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EFFECT OF DIFFERENT CURING METHODS ON THE PROPERTIES OF NORMAL STRENGTH CONCRETE

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Abstract— This paper is directed to evaluate effectiveness of different curing methods on the strength properties of concrete. The design mix of M30 according to ACI code was used. The compressive strength conducted in compression testing machine and flexural strength conducted in Universal Testing Machine. The specimens were cast for testing the compressive strength and flexural strength at 21days ,56days and 90 days of curing respectively using Four curing methods namely Wet curing, 3% NaCl solution curing, Cyclic curing and Air Curing to cure the specimens until the day of testing. Test results indicates that wet curing (WC), 3% NaCl curing as well as Cyclic curing provide much better results than Air Curing. The overall finding of this paper suggests that concrete should be cured by wet curing to attain a better compressive strength and flexural strength.

Index Terms— Wet Curing, 3% NaCl solution curing, Cyclic Curing, Air Curing Compressive strength, and Flexural Strength

1 Introduction

Concrete has been proved to be a leading construction material all over the world. Due to demand of new structures, new construction is increasing day by day These days, thousand tons of cement is being utilized at various parts around the world.For the reality, concrete is considered as composite mix of various substances, comprehensive of concrete, fine aggregate, coarse aggregates, water and once in a while admixture. The impact of curing is monstrously significant on the properties of concrete, particularly the total interaction of the concrete hydration that brings solidified concrete and greater toughness [1]. Curing is the way toward keeping up with solidified concrete under wet condition. Curing should be attempted for sensible timeframe, to guarantee that the substantial accomplishes its possible strength and sturdiness [2]. The strength properties of concrete are mainly due to its curing. The strength in concrete is usually achieved because cement hydrates [3] .Curing has a strong influence on the properties of hardened concrete. The parameter of the study includes various curing period and various curing methods i-e Dry curing, Immersion technique, Liquid membrane curing compound, water proofing compound [4]. It has been observed that concrete gets more than 80% strength of fully cured concrete whereas, after 3 days curing it gets more than 60% of fully cured concrete [5].

2 Literature Review

It has been generally believed that improper curing results in reduction of strength. It has been seen that in most of cases, improper curing occurs where members are either inclined or vertical. It can also occur where water is in low quantity [6]. The workability of concrete is improved with the increase of water quantity whereas this reduces strength. Thus, for high performance concrete, role of curing cannot be ignored. Wet-covering method is recommended for structural elements, such as columns, beams and slabs in other to produce concrete of a required compressive strength [7]. The presence of sulphate salts at high rates negatively affects the hardened properties of concrete [8].The impact of three normal curing strategies, for example ponding, sprinkling and wet cover curing on compressive strength conduct of concrete. The got results recommend that ponding technique for substantial curing is best among every one of the three strategies for substantial curing considered in this investigation [9]. To assess adequacy of various curing techniques and study the convince of environment on the strength properties of concrete. Test results demonstrates that water curing (WAC) Immersion , Ponding just as Membrane curing give much preferable outcomes over Plastic Sheeting strategy for curing [10].It is provided on concrete surfaces to give a productive curing. water curing (WC) as well as sprinkling (spraying) curing provided much better results than membrane (Plastic Sheeting) method of curing. The rate of drying was significant when the specimens were subjected to membrane (Plastic sheeting) method of curing. This thus hampered the hydration process and thus affected the compressive strength property of the hardened concrete. In concrete,curing is an essential process for achieving strength and greater durability, but now day's water scarcity is a major problem in the construction field.

3 Curing and its different methods

It is the process of keeping concrete wet for required duration of time. Due to the surrounding temperature water evaporates from concrete body leading to shortage of the water for hydration process. Therefore, supplying water to concrete surface is essential to ensure proper hydration of the cement and thus the resulting strength. Curing may occur after the new concrete is being set in the site, in light of the fact that the hydration of concrete requires some serious energy, it generally require days so curing should be accomplished for a sensible timeframe all together concrete can accomplish its underlying strength and sturdiness [11].

