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Study of Self Curing Concrete with Portland Pozzolana Cement

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ABSTRACT: This research is intended to furnish comparative Experimental investigation on the normal grades of M30 with Pozzolana Portland cement (PPC) using Lignosulphonate-based superplasticizer admixture incorporated along with the self-curing agent Polyethylene Glycol (PEG-400) have been studying compatibility between the self-curing compounds with ordinary Portland cement before appropriate combination is used in concrete and compared with the corresponding conventionally or accepted standards cured concrete. It was observed that M4 with 1.25% superplasticizer and 0.5% PEG performed better than other mixes considered in the study further workability as expected increased with increase in super plasticizer content.

KEYWORDS: Pozzolana Portland cement, Polyethylene Glycol, self-curing compounds et.

I. INTRODUCTION

Concrete is one of the oldest and most common construction materials in the world, mainly due to its low cost, availability, its long durability, and ability to sustain extreme weather environments. The worldwide production of concrete is 10 times that of steel by tonnage.

This thesis is aimed at experimental investigation of Self-Curing (Internal Curing) of concrete brought about by Self-Curing chemical, which is also known as poly ethylene glycol and superplasticizer. Curing plays a crucial role for concrete and hence it is very vital to cure concrete properly. If curing is sufficient, the concrete can attain various benefits, such as Enhanced strength, Good durability, Decreased shrinkage and therefore less cracking in conventional external curing, the whole three-dimensional microstructure does not get sufficient water for curing and saturation. Only the concrete surface gets cured. However, interior of the concrete mass remains unsaturated. This leads to generation of internal stresses and, in turn, more shrinkage and greater cracking. Many times, there is lack of curing on the construction sites and hence mechanical properties of concrete get hampered. Uniqueness of Self-Curing lies in the fact that the entire volume of concrete can be made to remain saturated by incorporating the Self-Curing agent. The Self-Curing polymer is hydrophilic in nature and helps to retain water by reducing evaporation.

1.1 Methods of Self-Curing

There exist two ways of Self-Curing.

The first way is to use Self-Curing polymer or Super Absorbent Polymer (SAP) and the second way is to utilize prewetted LWAs. In this experimental work, Self-Curing polymer as well as prewetted LWAs is made use of. In the laboratory work, Self-Curing is achieved by initially mixing liquid Polyethylene Glycol 400 (PEG400), at certain percentages by weight of cement, in to concrete, for its dual role of acting as an effective Self-Curing chemical as well as a SRA.

1.2 The Need of Self-Curing

The age-old techniques of curing, many times, don’t produce the desired results. If curing is meticulously planned, water evaporation reduction is possible; however, water reach to surface structural elements which are vertical is a major issue. Time consumed towards curing reflects structure’s stagnation period. This increases construction cost as well as time.

If the temperatures are high, the strength of ordinary concrete reduces because of cracks occurring between two constituents which are thermally incompatible, aggregates and paste of cement. Continuous moisture evaporation from the concrete surface takes place due to chemical potential difference between liquid and vapour phases. Moisture curing only influences the outer 30 mm to 50 mm of the concrete element surface. This underlines the fact that control of moisture is not primarily for compressive strength improvement. On the other hand, it is greatly effective on permeability and hardness of surface. Therefore, it controls the potential longevity of a system, especially those exposed to harsh environmental conditions. Moreover, the concrete mixes with water-cement ratio less than 0.4 are at increased risk of drying out from inside. Though supplying external water is essential to achieve complete advantages of such a concrete mix at the outer surface, it will not cure for a depth greater than 30 mm below the surface. Curing comprises of a task to control the temperature of concrete. Structures or slabs which are too cold during initial period after placement hydrate too gradually. This may necessitate the forms to be left in place for longer or use protective systems to avoid cracks due to plastic shrinkage. On the contrary, concrete which is allowed to get too hot in the initial stage is likely to be at increased risk of cracking because of difference between surface temperature and internal temperature. Concrete which gets hydrated at higher temperature is also greatly vulnerable to deleterious chemical reactions and attack by external chemical reagents. Water can be supplied through ponding (Exposed surface of concrete is immersed in water), spraying or by through making use of moist hessian or burlap coverings. Spraying as well as ponding are highly efficient methods; but there are many practical difficulties to practice those. Using coverings is a costly method both in terms of labour and materials utilized. The evaporation rate from concrete surface can also be reduced by plastic sheet covering. However, this method can be applied only for surfaces which are horizontal; moreover, sheeting can get displaced due to wind if proper care is not exercised. The water can also be retained by delayed removal of formwork. But it is practically not a feasible solution for a long time.

