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Experimental Investigation of Self-Curing Concrete by Using Natural and Chemical Admixtures

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Abstract

Background/Objectives: To develop a self-curing concrete economically. **Methods:** To make self-curing concrete, natural and chemical admixture were used; samples were cured in room temperature (15-20°c) and outdoor condition (30-35°c). Firstly, samples were divided into fourteen trials with different percentage of wood powder 2%, 4%, 6%, 7% and 8% and polyethylene glycol 400 (PEG400) 0.5%, 1%, 1.5%, 2%, 2.5%. Finally, 6% wood powder was found as optimum trial and again made trials of constant percentage of wood powder (6%) with different combinations of PEG400 (0.5%, 1%, 1.5%, 2% and 2.5%) in room and outdoor temperature. The specimens were cured for 7 and 28 days. **Findings:** The results show that the uses of wood powder and PEG400 have positive effect on mechanical properties of concrete compared with conventional concrete. **Improvements/Applications:** A mix of 6% wood powder with 1.5% polyethylene glycol 400 (PEG400) is found optimum and economical for M30 grade of concrete in room temperature but for having a good strength of grade M30 of concrete considering economical point for outdoor temperature a mix of 6% wood powder with 2.5% polyethylene glycol 400 (PEG400) can be effective and optimum.

Keywords: Outdoor Temperature, Polyethylene Glycol-400, Room Temperature, Self-Curing Concrete, Wood Powder

1. Introduction

Concrete is a superior building material with equivalent mixing of aggregate (fine and course), cement, and water and with or without chemical-mineral and other admixture in the adaptation with the production[1]. Due to its chemical characteristic to obtain eligible strength and other properties, concrete need to have sufficient amount of water, for this purpose curing should be done[2]. Curing is the proceeding of maintaining of moist condition on surface of finished concrete to promote continued hydration of cement[3]. For every $1m^3$ constructions concrete about $3m^4$ water required and most of this water is used for curing[5]. Many places we face that shortage of water for curing or space for curing is not sufficient and we face with difficulty so here self-curing concrete help us to sustain concrete/mortar strength at the early age before creating cracking because of internal and external pressure[3]. In places that faced with shortage of water due to permeate, autogenously cracking may result[6]. This study will cover Self-Curing concrete with ingredients of Cement, Aggregate, Water, Wood powder and Polyethylene Glycol 400 to achieve a suitable Self-Curing concrete which can have high property of Self-Curing against the severe condition of warm weather. The experiments are to be done for M30 grade of concrete with 0.45water cement ratio for the age of 7days and 28days. PEG600 0.5%, 1% and 2% and partially replace of light weight aggregate are studied. Compressive strength, flexural strength and split tensile strength in 3,7,14 and 28 days tested with mix design of M20. From all these combinations the 1% PEG had the best result[6]. Used 0.5% of PEG400 as Self-curing agent with M20 mix design at the age of 3,7 and 28 days, the average increase in compressive strength of12.73%, split tensile strength 13.31% with 5% PEG-400 was observed. It shows the better performance of Self-Curing concrete than conventional concrete[7]. In this study used wood powder, SAP (super absorbent polymer) as admixtures with percentage of (2,4 and 6) percent, comparing result for two and four percent with conventional concrete shown

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low strength but six percent of wood powder shown a high strength[1]. This study has divided in two use type of materials, first one with different percentage of (0%, 10%, 15%, 20%) is pre-soggy lightweight aggregate of volume of sand and other type is PEG by weight of cement with percentages of (1%, 2% and 3%) and all tests conducted in three different water cement ratio of 0.5, 0.4 and 0.3 with using different percentages of silica fume 0.0%-15% of weight of cement in 28days and 25c° The best result Shown as two percent of PEG with fifteen percent of light-weight aggregate combined with greater cement content and poorer water cement ratio[8]. By using Silica fume (up to 15%) Calortopis.G (0.2%, 0.3% and 0.4%), and Cypress (up to 15%) working on hardened and fresh properties of concrete best result was 0. 4% Calortopis.G, Cypress 15% and 15% of Silica fume[9].

2. Materials and Methods

Cement - In this study ordinary Portland cement grade 43 has been used.