A Ponding Method:

Ponding method is well adopted methods in concrete curing. It is suitable for curing horizontal surfaces such as floors, roof slabs, road and air field pavements.This method is more efficient but the more amount of water is required. Different curing methods are usually adopted to evaluate the compressive strength of concrete. The results show that ponding had the highest compressive strength and density, followed by wet covering, sprinkling, then uncured for two days, with the totally uncured cubes having the least compressive strength and density as well as highest shrinkage limit. Ponding method of curing was recommended to be the best of all the curing methods [12].

B. Air Curing (AC):

Air curing is a curing method wherein the concrete cubes are left in open air to be cured at. room temperature until tested.

This served as the control. It involved no form of active curing by just exposing the specimens to ambient air in the Laboratory.

C. Membrane Curing:

Membrane curing is used in areas of acute water scarcity. Water mixed while preparing fresh concrete is generally sufficient for the entire hydration reaction. In this method a sealing membrane is applied over concrete which will trap the water inside and avoid its escape through evaporation. Membrane may be actually a sheet of polythene or formed by application of chemicals. It comes under the classification of damp curing. Another strategy for curing is to cover the wetted solid surface by a layer of water confirmation material, which is stayed in touch with the concrete surface of seven days. Various strategies for curing specifically covering substantial surfaces with gunny sacks, sprinkling of water, Ponding method, Membrane curing, Steam curing and covering substantial surfaces with gunny packs. Normal concrete was prepared with a water-cement ratio of 0.40. Cube specimens were cast for testing the compressive strength at 7 and 28 days of curing respectively using five curing methods namely covering concrete surfaces with hessian or gunny bags, sprinkling of water, Ponding method, Membrane curing, Steam curing and Covering concrete surfaces with hessian or gunny bags, curing to cure the cube specimens until the day of testing. Test results indicates that water curing (WAC) as well as sprinkling (spraying) curing provided much better results than membrane (Plastic Sheeting) method of curing stream curing [13].

D. Sodium Chloride Solution Curing:

Sodium chloride or rock salt could be utilized as a dicing specialist to dissolve ice at temperatures underneath, it has a trademark sharp taste and is promptly dissolvable in water [14]. The outcome of the research work is that it will give its readers clear concept of effect of different curing methods on the workability and mechanical strength of the proposed M30 grade concrete. The outcome will also enhance the confidence of using different curing methods under different conditions. A research on effect of improper curing on properties of normal strength concrete. Three grades of concrete 30, 35 and 40 have been selected and the curing ages from 1 to 28 days have been selected. The experimental study concluded that compressive strength has improved with increasing curing period and increasing grade.carried out research on determining the effects of improper curing on mechanical strength of concrete. For that purpose, cubes, cylinders and slabs have been prepared and flexural strength have been determined using four-point testing method [15]. The comparative study of effect of salt water and fresh water on concrete was investigated.presents the result and findings of an experimental research on the effect of salt water and fresh water on compressive strength, flexural strength, split tensile strength of concrete. Thus, fresh water curing is found to be more suitable results compared to salt water curing [16]. Experimental investigations on the effect of sea water on the compressive strength of concrete. The study shows an increase in the compressive strength of concrete for concrete specimens mixed and cured with sea water. Compressive strength of the concrete was also affected when the concrete was cast with fresh water and cured with salt water and vice-versa [17].

4 MATERIALS

Cement:

Cement is a material that hardens and becomes strongly adhesive after application in plastic form. Cement is the main constituent of concrete. It is a basic ingredient of concrete, and mortar, etc. Cement is a fine, grayish powder. It is mixed with water and materials such as sand, gravel, and squeezed stone to make concrete. The cement and water form a paste that binds the other materials with each other as the concrete hardens. The ordinary or typical cement contains two basic ingredients namely argillaceous and calcareous sediments. In argillaceous materials clay is chief and in calcareous materials calcium carbonate is chief. Basic make-up/composition of cement is shown in Table 1. In this study, OPC grade 43 was used.