Applying curing compounds can be the option to retain the water through reducing the evaporation. Usually, these compounds are solutions of resin in solvent or emulsions of resin in water. Their application is done using roller, spray or brush. However, application time of these compounds plays a crucial role. Moreover, for remote areas like surfaces which are vertical, application is not so easy. A typical similarity of traditionally used curing methods is that the ‘external action’ is needed to make sure that they are properly applied as well as maintained well. One cubic meter finished concrete needs three cubic meter water, majority of it being used for curing. This shows that enormous amount of water is needed on construction sites. More importantly, making water available through external curing poses few shortcomings like potable water scarcity, inaccessible structures and low water-cement ratio of HPC. Innovative techniques in concrete curing methods are in demand in fast changing world. In near future, placement mechanization, maintenance and taking out of covers and curing mats will be vital because performance-based specifications will govern acceptance as well as payment. Moreover, high quality compounds and sealants which check loss of water and enhance wet curing will attract greater attention. Self-Curing concrete can be expected to be widely practiced method available in near future.

1.3 Objectives

1. To study the compatibility of modified lignosulphonates-based superplasticizer and polyethylene glycol (self-curing compound) of grade M30
2. To know the required dosages of the super plasticizer to have an initial slump of 150 mm to 160 mm and working slump of 50 mm for ready mix concrete
3. To know the variation of slump with time, compressive strength, split tensile strength, flexural strength, initial and final setting times of M30 grade of concrete.

II LITERATURE REVIEW

J. Jeyanthi et al (2022) This experiment investigated at the performance of self-curing agents in mortar cubes. Self-curing substances such as coir pith, Spinacia oleracea, and PEG 400 were utilized in this experimental work. First, the coir pith was partially replaced for fine aggregate in mortar cubes in varying percentage of 1%, 2% and 3% as a self-curing agent. The water absorbed earlier by coir pith will be utilized during cement hydration process and reduces shrinkage. The second step involves the usage of Spinacia oleracea extract in 0.6%, 0.8%, 1.0%, which was partially substituted for cement and act as a self-curing agent. Similarly, PEG 400 in 1%, 1.5%, 2% was partially replaced with cement and utilized as self-curing agent. The mechanical and durability features of mortar containing self-curing agents were investigated and compared to those of ordinary mortar. The results reveal that natural self-curing agents outperformed chemical self-curing agent.

Chandrasekhar et al (2022) study intended to determine the possibility of achieving self-curing self-compacting concrete (SCSCC). As curing agent plays a significant role in producing SCSCC, this study concentrates on assessing the impact of polyethylene glycol (PEG) addition at different rates of 0.5%, 1%, 1.5%, and 2% on the fresh, hardened, durability characteristics. Moreover, to improve the sustainability properties of SCSCC, manufactured sand (M-sand) obtained from rock crushing operations is used as a replacement for river sand. Generally, results indicate that using superplasticizer and M-sand is sufficient for achieving the required flowability for SCC mixtures without using specific fillers, promptly controlling bleeding and segregation, and maintaining the necessary compressive strength at all ages. The hardened properties of SCSCC were improved by increasing PEG content up to 1.5% with an optimal range of 0.5% superplasticizer. Also, results show that self-cured specimen cured with PEG has greater acid resistance as compared to the conventionally cured one.

S. Sowdambikai et al (2021) The investigational study observed the effects of self-curing agent Poly Ethylene Glycol (PEG) on various properties such as compressive strength, split tensile strength and flexural strength at discrete proportions of 0.5%, 1.0%, 1.5% & 2.0% by weight of cement. Also, the properties of concrete are predicted by the regression analysis. The amount of PEG to be added is optimized to be 1.5% by the weight of cement. Regression coefficients of 0.971 and 0.891 shows a proper correlation between compressive strength and flexural strength and also between compressive strength and split tensile strength.

