

To study effect Of Different Curing Methods on the Compressive Strength of Concrete

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Abstract

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 . 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. The overall finding of this study suggests that concrete should be cured by water curing to achieve a better compressive strength.

Keywords: Curing method, compressive strength, concrete, membrane

1. INTRODUCTION

There are various methods of curing. The adoption of a particular method will depend upon the nature of work and the climatic conditions. The following methods of curing of concrete are generally adopted. Curing of Concrete

- Covering concrete surfaces with hessian or gunny bags
- Sprinkling of water
- Ponding method
- Membrane curing
- Steam curing.

1.1 Covering Concrete Surfaces with Hessian or Gunny Bags

This is a widely used method of curing, particularly for structural concrete. Thus exposed surface of concrete is prevented from drying out by covering it with hessian, canvas or empty cement bags. The covering over vertical and sloping surfaces should be secured properly. These are periodically wetted. The interval of wetting will depend upon the rate of evaporation of water. It should be ensured that the surface of concrete is not allowed to dry even for a short time during the curing period. Special arrangements for keeping the surface wet must be made at nights and on holidays.

1.2 Sprinkling of Water

Sprinkling of water continuously on the concrete surface provides an efficient curing. It is mostly used for curing floor slabs. The concrete should be allowed to set sufficiently before sprinkling is started. The spray can be obtained from a perforated plastic box. On small jobs sprinkling of water may be done by hand. Vertical and sloping surfaces can be kept continuously wet by sprinkling water on top surfaces and allowing it to run down between the forms and the concrete. For this method of curing the water requirement is higher.

1.3 Ponding Method

This is the best method of curing. It is suitable for curing horizontal surfaces such as floors, roof slabs, road and air field pavements. The horizontal top surfaces of beams can also be ponded. After placing the concrete, its exposed surface is first covered with moist hessian or canvas. After 24 hours, these covers are removed and small ponds of clay or sand are built across and along the pavements. The area is thus divided into a number of rectangles. The water is filled between the ponds. The filling of water in these ponds is done twice or thrice a day, depending upon the atmospheric conditions. Though this method is very efficient, the water requirement is very heavy. Ponds easily break and water flows out. After curing it is difficult to clean the clay.

1.4 Membrane Curing

The method of curing described above come under the category of moist curing. Another method of curing is to cover the wetted concrete surface by a layer of water proof material, which is kept in contact with the concrete surface of seven days. This method of curing is termed as membrane curing. A membrane will prevent the evaporation of water from the concrete. The membrane can be either in solid or liquid form. They are also known as sealing compounds. Bituminized water proof papers, wax emulsions, bitumen emulsions and plastic films are the common types of membrane used.

Whenever bitumen is applied over the surface for curing, it should be done only after 24 hours curing with gunny bags. The surface is allowed to dry out so that loose water is not visible and then the liquid asphalt sprayed throughout. The moisture in the concrete is thus preserved. It is quite enough for curing.

This method of curing does not need constant supervision. It is adopted with advantage at places where water is not available in sufficient quantity for wet curing. This method of curing is not efficient as

compared with wet curing because rate of hydration is less. Moreover the strength of concrete cured by any membrane is less than the concrete which is moist cured. When membrane is damaged the curing is badly affected.

1.5 Steam Curing

Steam curing and hot water curing is sometimes adopted. With these methods of curing, the strength development of concrete is very rapid. These methods can best be used in pre cast concrete work. In steam

2. LITERATURE REVIEW

Concrete curing is one of the most important and final steps in concrete construction though it is also one of the most neglected and misunderstood procedures. It is the treatment of newly placed concrete during the period in which it is hardening so that it retain enough moisture to immunize shrinkage and resist cracking (Lambert Corporation, 1999).

Curing of concrete is a pre requisite for the hydration of the cement content. For a given concrete, the amount and rate of hydration and furthermore the physical make-up of the hydration products are dependent on the time-moisture-temperature history (Neil Jackson et al, 1996).

The necessity for curing arises from the fact that hydration of cement can take place only in water-filled capillaries. This is why loss water must be prevented. Furthermore, water lost internally by self-dedication has to be replaced by water from outside, i.e. Ingress of water into the concrete must take place. (Neville,et al,1987). Thus, for complete and proper strength developments, the loss of water in concrete from evaporation should be prevented, and the water consumed in hydration should be replenished. This the concrete continues gaining strength with time provided sufficient moisture is available for the hydration of cement which can be assured only by creation of favorable conditions of temperature and humidity. This

3. MATERIALS AND METHODS

Locally available crushed granite stones and fine aggregate (quartzite sand) were used as coarse and fine aggregate respectively. The fractions of different sizes of crushed granite stone and fine aggregates, as shown

Table 1: Gradation of crushed granite stone and quartzite sand.