Table 1: Composition limits of Portland cement

INGREDIENTS	% CONTENT
CaO (Lime)	60-67
SiO_2 (Silica)	17-25
Al_2O_3(Alumina)	3-8
Fe_2O_3 (Iron oxide)	0.5-6
MgO (Masgensia)	0.1-4
Alkalies	0.4-1.3
Sulphur	1-3

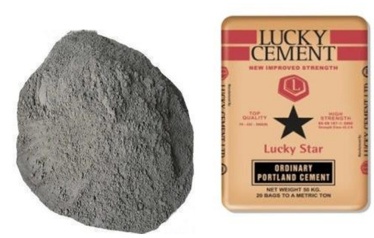

Figure :1 (Cement)

Lucky cement was used for casting cubes for all concrete mixes. The cement was of uniform color i.e. grey with a light greenish shade and was free from any hard lumps. Summary of the various tests conducted on cement are as under given below in table 2.

Table 2. Physical properties of lucky cement

Sr. No	Characteristics	Values obtained	StandardValues
1	Normal consistency	33%	----
2	Initial setting time	135 min	Not be less than 30 min
3	Final setting time	320 min	Not be greater the 375 min
4	Fineness	94.5%	More than 90%
5	Specific gravity	3.15	----

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Water:

Water should be clean and potable used for production of concrete. The W/C is the most important factor can be determined the strength of concrete. A lower water cement ratio will give a concrete that is stronger, while a higher water cement ratio sows lower strength. The workability and consistency are exaggerated by the water cement ratio, cement paste and the physical characteristics such as size, shape and grading of the aggregates.

Aggregate:

In any concrete, aggregates (fine sand and coarse) usually occupy about 70-75% and between 60-80% of the total volume of the concrete mass. The aggregates have to be graded so the whole mass of concrete acts as a relatively solids, homogeneous, dense combination with the smallest particles acting as inert filler for the voids that exist between the larger particles.

Fine Aggregates:

The sand utilized for the experimental program was locally obtained. The sand was first sieved through 4.75 mm sieve to eliminate any particles greater than 4.75 mm and then was washed to separate dust. Properties of fine aggregate used in the exploratory work are tabulated in Table: 3. The aggregates were sieved through a set of sieves to acquire sieve analysis and alike is presented in Table:4.

Figure.2 F.A (Sand)

Table .3 Physical properties of Sand

Sr. No	Characteristics	Value
1	Type	Bolari Sand
2	Specific gravity	2.58
3	Fineness modulus	2.70
4	Water absorption	1.18%

Coarse Aggregates:

The material which is retained on IS sieve no. 4.75 is designated as a coarse aggregate. The squeezed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the locally accessible coarse aggregate having a maximum size of 19 mm was utilized in our work. The aggregates were washed to withdraw dust and dirt and were dried to surface dry condition. The aggregates were tested in Lab.

Total weight of sample=5kg

Table 4: Sieve Analysis of Coarse Aggregates

Sieve	Weight retained(kg)	Percentage weight retained	Cumulative percentage weight retained	Percentage passing
25mm	0	0	0	100
19.5mm	750	15	15	85
12.5mm	1340	26.8	41.8	58.2
9.5mm	1755	35.1	76.9	23.1
4.75mm	1115	22.3	99.2	0.8
Pan	40	0.8	100	0

4 Results and Discussion

A. Compressive Strength:

The compressive strength of concrete specimens will be conducted at specified curing periods. For the testing of compressive strength, specimens like cubes and cylinders of various sizes are tested in Compressive Testing Machine. CTM has been used for the testing of cubes, which is available in Concrete Lab.

