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A Comparative Study on Methods of Curing Concrete –Influence of Humidity

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ABSTRACT

Efficient uninterrupted curing is the key to quality concrete. Proper curing of concrete is crucial to obtain design strength and maximum durability. The curing period depends on the required properties of concrete, the purpose for which it is to be used, and the surrounding atmosphere namely temperature and relative humidity. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength. Curing may be applied in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method. The present paper is directed to evaluate effectiveness of different curing methods and study the influence of climate on the strength properties of concrete.

Key Words: *Curing of concrete Hydration of cement Relative humidity*

I. INTRODUCTION

Concrete is the key material used in various types of construction. The quality of concrete is defined by its strength and durability. The compressive strength of concrete is one of the most important and useful properties that quantify the quality of concrete. For concrete, to gain the required strength, hydration of cement in the mix must be complete. Proper hydration of cement ensures good quality concrete with sufficient strength. For proper hydration to occur, fresh concrete must be placed in a favourable environment. An attempt is made in this work to highlight the affect of different curing methods and that of climate on the quality of the Concrete.

II. RESEARCH METHODOLOGY

1.1 Concrete Mix

Design of concrete mix is a crucial stage in the preparation of fresh concrete which involves selecting suitable ingredients and determining their relative amounts with an objective of producing a concrete of the required strength, durability and workability as economically as possible. The properties of different ingredients required for preparation of concrete viz. cement, fine aggregate (sand), coarse aggregate (crushed stone), water and super plasticizer (as necessary) are presented vide Tables 1 to 3.

Ordinary Portland cement of 53 grade satisfying the requirements of IS: 12269-1987 with 28-days compressive strength of 58.5 Mpa is used. The physical properties are given in the Table 1. Natural River sand confirming to Zone II (Medium sand) of IS: 383-1970 with fineness modulus of 2.81 is used as fine aggregate and Crushed angular granite metal with 12mm downgraded size from a local source with a fineness modulus of 7.24 was procured to be used as coarse aggregate. The sieve analysis of fine and coarse aggregates are as in tables 2 and 3 respectively.SP430 supplied by M/s Fosroc Chemicals Limited is considered for super plasticizer

Mix design was done aiming at M60 grade concrete as per ACI regulations. After a number of trails the final mix proportion is determined to be 1:1.35:2.19:0.29:0.8. The quantity of raw materials per cubic meter of concrete is as depicted in Table 4

Table1 Physical properties of OPC 53 grade cement

Properties	Test Results	IS : 12269-1987
Standard Consistency	32%	
Initial Setting Time	42 min	30 min
Final Setting Time	360 min	600 min
Specific Gravity	3.15	
Fineness (residue on 90µ IS Sieve)	2.6%	10%
Compressive Strength 3 day 7 day 28 day	 27.0 MPa 41.2 MPa 58.5 MPa	 20 MPa 30 MPa 50 MPa

Table2 Sieve Analysis of Fine Aggregate

Sieve Size	Wt. retained (gm)	% Wt. Retained	Cumulative % Wt. Retained	Cumulative % Wt. Passing
4.75	13.5	1.35	1.35	98.65
2.36	42	4.2	5.55	94.45
1.18	243	24.3	29.85	70.15
600 µ	334	33.4	63.25	36.75
300 µ	234	23.4	86.65	13.35
150 µ	80.5	8.05	94.7	5.3
<150 µ	53	5.3	100	--

Table 3 Sieve Analysis of Fine Aggregate

Sieve Size	Wt. Retained (kg)	% WT. Retained	Cumulative % Wt. Retained	Cumulative % Wt. Passing
80	0	0	0	0
40	0	0	0	0
20	0.7	35	35	65
10	1.15	57.5	92.5	7.5
4.75	0.13	6.5	99	1
2.36	0.009	0.45	99.45	0.55
1.18	0	0	99.45	--
600 µ	0	0	99.45	--
300 µ	0	0	99.45	--
150 µ	0	0	99.45	--

Table 4 Quantities of raw materials per one cubic meter concrete

Mix	Cement (kg)	Fine Aggregate (Kg)	Coarse Aggregate (kg)	Water (kg)	Super plasticizer
M60	504.21	683.24	1108.13	141.61	4.6681

1.2 Curing methods

Different curing methods namely ponding, jute bag curing, single layered membrane curing, double layered membrane curing and air curing are considered to study the affect of different methods of curing and climate on the quality of concrete. The curing compounds used for membrane curing are C1-ia white pigmented liquid paraffin based curing compound confirming ASTM C 309 Type2 Class A. C2 - a wax based paraffin emulsion confirming ASTM C 309 Type2 Class B. C3 – a white pigmented wax based compound confirming ASTM C 309-74. Concrete samples were tested after curing of 3 days, 7 days and 28 days. Curing compound was sprayed immediately after removal from moulds and in case of the double coat the second coat was applied after 5 minutes of application of first coat. Jute bag curing was done by spraying water once in the morning at 10 am and in the evening at 4.00pm