Polyethylene Glycol 400 (PEG400) - PEG400 has been used having specific gravity of 1.1254 to reduce evaporation of water from surface of concrete, it helps in curing by reducing hydration, shrinkage and vapor pressure of concrete thus helps enhancement of concrete strength[10-11].

Wood Powder (WP) - Wood powder as a natural material helps as water saving agent for cement particles hydration at 28days curing of self-curing concrete thus concrete doesn't need extra water for curing. It also reduces autogenesis cracking, shrinkage. Increase permeability for water absorbing and work as an internal curing. Wood powder having 82.2% Water Absorption and specific gravity of 1.076 has been used as a water saver.

Course aggregate - Used natural course aggregate have ability of transitory 20mm sieve and retentive from 12.50mm sieve with specific gravity of 2.80 and Course aggregate specification studied as per to IS code 383:1970[12-13].

Fine aggregate - Passed over sieve of 4.75mm with specific gravity of 2.70 and fine aggregate specification studied as per IS code 383:1970[12-13].

2.1 Mix Proportions

Mix design of M30 grade of concrete has been done according to IS: 10262:2009[14] with water cement ratio of 0.45. All tests conducted in fourteen trials of different percentage of admixtures, for having an accurate result the optimum trial was tested in room temperature and outdoor temperature. Percentage of wood powder is taken from total concrete's volume and then replaced by its weight with sand and the Table 1 show the percentage of admixtures, water cement ratio

Table 1. Mix proportion

Trial ID	curing agent		W/C	Quantity (kg/m^3)					
	PEG400 (%)	WP (%)		cement	F.agg	C.agg	water	PEG400	WP
Conventional	0.00	0.00	0.45	425.70	719.70	1166.77	191.58	0.00	0.00
Trial 1	2.50	8.00	0.45	425.70	703.11	1166.77	194.58	10.64	16.59
Trial 2	2.00	7.00	0.45	425.70	705.18	1166.77	196.71	8.51	14.52
Trial 3	1.50	6.00	0.45	425.70	707.26	1166.77	198.83	6.39	12.44
Trial 4	1.00	4.00	0.45	425.70	711.40	1166.77	200.96	4.26	8.30
Trial 5	0.50	2.00	0.45	425.70	715.55	1166.77	203.09	2.13	4.15
Trial 6	2.50	8.00	0.45	425.70	703.11	1166.77	194.58	10.64	16.59
Trial 7	2.00	7.00	0.45	425.70	705.18	1166.77	196.71	8.51	14.52
Trial 8	1.50	6.00	0.45	425.70	707.26	1166.77	198.83	6.39	12.44
Trial 9	1.00	4.00	0.45	425.70	711.40	1166.77	200.96	4.26	8.30
Trial 10	0.50	2.00	0.45	425.70	715.55	1166.77	203.09	2.13	4.15
Trial 11	2.50	8.00	0.45	425.70	703.11	1166.77	194.58	10.64	16.59
Trial 12	2.00	7.00	0.45	425.70	705.18	1166.77	196.71	8.51	14.52
Trial 13	1.50	6.00	0.45	425.70	707.26	1166.77	198.83	6.39	12.44
Trial 14	1.00	4.00	0.45	425.70	711.40	1166.77	200.96	4.26	8.30

and quantity of all materials in kg/m^3 under title of mix proportion.

2.2 Mixing, Casting and Curing Methods

As per is code: 516: 1959 manual hand mixing method is performed for all mixes. Firstly cement should mix with fine aggregate then course aggregate with dry admixture and wet admixture should be mixed with water properly and then mix these all and mixing should be continuing until the concrete appears to be homogeneous and desired consistency.

The casting instantly followed mixing, after carrying to remove surplus material and to achieve a smooth finish the top surface of the specimens was scratch. The samples were removed from molds after 24hr of storage under laboratory condition. As it's clear that curing is the proceeding of maintaining of moist condition on surface of finished concrete to promote continued hydration of cement, in this paper air curing in two different temperatures as room temperature (15-20°c) and outdoor temperature(30-35°c) have been studied.