Xiao Yuan et al (2020) The study aim was to make comparison between self-curing and traditional concrete qualities in terms of hardiness and water absorption. The study was experimental in nature and made use of material including Portland Pozzolana cement, fine aggregate, and angular coarse aggregate. The three grades of concrete were used in the experiment including M10, M20, and M30 based on cube and cylinder format. The tests involved in the study included non-destructive test, compression and split tensile strength test, and water absorption test. The findings show that overall, self-curing concrete shows better performance compare to the sprinkler or fully cured concrete. Thus, the study makes recommendation that traditional concrete may be replaced with the self-curing concrete.

Dada S. Patil et al (2020) This paper discusses an experimental investigation of short-term static modulus of elasticity and Poisson’s ratio of M20 grade of self-curing concrete using PEG 400 as a self-curing agent. Three different dosages of 1%, 1.5% and 2% of PEG 400, expressed as percentage of weight of cement, were used. The conventional cylindrical specimens were subjected to water curing for 28 days, whereas self-cured cylinders were exposed to air curing in an open shaded area for 28 days. Indian Standard: IS 516- 1959 and American Society for Testing and Materials (ASTM) standard: C469/C469M-2014 were followed for testing conventional as well as self-cured specimens. The laboratory investigation was aimed at comparing the values of the two elastic constants obtained for the self-cured concrete with that for the conventional mix, by both the methods. Though conventional concrete had highest values of density and compressive strength, it was observed that concrete with 1.5% PEG 400 exhibited greatest values of modulus of elasticity, by both the methods. Dosages of 1.5% and 2% of PEG 400 resulted in to higher values of Poisson’s ratio in comparison with that for conventional mix and 1% PEG 400 mix.

III. EXPERIMENTAL PROGRAM

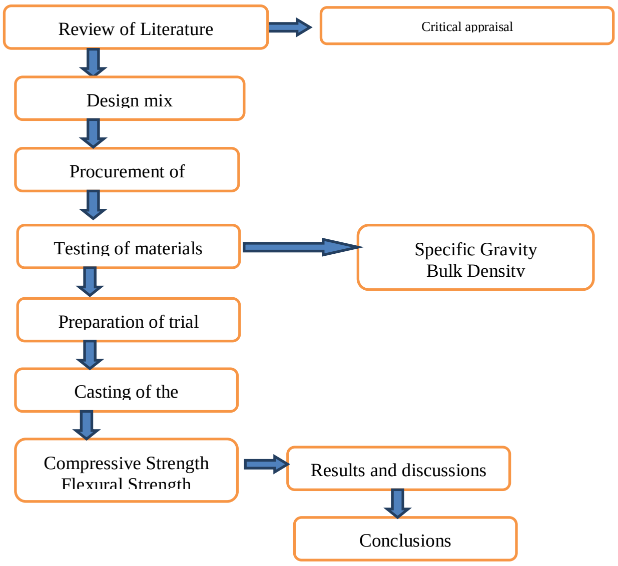

Fig 1: Flow Chart of Experimental Program

3.1 Mixture Proportions

The mixture proportions are shown in in particular, weights of coarse and fine aggregate, cement and water, and admixture dosages are detailed. Relevant parameters for each mix, such as the water-cement ratio, slump at hatching and delivery, travel time the control mix containing cement, natural sand and coarse aggregate is designed as perIndian Standard Recommended Guidelines IS: 10262-2009.Mix of ingredients is done in rotating pan mixer. Followed by through mixing with trowels is adopted before placing in moulds. Required materials like coarse aggregate, fine aggregate, cement, pond ash,fly ash and water are weighed and are introduced into the mixer in sequence of coarse aggregate, fine aggregate, cement and other ingredients and then water is added. The period of mixing shall not be less than 2 minutes after all the materials are in the drum and shall continue till the resulting concrete is in uniform appearance

Table: 3.1 Materials required for 1m^3

Grade of Concrete	Water/Cement Ratio	Cement Kgs	Water Litres	Coarse Aggregate Kgs	Fine Aggregate Kgs
M30	0.44	373	164	1105	825

Table 3.2 Final Mix Design Proportions

Mix	SP	PEG	Cement Content kg/m^3	FA kg/m^3	CA kg/m^3	Water kg/m^3	Super-Plasticizer kg/m^3	Water Cement Ratio
M1	0	0	373	825	1105	164	2.68	0.44
M2	0.5%	0	373	825	1105	164	2.68	0.44
M3	1.0%	0	373	825	1105	164	2.68	0.44
M4	1.25%	0	373	825	1105	164	2.68	0.44
M5	1.5%	0	373	825	1105	164	2.68	0.44
M6	1.25%	0.5%	373	825	1105	164	2.68	0.44
M7	1.25%	1.0%	373	825	1105	164		0.44