III. 3 DATA ANALYSIS

Concrete was prepared in a pan mixer and cube moulds were filled using a vibrating table. The curing was done by all the methods cited in research methodology. Fig. 1 depicts the curing techniques used. The Compressive strength was determined on the compression testing machine at the end of 3 days, 7 days and 28 days of curing. The entire casting and testing procedure for the jute bag curing and air curing was done twice, once in December and then in February. Day to day Metrological data was collected for the entire month of December and February. Table 5 shows average values of the data collected. The compressive strength of the 15cmX15cmX15cm concrete cubes are presented vide Tables 6

Table 5 Meteorological data for the months of December and February

Month	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Rel. Humidity (%) 0530 hrs	Rel. Humidity (%) 1730 hrs
December	26.53	14.29	73	38.68
February	34.8	18.9	56	32

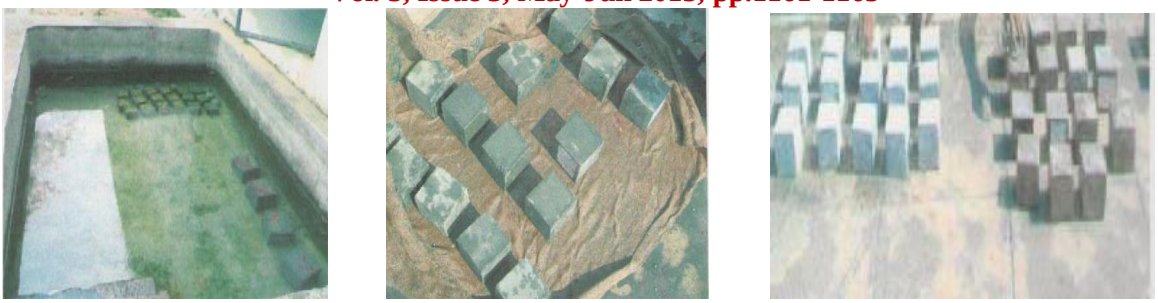

Figure 1 Ponding, Jute bag curing, Membrane Curing and Air Curing of Concrete Cubes

Table 6 Compressive strength of concrete for different types of curing

Sno.	Type of curing	Compressive strength (MPa) at the end of		
		3 days	7 days	28 days
1	Ponding	33.59	44.13	66.13
2	Membrane curing with C1 Single coat	29.05	38.39	58.21
3	Membrane curing with C1 Double coat	31.6	41.04	61
4	Membrane curing with C2 Single coat	30.1	38.49	56.9
5	Membrane curing with C2 Double coat	30.84	39.86	59.86
6	Membrane curing with C3 Single coat	25.94	33.03	50.6
7	Membrane curing with C3 Double coat	29.05	38.39	58.21
8	Jute Bag curing-December	30	43.92	61.23
9	Jute Bag curing- February	27.2	36.49	51.58
10	Air Curing-December	33.3	40.56	49.89
11	Air Curing-February	23.85	32.6	38

IV. RESULTS

The test results are plotted as shown in Figure 2-4. Rate analysis is done to check the cost effectiveness of the different types of curing methods based on the rates in the market. It is found that curing compounds are cost effective.