3.Results and Discussions

For testing the IS code: 516: 1959 has been followed and tests results shown in Table 2, tests were done after 7days and 28 days air curing on hardened concrete. All test were done in 14 trials, first five trials for finding the optimum percentage between different percentage of WP and PEG400 and acceptable result for this testing was trial-3, next trials up to trial-10 tested 6% of WP with different percentage of PEG400 in room temperature and optimum trial for this testing was trial-8, then up to trial-14 samples tested in outdoor temperature and trial-12 shown optimum result.

3.1 Compressive Strength

Compressive strength is an important mechanical test for measuring the maximum amount of compressive load[15]. In this paper compressive strength of self-curing concrete in room temperature compared with compressive strength of conventional concrete and result shown 12.08% increment in compressive strength of self-curing concrete than conventional concrete and same experi-

Table 2. Test results

Results of different percentage of WP with different percentage of PEG in room temperature							
		Conventional	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
		0%	**WP: 8%, PEG:2.5%**	**WP: 7%, PEG:2%**	**WP: 6%, PEG:1.5%**	**WP: 4%, PEG:1%**	**WP: 2%, PEG:0.5%**
7 days	Compressive strength (N/mm^2)	21.11	10.75	12.16	12.55	17.23	19.29
	Flexural strength (N/mm^2)	2.46	2.34	2.56	2.81	2.4	2.01
	Split tensile strength (N/mm^2)	1.83	2.21	2.43	2.61	2.35	1.94
28 days	Compressive strength (N/mm^2)	30.12	26.65	31.44	33.76	30.54	24.21
	Flexural strength (N/mm^2)	3.94	3.76	4.11	4.56	3.85	3.45
	Split tensile strength (N/mm^2)	3.02	3.54	3.93	4.13	3.78	3.29
		Conventional	**Trial 6**	**Trial 7**	**Trial 8**	**Trial 9**	**Trial 10**
		0%	**WP:6%, PEG:2.5%**	**WP:6%, PEG:2%**	**WP:6%, PEG:1.5%**	**WP:6%, PEG:1%**	**WP:6%, PEG:0.5%**
28 days	Compressive strength (N/mm^2)	30.12	31.4	33.8	33.76	29.89	28.3
	Flexural strength (N/mm^2)	3.94	4.12	4.23	4.16	3.81	3.73
	Split tensile strength (N/mm^2)	3.02	3.88	3.96	3.87	3.54	3.61
		Conventional	**Trial 11**	**Trial 12**	**Trial 13**	**Trial 14**	
		0%	**WP:6%, PEG:2.5%**	**WP:6%, PEG:2%**	**WP:6%, PEG:1.5%**	**WP:6%, PEG:1%**	
28 days	Compressive strength (N/mm^2)	30.12	31.2	30.87	29.3	28.9	
	Flexural strength (N/mm^2)	3.94	4.08	3.92	3.81	3.78	
	Split tensile strength (N/mm^2)	3.02	3.9	3.87	3.71	3.65	

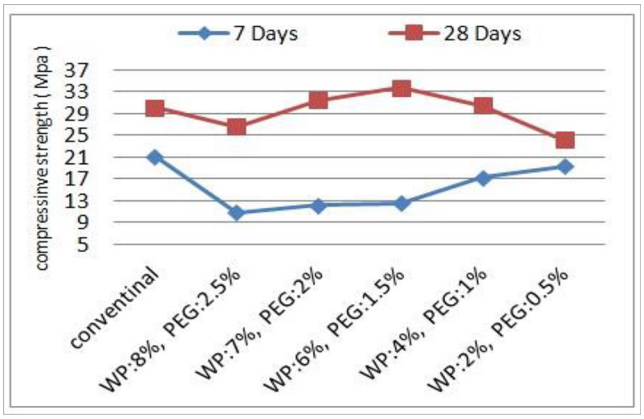

Figure 1. 7 days and 28 days of compressive strength.

