The (NS-SCC) and (HS-SCC) can be obtained by using an appropriate amount of self-curing chemicals. For (NS-SCC) PEG 400 gives us good workability and sufficient. While for (HS-SCC) concrete PEG 600 is suggested [8].

5. Conclusion Based on the literature study:

In the present study, several research papers were studied and the following conclusions are obtained:

- The self-curing method is applicable for both normal and self-compacting concrete in both laboratory and actual practices.
- Durability and workability of the concrete are enhanced by the use of self-curing admixtures.
- Mostly in all the cases, the strength of self-curing concrete is higher than conventional concrete with the same mix design.
- Self-curing concrete is answerable to many tribulations faced due to the lake of appropriate curing of concrete.
- Self-curing concrete used in desert regions as well as where the shortage of water is a major problem.
- Self-curing concrete is used in simple as well as complex structures shape. Where there is a problem of doing curing with another method.
- For maximum strength (compressive; tensile and flexural strength) the optimum dosages of PEG and PVA for different grades of concrete were found to be 0.5% to 1%.
- When mixing the two chemical curing agents used as 1.0%PEG400+0.01%PAM, the mechanical properties of SC concrete significantly improved compared to using each of PEG400 or PAM individually at all ages.
- By using the Sodium polyacrylate as filler in concrete or replacement in cement will reduce environmental pollution.
- From the research, it is found that the use of recycled aggregate such as Dolomite; Crushed concrete and Crushed red brick can be used in a self-curing concrete because it has the capability to store the high amount of water.
- Water-soluble chemical sodium-lignosulphonate is probably to use as a self-curing agent and the optimum strength of concrete was found to use 0.5% of sodium-lignosulphonate when compared with normal concrete.
- By the use of silica fume the significant development in all considered property of concrete due to the addition of 15% silica fume (SF) along with the self-curing agent.
- In different grades of concrete, the use of SAP increased the compressive strength and the most favorable of SAP is 0.5 to 1% weight of cement.
- A limestone with silica fume of 8% and quarry dust of 30% and 14% clinkers are worn as a mineral admixture without affecting the self-compacting ability of concrete.

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