ANALYSIS OF DIFFERENT CURING CONDITION IN STRENGTH OF CONCRETE

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Abstract: Concrete requires curing in order that cement hydration can proceed so as to allow for development of strength, durability and other mechanical characteristics. To obtain good concrete, the placing of an appropriate mix must be followed by curing in a suitable environment, especially during the early stages of hardening. Curing is the name given to procedures used for promoting hydration of cement, and consists of a control of temperature and moisture movement from and into the concrete. Curing as the process of protecting concrete for a specified period of time after placement, to provide moisture for hydration of the cement, to provide proper temperature and to protect the concrete from damage by loading or mechanical disturbance. The mechanical properties studied in this research are compressive strength at the both early and later ages. The compressive strengths throughout the study were tested for the specimens (concrete cubes) at 1, 3, 7, 28 days.

A number of curing techniques can be applied depending on various factors considered on site or due to the construction method. They range from the most popular water-submerged curing to moist sand, water-spray curing, polythene membrane sealing and steam curing (autoclaving). In this study compressive strength and flexural strength have been analyzed in which the concrete cubes and beams were kept in different curing conditions like normal, boiling water, warm water and steam curing condition. From the study it was found that accelerating curing condition is very effective means for analyzing the strength at early stage.

Keywords: Cement, Water, Compressive Strength, Concrete, Flexural Strength.

1. SCOPE & OBJECTIVES OF THE RESEARCH WORK

The present study is limited to the compressive and flexural strength of concrete also various accelerating curing conditions have been applied to get the early strength of concrete. The Accelerated admixtures have not been used in the study and two different grade of concrete have been used in the study. The objective finally will be

1. To study the strength properties of concrete made by submerged curing for 28 days, hot water curing and boiling water curing.
2. To study the strength properties of concrete Grade M25 and M40.
3. Predict the 28 days Strength of concrete using the result of boiling and warm water curing method.
4. Both Compressive strength and Flexural Strength test will be conducted.

2. EXPERIMENTAL METHODOLOGY

TEST DATA FOR MATERIALS

a)	Cement used	OPC- 43 grade conforming to IS 8112
b)	Sp.gr of cement	3.15
c)	Sp.gr of Coarse aggregate	2.750
	Sp.gr of Fine aggregate	2.575
d)	Water absorption	
	Coarse aggregate	0.70%
	Fine aggregate	1.00%
e)	Free surface moisture	
	Coarse aggregate	0.14%
	Fine aggregate	0.60%
f)	Sieve analysis	

Sieve Analysis of Coarse Aggregates (Gravel) 5 kg (dry sample)

Sieve Size	Wt. of Sample Retained	Cum Wt. Retained	% Wt. Retained	% Passing
40 mm	0.0 kg	0.0	0.00	100
20 mm	2.646 kg	2.65	53.0	47
10 mm	2.043	4.4	94.0	06
4.75 mm	0.311	5.00	100	00

Sieve Analysis of Fine Aggregates (Gravel) 2 kg (dry sample)

Sieve Size	Wt. of Sample Retained	Cum Wt. Retained	% Wt. Retained	% Passing
4.75 mm	0.148 kg	0.148	7.4	92.60
2.36 mm	0.222 kg	0.570	18.50	81.50
1.18 mm	0.485 kg	0.855	42.75	57.25
600 μ	0.452 kg	1.307	65.35	34.65

300	0.608 kg	1.915	95.75	04.25
150	0.070 kg	1.985	99.25	00.75
Dust Collection	0.015 kg	-	-	-

TARGET STRENGTH FOR MIX PROPORTIONING

$f'_{ck} = f_{ck} + 1.65\ s = 25 + 1.65 \times 4 = 31.6\ N/mm^2$
where , f'_{ck} = target average compressive strength at 28 days
f_{ck} = characteristics compressive strength at 28 days,
s = standard deviation
from Table 1 of IS 10262-2009 , s = 4 N/mm^2

SELECTION OF WATER CEMENT RATIO

From Table 5 of IS 456-2000, maximum water cement ratio = 0.50,
based on experience , adopt water cement ratio = 0.50
0.45 < 0.50 Hence O.K

SELECTION OF WATER CONTENT

From Table 2 of IS 10262-2009 , max water content = 186 lit for slump of 25mm-50mm , 3% water is to be added for every another 25mm .
186 + (186x3/100) = 191.58 lit

CALCULATION OF CEMENT CONTENT

W/C ratio = 191.58 / 0.45 = 425.73 kg/m^3.
From table 5 of IS 456-2000, minimum cement content for 'mild' exposure condition is 300 kg/m^3.
425.73 kg/m^3 > 300 kg/m^3 Hence O.K