SIEVE SIZE	% FINER BY MASS	
	Crushed Granite Stone (Fineness Modulus: 4:81)	Sand (Fineness Modulus:4.23)
28.00mm	100	
20.00mm	85.91	

curing the temperature of steam should be restricted to a maximum of 75⁰C as in the absence of proper humidity (about 90%) the concrete may dry too soon. In case of hot water curing, temperature may be raised to any limit, ay 100⁰C. At this temperature, the development of strength is about 70% of 28 days strength after 4 to 5 hours. In both cases, the temperature should be fully controlled to avoid non-uniformity. The concrete should be prevented from rapid drying and cooling which would form cracks

process of creation of an environment during a relatively short period immediately after the placing and compaction of the concrete, favorable to the setting and the hardening of concrete is termed curing (Gambier, 1986).

A proper curing maintains a suitably warm and moist environment for the developments of hydration products, and thus reduces the porosity in the hydrated cements paste and increases the density of microstructure in concrete. The hydration products extend from the surfaces of cement grains, and the volume of pores decreases due to proper curing under appropriate temperature and moisture (Safiudeen et al,2007). A proper curing greatly contributes to reduce the porosity and drying shrinkage of concrete, and thus to achieve higher strength and greater resistance to physical or chemical attacks in aggressive environments. Therefore, a suitable curing method such as water ponding (immersion), spraying or sprinkling of water, or covering with polythene sheet material is essential us order to produce strong and durable concrete.

The study present the effect of different curing methods on the compressive strength of concrete using Portland cement and finally identifies the most effective curing process for normal concrete.

in Table 1 were in the ranges specified in Bs 812 (1960) methods for sampling and testing of aggregates.

Ordinary Portland cement was used as the main binder. Portable water from borehole was used for preparing the concrete. It was also used for curing purposes. The major properties of the constituent materials are given in Table 2.

14.00mm	19.86	
10.00mm	10.82	
6.30mm	1.28	
5.00mm	0.29	99.48
3.35mm	–	99.21
2.00mm	–	98.47
1.18mm	–	93.60
850µm	–	86.97
600µm	–	75.40
425µm	–	56.62
300µm	–	43.66
150µm	–	13.53
75µm	–	10.03

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Table 2: Properties of the constituent materials of concrete

Materials	Properties
Crushed Granite Stone	Max. size:20mm,unitweight: 434.50kg/m ³ Specific gravity: 2.68, Absorption:0.77%, Moisture content: or 14%, void ratio: 0.46, Porosity: 9.27%
Fine Aggregate	Max. size:5mm, unit weight: 518.70kg/m ³ , Specific gravity: 2.77, Absorption:2.29%, Moisture content:4.71%, void ratio: 0.45, Porosity: 0.07%
Ordinary Portland Cement	Specific Gravity: 3.15, unit weight: 1440kg/m ³
Borehole Water	Density: 1000kg/m ³ , PH = 6.9

4. MIXTURE PROPORTIONS OF CONCRETE

The normal concrete was prepared based on water cement ratio of 0.50 and a cement content of 340kg/m³ to obtain a compressive strength greater than 20N/mm² at 28 days (Immersion method of curing). Quartzite sand was used with a quantity of 33.33% of total aggregates by weight. The concrete mixture was proportioned to have a minimum slump of 48mm and also a minimum compacting factor or 0.94. The concrete mixture was assumed to be fully compacted and the proportions of the materials were determined on the basis of absolute volume of the constituents. The details of mixture proportions are given in table 5.

5. MIXTURE PROPORTIONS OF CONCRETE

Crushed granite stone	-	1360	Kg/m ³
Fine aggregate	-	680	Kg/m ³
Ordinary Portland Cement	-	340	Kg/m ³
Portable Borehole Water-			170 Kg/m ³

6. TESTING OF FRESH CONCRETE

The fresh concrete was produced using manual method of mixing in the civil engineering laboratory of F.U.T Minna. Immediately after mixing, the fresh concrete was tested for slump and compacting factor. The slump and compacting factor tests were determined according to Bs 812 (1960)

7. PREPARATION OF TEST SPECIMENS

A total of 48 cubes having dimensions 150mm x

150mm x 150mm each were cast. The specimens were molded in oiled timbers moulds using three layers of filling and each layer tamped 25 times to expel the entrapped air. The tops of the cubes were marked after a while for identification purpose. Immediately after this, the specimens were kept in a cool place in the laboratory. The specimens were removed from the wooden moulds at the age of 24+ – 2 hours.