IV. EXPERIMENTAL RESULTS

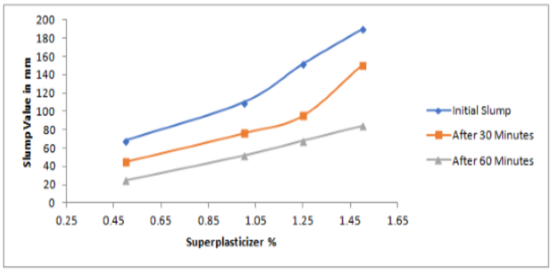

Fig.2 Slump Test on Concrete

4.1 Slump test on Concrete

The comparison of workability with different dosage of M1 concrete mix is shown. From Figure 4.1, a maximum slump gain was described in samples M2, M3, M4 and M5 compared with the specific sample. The highest slump gain was for M5, which showed that the more the amount of the superplasticizer is the maximum the flowability of the concrete shall be producedThe values of slump for the required initial slump of 100 mm to 190 mm and the slump after 60 minutes of 50 to 90 mm has been achieved with the addition of 1.0% ,1.25 and 1.5% Modified lignosulphonates. M2, M3, M4 and M5 were 25, 52, 68, 84mm respectively for M30. Therefore, the workability of concrete showed enhancing concerning to increasing dosage of the MLS superplasticizer. The lowest slump value was reported for M2, indenters the maximum slump value was verified for M5, and the measured slump values of all samples were to be increased continuously to a greater amount in relation to that of the control sample. Further, through visual inspections, it was noted that in the case of zero M1, where no MLS superplasticizer was added, the mixture was resisting flow to work with at room temperature and had a very rigid flow characteristic compared to the other. The simple flowability and drops in viscosity were described as the dosage of the MLS superplasticizer was enhanced sample by sample. The slump test results clearly show that the MLS superplasticizer was effective in increasing the flowability of the concrete to a considerable level

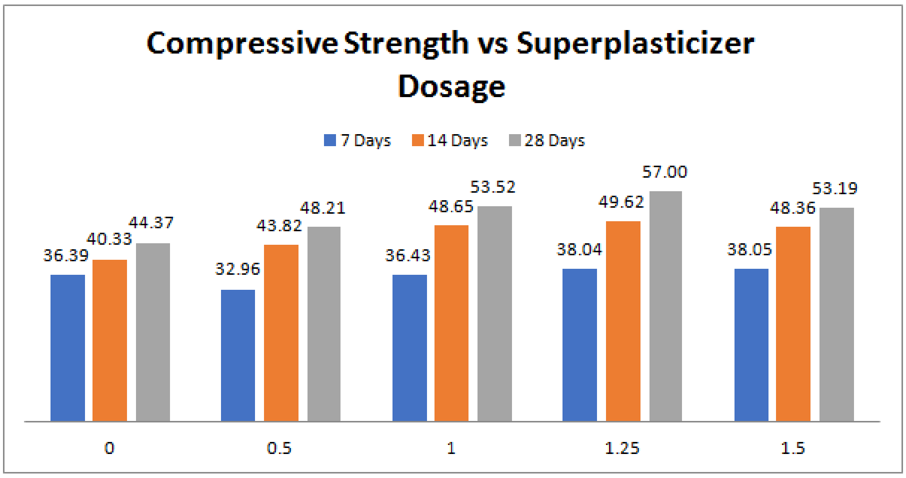

Fig 4.2 Bar Chart of Compressive strength vs. Age of concrete for M30 concrete mix

4.2 Compressive Strength

It can be observed from table and figures above that maximum compressive strength developed for M4 which was 8.48% more after 7 days, 23.03% more after 28 days and 28.49% more after 54 days of curing when compared to M1 and from there on the there is a decrease in the compressive strength of concrete. Hence it can be deduced that optimum superplasticizer content for compressive strength is 1.25% which was obtained for M4 mix.