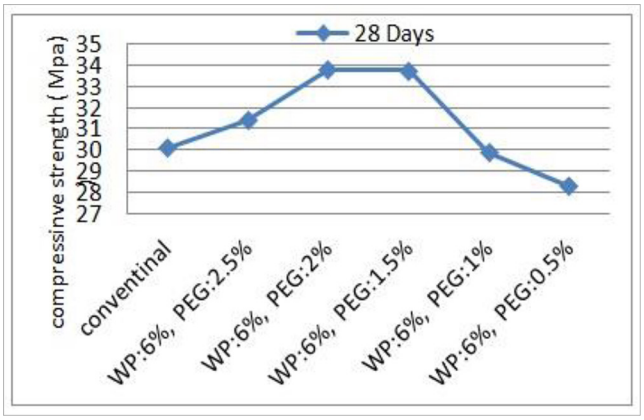

Figure 2. Results of 6% wood powder with dissimilar percentage of polyethylene glycol in room temperature.

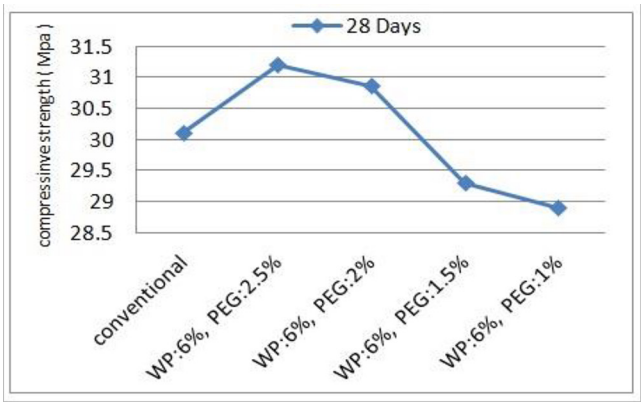

Figure 3. Results of 6% WP with different percentage of PEG in outdoor temperature.

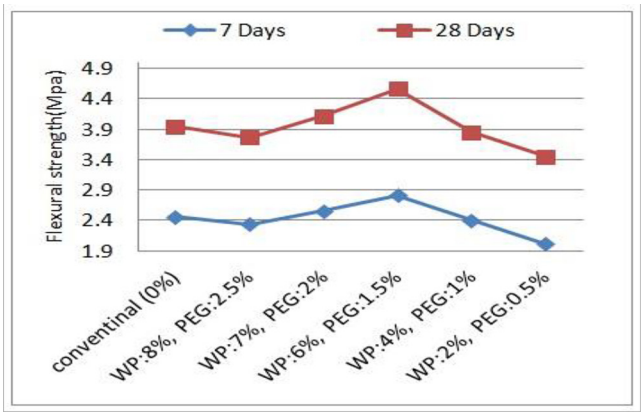

Figure 4. Flexural strength of 7 days and 28 days.

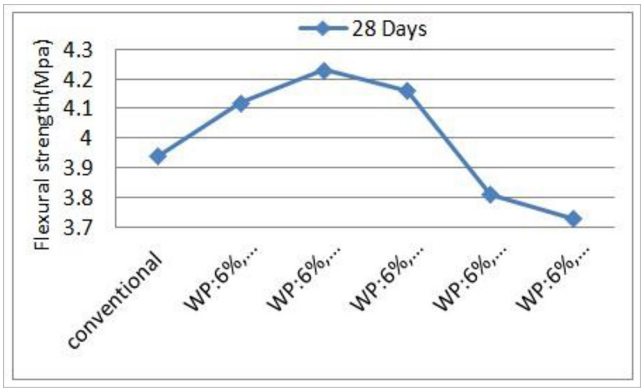

Figure 5. Outcome of dissimilar percentage of polyethylene glycol with 6% wood powder in room temperature.

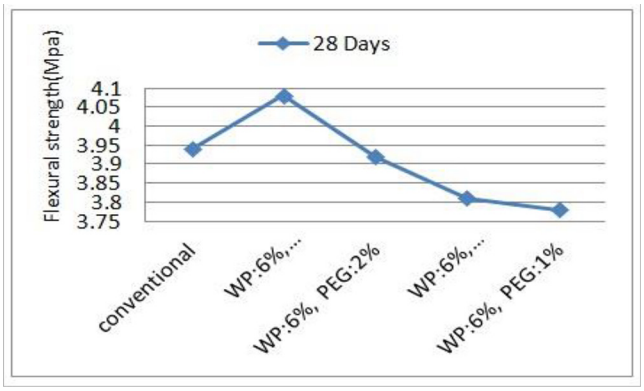

Figure 6. 6% Wood powder with dissimilar percentage of Polyethylene glycol in outdoor temperature results.

ment done by comparing of compressive strength of self-curing concrete in outdoor temperature with conventional concrete and result shown 2.49% higher strength of self-curing concrete.