Curing -The test specimens were cured under three types of curing until the day of testing. These were water curing(WAC), sprinkling of water (SWC) and wrapping with plastic sheeting (PSC).In water curing, the specimens were weighed and immersed in water. Portable borehole water was used in water curing. In sprinkling method, the specimens were also weighed and kept moist by sprinkling water on the specimens 2 times daily (morning and evening) until the date of testing. In plastic sheeting, the specimens were weighed and wrapped in flexible plastic sheets until the testing date. At least 2 layers of wrapping were used to prevent moisture movement from concrete surface. The curing temperature was maintained at 27 + 2°C in all the curing methods.

8. TESTING OF THE HARDENED CONCRETE

The compressive strength of the test cubes were determined by crushing the cubes under the compression machine. A total of 48 cubes in all were crushed, 16of these cubes were for immersion method, the next 16 cubes were for sprinkling method while the last 16 cubes were for membrane of these cubes were for 5 sprinkling method while the last 16 cubes were for membrane method (Polythene Sheet). The length of curing dates considered was 7 and 28 days respectively.

9. RESULT AND DISCUSSIONS

9.1 Fresh Properties

The slump and compacting factor of the concrete were 48mm and 0.94 respectively indicating that the concrete mix has adequate mobility and stability i.e the mix fall within the range of medium workability. The average result of 0.94 obtained as the compacting factor indicated that the concrete can be manually compacted. The concrete can also be used for heavily reinforced sections with vibrations (Neville et al, 1987).

9.2 COMPRESSIVE STRENGTH

Table 4: Compressive strength of cubes cured for 7 days using immersion method of curing.

Identification Mark	Age of Curing (days)	Wt of Cube (KG)	Dimension of the Cube (mm x mm x mm)	Density of Cube (Kg/m ³)	Area of Cube (mm ²)	Failure Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
F11	7	7.96	150 X 150 X 150	2358.52	22500	330.67	14.70	
F12	7	7.68	150 X 150 X 150	2275.56	22500	328.00	14.58	
F13	7	7.65	150 X 150 X 150	2266.67	22500	294.67	13.10	
F14	7	7.53	150 X 150 X 150	2231.11	22500	346.67	15.41	13.56
F15	7	7.90	150 X 150 X 150	2340.74	22500	310.67	13.81	
F16	7	7.84	150 X 150 X 150	2322.96	22500	273.33	12.15	
F17	7	8.04	150 X 150 X 150	2382.22	22500	280.00	12.44	
F18	7	7.79	150 X 150 X 150	2308.15	22500	276.67	12.30	

Table 5: Compressive strength of cubes cured for 28 days using immersion method of curing

Identification Mark	Age of Curing (days)	Wt of Cube (KG)	Dimension of the Cube (mm x mm x mm)	Density of Cube (Kg/m ³)	Area of Cube (mm ²)	Failure Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
F21	28	7.52	150 X 150 X 150	2228.15	150 X 150	496	22.04	
F22	28	7.60	150 X 150 X 150	2251.85	150 X 150	492	21.87	
F23	28	7.92	150 X 150 X 150	2346.67	150 X 150	442	19.84	
F24	28	7.94	150 X 150 X 150	2352.59	150 X 150	520	23.11	20.34
F25	28	7.96	150 X 150 X 150	2358.52	150 X 150	466	20.71	
F26	28	7.83	150 X 150 X 150	2320.00	150 X 150	410	18.22	
F27	28	7.80	150 X 150 X 150	2311.11	150 X 150	420	18.67	
F28	28	8.19	150 X 150 X 150	2426.67	150 X 150	415	18.44	

Table 6:- Compressive strength of cubes cured for 7 days using sprinkling method of curing

Identification Mark	Age of Curing (days)	Wt of Cube (KG)	Dimension of the Cube (mm x mm x mm)	Density of Cube (Kg/m ³)	Area of Cube (mm ²)	Failure Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
S11	7	8.40	150 X 150 X 150	2488.89	150 X 150	323	14.37	
S12	7	8.50	150 X 150 X 150	2518.52	150 X 150	286	12.71	
S13	7	8.60	150 X 150 X 150	2548.51	150 X 150	274	12.18	
S14	7	8.78	150 X 150 X 150	2595.56	150 X 150	278	12.36	12.25
S15	7	8.48	150 X 150 X 150	2512.59	150 X 150	268	11.82	
S16	7	8.42	150 X 150 X 150	2494.81	150 X 150	266	11.82	
S17	7	7.90	150 X 150 X 150	2340.74	150 X 150	257	11.43	
S18	7	7.69	150 X 150 X 150	2278.52	150 X 150	254	11.29	

Table 7: Compressive strength of cubes cured for 28 days using sprinkling method of curing.