Figure:3 Compressive testing Machine

The results of Compressive strength are plotted in Table.5 and Figure.4

Table 5: Average Compressive Strength

Age of curing	Curing Methods	Compressive Strength (MPa)
21 days	Wet Curing	30.75
	3% NaCl solution curing	27.35
	Cyclic Curing	23.73
	Air Curing	20.94
56 days	Wet Curing	37.85
	3% NaCl solution curing	33.62
	Cyclic Curing	26.89
	Air Curing	23.52
90 Days	Wet Curing	38.13
	3% NaCl solution curing	36.85
	Cyclic Curing	27.20
	Air Curing	24.07

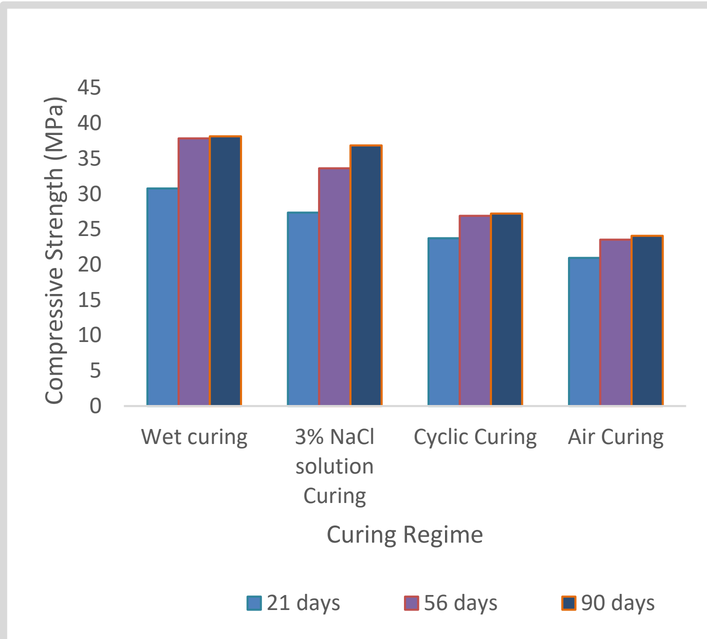

Figure.4 Average Compressive strength Comparison

B. Flexural strength test:

The flexural strength of concrete specimens was conducted at specified curing periods. For the testing of flexural tensile strength, UTM machine has been used which is available in Concrete Lab.

Figure: 5 Universal Testing Machine

The results of flexural strength are plotted in Table.6 and Figure 6.

Table 6: Average Flexural Strength

Age of curing	Curing Methods	Flexural Strength (MPa)
21 days	Wet Curing	4.00
	3% NaCl solution curing	3.61
	Cyclic Curing	3.27
	Air Curing	2.97
56 days	Wet Curing	4.56
	3% NaCl solution curing	4.23
	Cyclic Curing	3.64
	Air Curing	3.36
90 Days	Wet Curing	4.79
	3% NaCl solution curing	4.49
	Cyclic Curing	4.18
	Air Curing	3.44

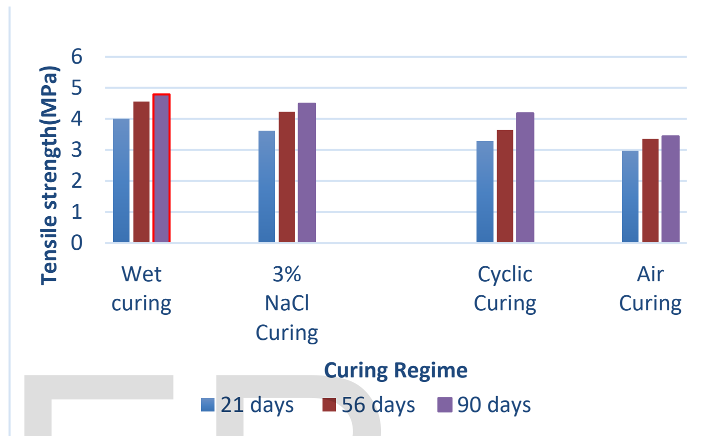

Figure.6 Average Flexural strength Comparison

4. Conclusions

Following conclusions can be drawn on the basis of the results:

- Different curing methods have different impact on the compressive strength and flexural strength of concrete.
- The minimum Compressive strength and flexural strength was observed in Air curing.
- An increase in strength was observed by increasing curing of concrete, wet curing gave the maximum strength as compare to NaCL curing, Cyclic Curing and Air curing respectively.
- Totally uncured concrete shrinks when compared to other curing methods.
- The salt water should be used and not feared for casting and curing of concrete during construction most especially in coastal environment.

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