Figures 1-3 show the testing results of compressive strength in different conditions, in this plot trial-8 has optimum result for room temperature and trial-12 is an optimum mix for outdoor temperature.

3.2 Flexural Strength

Flexure strength test use to determine flexibility or flexibility module of the material[16,17]. In this excremental work self-curing concrete flexural strength in room temperature and outdoor temperature compared with conventional concrete and result shown than self-curing agent increase the flexural strength of concrete. Figures 4-6 shows the flexural strength results in different conditions trial-8 has optimum result for room temperature and trial-12 is an optimum mix for outdoor temperature.

3.3 Split tensile Strength

This is one of the three common tests of the concrete, due to happening direct tensile force on concrete it can bring cracks[18]. Wood powder acts as a fiber material in concrete to raise the tensile strength as wood powder with split tensile strength has parabolic graph, such that lower amount of wood powder will have small changes in tensile strength and higher amount of wood powder will also decrease split tensile strength of concrete. As per comparing of indoor temperature and about same with outdoor temperature results with conventional concrete 28% increasing strength found.

Figures 7-9 show the split tensile strength results in different condition of weather, trial-8 and trial-12 have optimum result for room and outdoor temperature.

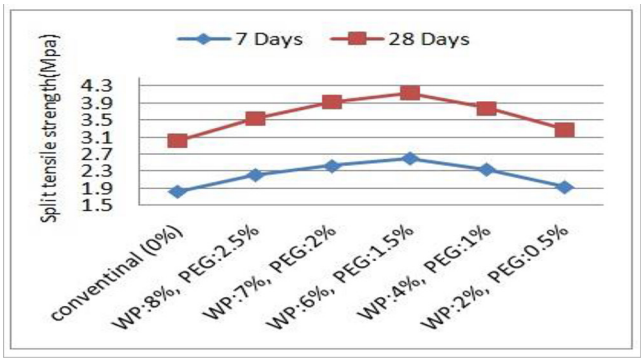

Figure 7. Outcome of 7 days and 28 days of split tensile.

Figure 8. Different percentage of PEG with six percent of WP in room temperature.

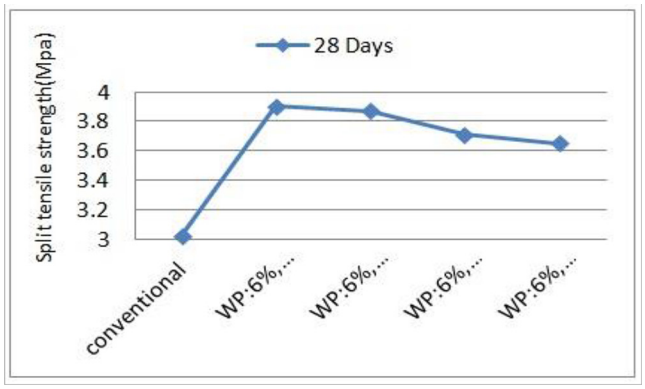

Figure 9. Six percent WP with different percentage of PEG results in outdoor temperature.

4. Conclusion

1. By increasing self-curing agent, the compressive strength result of 7 days will decrease because of absorbing more moisture in concrete and being wet after 7 days air curing,
2. In room temperature, Trial-7 has high strength but as optimum trial-8 has been chosen because both results are pass but according to economical point if less percentage of admixture can gain required strength so no need of wasting more admixtures,
3. Using more wood powder will decrease concrete's strength but help to absorb more moisture,
4. Use of self-curing agent in concrete can increase the strength of concrete comparing with conventional concrete, and
5. After investigations and experimental works it is clear that we can have an economical self-curing concrete with wood powder (easily available) and PEG400 (~ 95INR/Liter). As per table 1, for 1m3 concrete we have used 8.5bag of cement and for this only 6.4Liter PEG400 and 12.5kg WP needed.

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