Identification Mark	Age of Curing (days)	Wt of Cube (KG)	Dimension of the Cube (mm x mm x mm)	Density of Cube (Kg/m ³)	Area of Cube (mm ²)	Failure Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
S21	28	8.76	150 X 150 X 150	2595.56	150 X 150	485	21.56	
S22	28	8.58	150 X 150 X 150	2542.22	150 X 150	429	19.07	
S23	28	8.42	150 X 150 X 150	2494.81	150 X 150	411	18.27	
S24	28	8.31	150 X 150 X 150	2462.22	150 X 150	417	18.53	18.38
S25	28	8.19	150 X 150 X 150	2426.67	150 X 150	399	17.73	
S26	28	8.08	150 X 150 X 150	2394.07	150 X 150	400	17.78	
S27	28	8.25	150 X 150 X 150	2444.40	150 X 150	386	17.16	
S28	28	7.86	150 X 150 X 150	2328.89	150 X 150	381	16.93	

Table 9: Compressive strength of cubes cured for 28 days using the Membrane Method (Plastic Sheetting).

Identification Mark	Age of Curing (days)	Wt of Cube (KG)	Dimension of the Cube (mm x mm x mm)	Density of Cube (Kg/m ³)	Area of Cube (mm ²)	Failure Load (KN)	Compressive Strength (N/mm ²)	Average Compressive Strength (N/mm ²)
P21	28	8.80	150 X 150 X 150	2607.41	150 X 150	397	17.64	
P22	28	8.51	150 X 150 X 150	2521.48	150 X 150	409	17.84	
P23	28	8.31	150 X 150 X 150	2462.22	150 X 150	400	17.78	
P24	28	8.20	150 X 150 X 150	2429.62	150 X 150	366	17.16	17.42
P25	28	7.93	150 X 150 X 150	2349.63	150 X 150	410	18.22	
P26	28	7.72	150 X 150 X 150	2287.41	150 X 150	378	16.80	
P27	28	7.69	150 X 150 X 150	2278.52	150 X 150	381	16.93	
P28	28	7.67	150 X 150 X 150	2272.59	150 X 150	375	16.67	

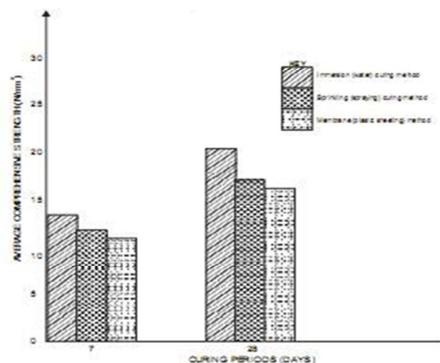


Fig 3: Graph of average compressive strength versus curing ages for Different methods of curing used in the experiment

The results of compressive strength have been presented in tables 4-9 and in the graphical representation of average compressive strength versus curing age for different methods of curing used in the experiment (see fig 3). In all curing methods, the compressive strength of the concrete increases with age. The highest compressive strength at all ages was produced by immersion (water) curing. The average compressive strength of water cured concrete was 13.56w/mm² and 20.34 N/mm² at 7 and 28 days respectively. Sprinkling method produced compressive strength close to immersion (Water) curing. Sprinkling method produced a compressive strength of 12.25w/mm² and 18.38N/mm² at 7 and 28 days respectively. The development of higher compressive strength in immersion (Water) curing and sprinkling method of curing is credited to sufficient moisture and suitable vapor pressure, which were maintained to continue the hydration of cement.

Plastic sheeting (membrane) method of curing produced the lowest compressive strength at all ages. It caused a reduction in compressive strength of 1.89N/mm² and 2.92N/mm² at 7 and 28 days, respectively, as compared to water curing. The early drying of concrete stopped the cement hydration before the pores were blocked by adequate calcium silicate hydrate.

10. CONCLUSIONS

1. Water curing was the most effective method of curing. It produced the highest level of compressive strength. This is due to improve pore structure and lower

porosity resulting from greater degree of cement hydration reaction without any loss of moisture from the concrete specimens.

2. Sprinkling method of curing produces higher compressive strength than plastic sheeting. This is attributed reduced the moisture movement from concrete specimens leading to enhanced degree of cement hydration.

3. Plastic sheeting method of curing produces lowest level of compressive strength. This is because the moisture movement from the concrete specimen is higher in plastic sheeting method, which did not provide any protection against early drying out of concrete. Hence hydration of cement reaction was abated.

4. The extent of moisture movement was greatly dependent of the method of curing. Greater moisture movement occurs under plastic sheeting (membrane) method, and it significantly affected the strength property of the concrete.

5. Normal concrete should be cured by water curing (immersion) method in order to achieve good hardened properties. Water curing produces no loss of moisture, and therefore enhances cement hydration reaction. In case of water shortage, sprinkling curing can be adopted instead of wrapped (plastic sheeting) curing.

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