Age of concrete	**Dosage of SP (%)**	**Strength (MPa)**	**% Change**
7 Days	0	2.52	-
	0.5	2.31	-8.41
	1	2.85	13.08
	1.25	3.00	18.69
	1.5	2.81	11.21
14 Days	0	3.61	-
	0.5	3.66	1.31
	1	3.73	3.27
	1.25	3.92	8.50
	1.5	3.75	3.92
28 Days	0	3.97	-
	0.5	4.02	1.31
	1	4.10	3.27
	1.25	4.31	8.50
	1.5	4.13	3.92

4.3 Split Tensile Strength

It can be observed from table and figures above that maximum split tensile strength developed for M4 which was 18.69% more after 7 days, 8.60% more after 28 days and 8.40% more after 54 days of curing when compared to M1 and from there on the there is a decrease in the compressive strength of concrete. Hence it can be deduced that optimum superplasticizer content for split tensile strength also was found to be 1.25% which was obtained for M4 mix.

4.4 Flexural Strength of Concrete

Similar to split tensile strength and compressive strength the flexural strength was maximum at 1.5% dosage of superplasticizer 20.83%,29.09% and 31.75% more than M1 at 7, 28 and 54 days respectively.

4.5 Setting Time of Concrete

The results of setting times of Portland Pozzolana cement concretes without addition of superplasticizer are compared with the Portland Pozzolana cements by adding the modified lignosulphonates (MLS) based superplasticizer and polyethylene glycol (self-curing compound). By these results it is observed that the initial and final setting times of ordinary Portland cement concretes with addition of superplasticizer and self-curing compound are relatively higher when compared to the results of Portland Pozzolana cement without addition of superplasticizer. The prolonged setting times in the ordinary Portland cement concretes is due to the properties of cementitious material, superplasticizer and self-curing behaviour of polyethylene glycol. It is also observed that the combination of superplasticizer and polyethylene glycol increased the setting times of concrete compared to the normal concrete without of superplasticizer

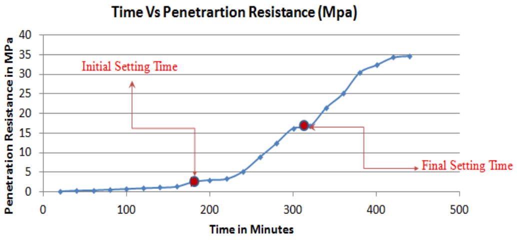

Fig:4.3 Penetration resistance of M30 grade concrete with Modified lignosulphonates and poly ethylene glycol (PEG-400) with PPC cement

V. CONCLUSIONS

- The slump retention capacity of concrete was to be maximum for M5 mix where the slump was about 190mm compared to 38 for M1, even after 60 minutes of mixing the slump was observed to be at 84mm much higher than other dosages which indicates higher the dosage better will be slump retention capacity of concrete.

- Increase in Compressive strength was highest for M4 which was 8.48%, 23.03% and 28.49% greater than M1 at 7, 14 and 28 days of curing dosage of superplasticizer was 1.25%.

- Split tensile strength of M4 increased by 18.69%,8.50% and 8.50% when compared to M1 at 7,14 and 28 days and similar trend was observed for flexural strength where the increase was 20.83%, 29.09% and 31.75% after 7, 14 and 28days of curing.

- Considering the results obtained it can be deduced that better results were obtained at 1.25% dosage of superplasticizer therafter the strength was observed to decrease in all the mechanical parameters.
- At 0.5% PEG dosage the compressive strength was maximum which was about 50.23MPa and this was same for split tensile and flexural strength which were 4.18MPa and 5.53MPa respectively after 28 days.

- Optimum dosage of superplasticizer and PEG was found to be 1.5 % and 0.5% respectively for which penetration resistance test was conducted where intial setting time was obtained at 3.5 hrs and final setting time at 5.6 hrs.

5.1 Future Scope

The research program has provided a basis for further research and has raised a few specific questions that further research can address. It is recommended that studying the compatibility of superplasticizers belonging to different families' viz.,

(i) Modified lignosulphonates (MLS)
(ii) Sulphonated naphthalene-formaldehyde (SNF)
(iii) Sulphonated melamine-formaldehyde (SMF) and
(iv) Polycarboxylate ether (PCE) with self-curing compound (polyethylene glycol) as a combination with Pozzolana Portland cement. It is also suggested to investigate Polyethylene Glycol Along with different cement and chemical admixtures. Economic feasibilities of course, from the point of view of improving their overall performance.

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