MIX CALCULATION PER UNIT VOLUME
Volume of Coarse aggregate = 0.62
Volume of Fine aggregate = 0.38

a) Volume of Concrete = 1 m^3
b) Volume of Cement = (Mass of cement / Sp. gr. of cement) x (1/1000) = (425.73/3.15) x (1/1000) = 0.135m^3
c) Volume of water = (Mass of water / Sp. gr. of water) x (1/100) =(191.58/1)) x (1/1000) = 0.191 m^3
d) Volume of all in aggregates = [a – (b + c)] = 1 – 0.326 = 0.674 m^3
e) Mass of Coarse Aggregate – 0.674 x 0.62 x 2.75 x 1000 = 1149.17 kg/m^3
f) Mass of Fine Aggregate – 0.674 x 0.38 x 2.575 x 1000 = 659.50 kg/m^3

MIX PROPORTION FOR M 25 GRADE OF CONCRETE

water	Cement	Fine Aggregates	Coarse Aggregates
191.58 lit	425.73 kg/m3	659.50 kg/m3	1149.17 kg/m3
0.45	1	1.540	2.690

Concrete Mix Design For M 40 grade of concrete.

TEST DATA FROM MATERIALS

1	Cement used	OPC 43grade (Ultratech)
2	Specific Gravity of Cement	3.15
3	Specific Gravity of Coarse aggregate	2.74
	Specific Gravity of fine aggregate	2.74
4	Water absorption Coarse aggregate	0.5 %
	Water absorption fine aggregate	1 %
5	Free (surface) moisture Coarse aggregate	Nil
	Free (surface) moisture fine aggregate	Nil
6	Sieve analysis Coarse aggregate	Confirming to Table IS 2 of IS 383
	Fine aggregates	Confirming to Zone I of Table 4 of IS 383

Design Stipulations for proportioning

a)	Grade designation	M40
b)	Type of cement	OPC 43grade (Ultratech)
c)	Max nominal size of aggregates	20 mm
d)	Minimum cement content	320 kg/m3
e)	Maximum w/c	0.45
f)	Workability	100 mm
g)	Exposure condition	Severe
h)	Degree of supervision	Good
i)	Type of aggregate	Crushed angular
j)	Maximum cement content	450 kg/m3

Target Mean Strength
$f'_{ck} = f_{ck} + 1.65\ s = 40 + 1.65 \times 5 = 48.25\ N/mm^2$
where, f'_{ck} = target average compressive strength at 28 days
f_{ck} = characteristics compressive strength at 28 days,
s = standard deviation from Table 1 of IS 10262-2009, s = 5 N/mm^2

Selection of water content
From Table 2, from IS 10262-2009 maximum water content for 20mm aggregate = 186 litres (for 25 to 50 mm slump range)
Estimated water content for 100mm slump = 186 + ((6/100) x 186 = 197 litres let us take 195 litres.

Calculation of cement content
Water cement ratio = 0.44
Cement content = 195 / 0.44 = 443.18 kg/m^3 , from Table 5 of IS 456, minimum cement content for severe exposure condition = 320 kg/m^3
443.18 kg/m^3 > 320 kg/m^3 hence O.K

MIX PROPORTION FOR M 40 GRADE OF CONCRETE

Water	Cement	Fine Aggregates	Coarse Aggregates
195 lit	443.18 kg/m3	499 kg/m3	1315 kg/m3
2.966	0.44	1	1.125

3. RESULTS AND DISCUSSION

The Below Mentioned Results Are Of Determination Of Early Strength Gaining Process Of Cement Concrete And Prediction Of 28th Day Strength Of Cubes.

- It is very important to select suitable ingredients of concrete and to determine their relative amounts with the objective of producing a concrete of required, strength, durability, and workability as cheap as possible. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, the plastic and the hardened states. If the concrete in plastic state is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.
- The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate.
- Concrete hardens and gains strength as it hydrates. The hydration process continues over a long period of time. Generally hydration process takes place when water comes in contact with cement, it happens rapidly at first and slows down as time goes by. In mixing and in curing generally water that is used is underground water or from any other source from where potable water can be obtained. The temperature of water used during all these process is generally 25^0C to 30^0C depending upon the weather condition.
- The hydration process affects the quantity and rate of heat evolution. The net heat evolved at any given age of setting of concrete is entirely due to the hydration which has taken place up to the time of setting. The water causes the hardening of concrete through a process called hydration. It is a chemical reaction in which the major compounds in cement forms chemical bonds with water molecules and become hydrates or hydration products. The role of water is important because too much water reduces concrete strength, while too little will make the concrete unworkable. Portland cement is a hydraulic cement which derives strength from chemical reactions between the cement and water. Cement consists of the following major compounds:

- Tricalcium silicate C_3S
- Dicalcium silicate C_2S
- Tricalcium aluminate C_3A
- Tetracalcium aluminoferrite C_4AF
- Gypsum CSH_2