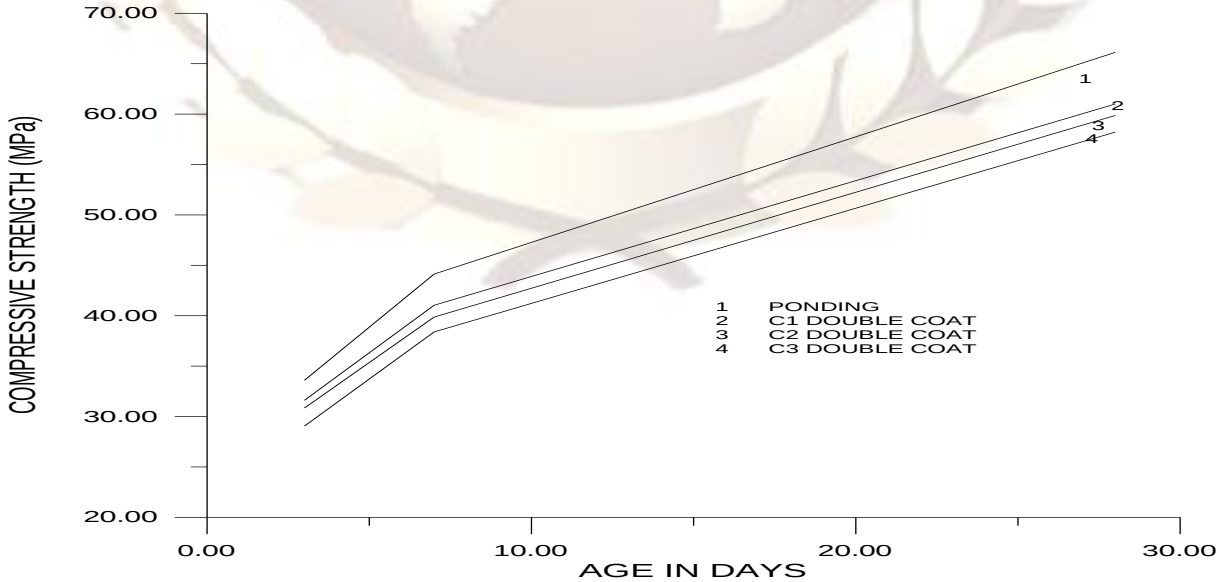

Fig.2 Compressive Strength of concrete for Ponding and Double coat membrane

Fig.3 Compressive Strength of concrete for Ponding and single coat membrane

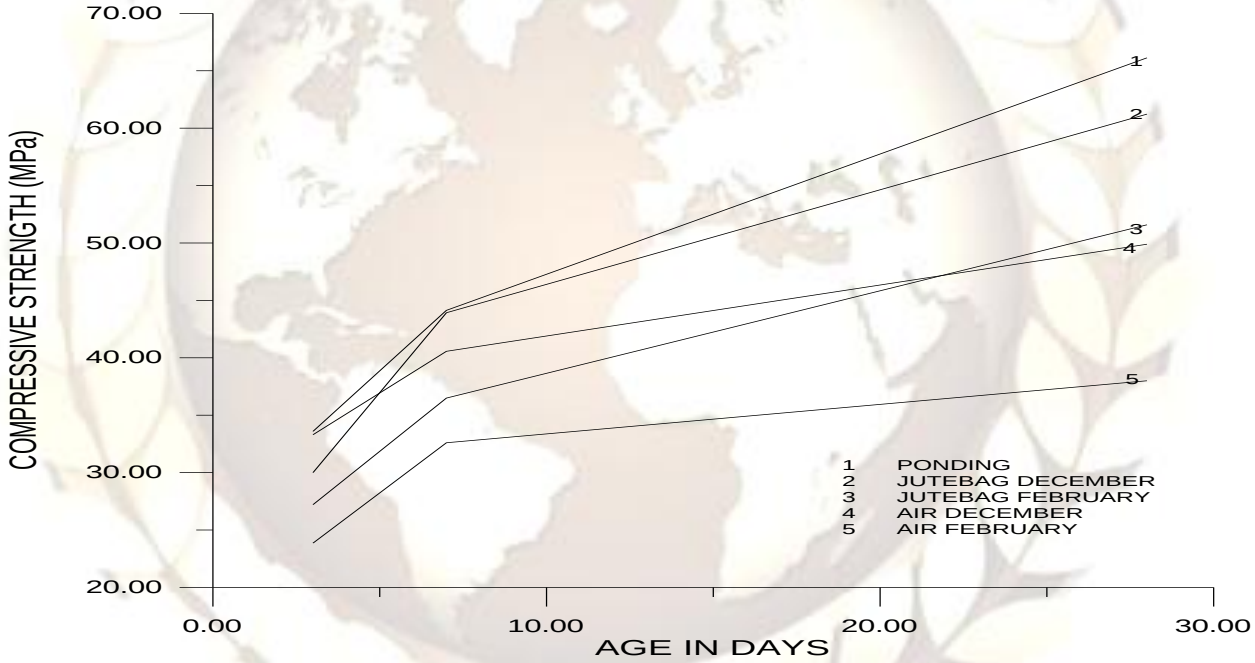

Fig.4 Compressive Strength of concrete for Ponding, Jute bag and Air curing

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VI. CONCLUSION

1. Use of curing compounds resulted in strength up to 85 to 90 % of ponding.
2. White based curing compounds were found effective than membrane based Curing compounds.
3. A double layer application of a high efficiency index curing compounds such as C1 and C2 did not significantly improve the concrete properties when compared with the corresponding single layer application. However a double layer application of a low efficiency index curing compound C3 clearly improved the concrete properties when compared with the corresponding single layer application. The results indicated that, if a high efficiency index curing compound is uniformly applied with a sufficient amount, no double layer application is necessary.
4. Air curing during December with relative humidity (73%) and temperature (26.53^0C) showed that 28 days compressive strength was in comparison with jute bag curing as the cubes

could have absorbed the moisture which helped in gaining strength.

5. Air Curing during February with relative humidity (56%) and temperature (34.8^0C) resulted in a compressive strength of 38Mpa which is 76.16% of the strength achieved through air curing in December showing relative humidity as prime factor in determining the quality of concrete.
6. Compound curing is found to be cost effective compared to conventional jute bag curing since ponding is not suitable in-situ for all components of the structure.

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