4. ANALYSIS OF RESULTS

Table of - Av. Compressive Strength Test after No. of days Curing

No.	Mix Grade	1 day normal curing (N/mm^2)	3 day normal curing (N/mm^2)	7 day normal curing (N/mm^2)	28 day normal curing (N/mm^2)	Standard Value (N/mm^2)	Targeted Strength (N/mm^2)
1	M25	5.00	11.73	24.44	29.35	25	35.31
2	M40	8.00	18.76	39.10	46.96	40	56.49

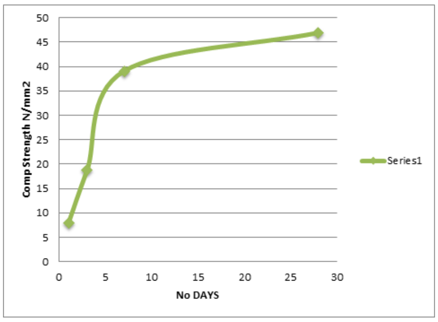

Figure IN Graph for Comp Strength of M25 concrete for 1, 3, 7, 28 days immersed in water at room temperature

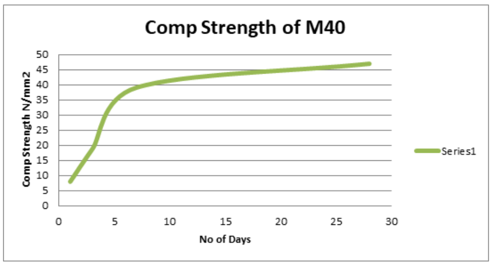

Figure in Graph for Comp Strength of M40 for 1, 3, 7, 28 days immersed in water at room temperature

Table of - Av. Strength Test after No. of days Accelerated Curing

No.	Mix Grade	23 hrs normal curing & 3 ½ hrs boiling water curing. (N/mm^2)	3 days normal curing & 3 ½ hrs boiling water curing. (N/mm^2)	7 day normal curing (N/mm^2)	28 day normal curing (N/mm^2)	Standard Value (N/mm^2)	Targeted Strength (N/mm^2)
1	M25	24.0625	22.71	24.44	29.35	25	35.31
2	M40	38.5	36.336	39.10	46.96	40	56.49

Table of- Av. Strength Test after No. of days Accelerated Warm water curing

No.	Accelerating Admixture	23 hrs normal curing	20 hrs warm water curing (N/mm)	3 days normal curing (N/mm^2)	3 days normal curing & 3 ½ hrs warm water curing. (N/mm^2	7 day normal curing (N/mm^2)	28 day normal curing (N/mm^2)
1	M25	5.00	13.53	11.73	21.44	24.44	29.35
2	M40	8.00	21.64	18.77	34.30	39.10	46.96

Table of - Av. Strength Test after No. of days Curing Accelerated (Steam) Curing

No.	Accelerating Admixture	23 hrs normal curing (N/mm^2)	23 hrs Steam curing. (N/mm^2)	3 days normal curing (N/mm^2)	3 days Steam curing. (N/mm^2)	7 day normal curing (N/mm^2)	28 day normal curing (N/mm^2)
1	M25	5.00	13.20	11.74	23.47	24.44	29.35
2	M40	8.00	21.12	18.77	37.55	39.10	46.96

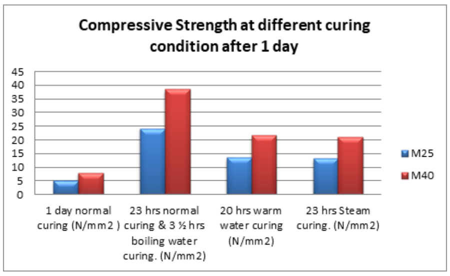

Figure of Graph for Compressive Strength at different curing condition after 1 day for M25 and M40 grade concrete

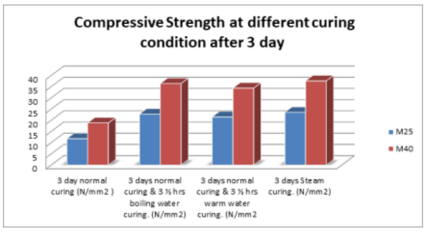

Figure of Graph for Compressive Strength at different curing condition after 3 day for M25 and M40 grade concrete

5. CONCLUSIONS

1. Moist sand curing method produced specimens with the highest compressive strength while Air curing produced the lowest.
2. All the methods of curing considered, except air curing (the control) produced concrete specimens that met the minimum compressive strength specified by the available code.
3. .The volume of specimen decreases, the effect of temperature curing on compressive strength increases, and the rate of increase in compressive strength increases.
4. There exists a weak positive correlation between density and compressive strength of concrete.
5. There was no controlled temperature for any of the curing techniques. All the samples under the four different methods were cured under the same temperature. Based on the uniform platform that was created for all the samples, the study concludes that the water curing and jute bag methods are the most efficient methods of curing.

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