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Effect of Curing Methods on Various Concrete Grades

Er. Rajesh Sharma[1], Dr. Hemant Sood[2]
ME Student[1], Professor & Head[2]
Department of Civil Engineering
National Institute of Technical Teachers Training & Research, Chandigarh, India

Abstract:
In this research study, the comparison of strength properties of concrete has been assessed by different curing methods. The curing methods adopted are Air Curing, Immersion curing or ponding, Plastic Films or Polythene Curing, Wet Covering or Burlap Curing, Fogging and Sprinkling or Spray Curing and Membrane curing. (i)Air Curing: This served as the control. It involved no form of active curing by just exposing the specimens to ambient air in the Laboratory. (ii)Immersion Curing: This involved the submersion of the concrete cube specimens in water. (iii) Plastic Films or Polythene Curing: The specimens were covered with at least two layers of polythene membrane to prevent moisture movement from the concrete specimens. (iv) Wet Covering or Burlap Curing: This involved covering the concrete cube specimen underneath burlap which was kept wet periodically. (v)Fogging and Sprinkling or Spray Curing: This involved the spraying of water on the concrete cube specimens twice daily. (vi)Membrane: Forming Curing Compounds: - This involved the application of one coat of curing compounds to prevent moisture from the concrete specimens

Keywords: OPC Cement, Compressive Strength, Flexural Strength, Split Tensile Strength,

1. INTRODUCTION

Concrete is the most widely used man-made construction material in the world, and is second only to water as the most utilized substance on the planet. The popularity of concrete is due to the fact that from the common ingredients, the properties of concrete are tailored to meet the demand of any particular application. In the last decade and so, tremendous infrastructure development has taken place in all over the world. Curing of concrete plays major and unique role in developing the strength and hardness of concrete, which leads to its improvement in durability and performance. Practically at site of work good curing is not achieved in many countries in many cases due to practical difficulties and not so aware about curing. Curing is most essential if concrete is to perform the intended function over the design life of the structure while excessive curing time may lead to the escalation of the construction cost of the project and unnecessary delays. Where there is a scarcity of water and on sloping surfaces where curing with water is difficult and in cases where large areas like pavements have to be cured, the use of curing compound may be resorted too. When the ambient temperature is sufficiently well above freezing, the curing of pavements and slabs can be accomplished by pounding or immersion, other structures can be cured by spraying or fogging. Moisture retaining coverings saturated with water, such as burlap or cotton, these methods afford some cooling through evaporation, which is beneficial in hot weather concreting. Another group of methods are based on prevention of moisture loss from concrete by sealing the surface through the application of water proof curing paper, polyethylene sheets, or membrane forming curing compounds. When the ambient temperature is low, concrete must be protected from freezing by the application of insulating blankets, the rate of strength gain can be accelerated by curing concrete with the help of live steam, heating oil's, or electrically heated forms or pads. The amount of mixing water in concrete at the time of placement is normally more than must be retained for curing. However excessive loss of water by evaporation may reduce the amount of retained water below that necessary for development of desired properties. The potentially harmful effects of evaporation shall be prevented either by applying water or preventing excessive evaporation. In this study, attempt has been made to compare the different methods used for curing and their effect on different grades of concrete. The different methods used for curing are (i) Air Curing (ii) Immersion Curing (iii) Plastic Films or Polythene Curing (iv) Wet Covering or Burlap Curing (v) Fogging and Sprinkling or Spray Curing .(vi) Membrane Forming Curing Compounds. In air curing involved no form of active curing by just exposing the specimens to ambient air in the Laboratory. In immersion the concrete cube specimens were cure by submersion in water. In plastic sheets curing the cubes were covered with two layers of polythene membrane to prevent moisture movement from the concrete specimen .In the wet covering the concrete cube specimen underneath with cover or burlap which were kept wet all time of curing period. In the sprinkling method the concrete cube were sprayed with water twice daily. In membrane forming the cubes were coated with one coat of curing compounds to prevent moisture from the concrete specimens. The curing compound used is "Concure LP90" manufactured by Fosroc Chemicals (India) Pvt. Ltd. Bangalore 560024.

2. MATERIALS AND METHODOLOGY

a) In this project cement used was Ordinary Portland cement of Ultratech make conforming to IS 8112: 1989.

b) Fine aggregate corresponding to zone-III and procured locally was used for this research study.

c) Coarse aggregates used were 20mm and 10mm and was mixed in the proportion of 2:1 to make it well graded as per the requirements of mix design as per BIS: 10262.

d) For curing normal water was used, for wet cover curing jute waste bags were used, for plastic cover curing plastic sheet available in local market used and membrane curing Concure LP90was used.

Mix Design

Concrete of grade M 25 and M 30 were designed as per BIS: 10262-2009 and design proportion achieved has been highlighted under table 1and table2

Table.1. Test results of Concrete for M25Concrete grade

Material	Cement	Fine aggregate	Coarse aggregate
Mix proportion	1	1.74	3.36
Specific gravity	3.15	2.63	2.77

Table.2. Test results of for M30 Concrete Grade

Material	Cement	Fine aggregate	Coarse aggregate
Mix proportion	1	1.74	3.36
Specific gravity	3.15	2.63	2.77

Workability

Workability describes the state of fresh concrete. Workability was checked just before placing of the concrete by measuring its slump value. The size of the slump cone used was 20-cm diameter base, 10 cm diameter top and 30 cm height as per IS:456-2000.

Casting

Cubes for of size 15cmX15cmX15cm were casted for determination of compressive strength, Beams of size 10cmX10 cmX50 cm for determination of flexural strength and cylinder of size 10 cm diameter and 20 cm height were cast for M 25 and M 30 grade of concrete as per IS:456-2000.

Curing

Curing was done by different methods. The cubes, beams and cylinders were tested at different age of 7, 14, 28 and 56 days as per IS: 456-2000.

3. RESULTS

3.1 Compressive Strength

The results of compressive strength obtained at different ages for M25 and M30grade of concrete, with different method of curing at different age have been presented as below.

Table.3. Test results of Compressive Strength and compression of strength with reference to immersion curing for M25 grade of concrete

Table Showing Compressive Strength of Cubes									
Grade M25									
Method	Symbol	Days							
		7	%age Compressive strength with reference to immersion curing	14	%age Compressive strength with reference to immersion curing	28	%age Compressive strength with reference to immersion curing	56	%age Compressive strength with reference to immersion curing
Immersion Curing	M-IF	21.92	66.02%	28.78	86.69%	33.2	100.00%	35.56	107.11%
Air Curing	M-AF	13.25	39.91%	21.92	66.02%	18.93	57.02%	18.94	57.05%
Wet Covering Curing	M-WF	21.72	65.42%	27.74	83.55%	31.86	95.96%	33.54	95.96%
Plastic Films Curing	M-PF	17.92	53.98%	25.86	77.89%	27.85	83.89%	29.04	83.89%
Sprinkling Curing	M-SF	17.88	53.86%	24.28	73.13%	25.68	77.35%	29.26	77.35%
Membrane Curing	M-MF	18.24	54.94%	23.88	71.93%	28.22	85.00%	29.74	89.58%

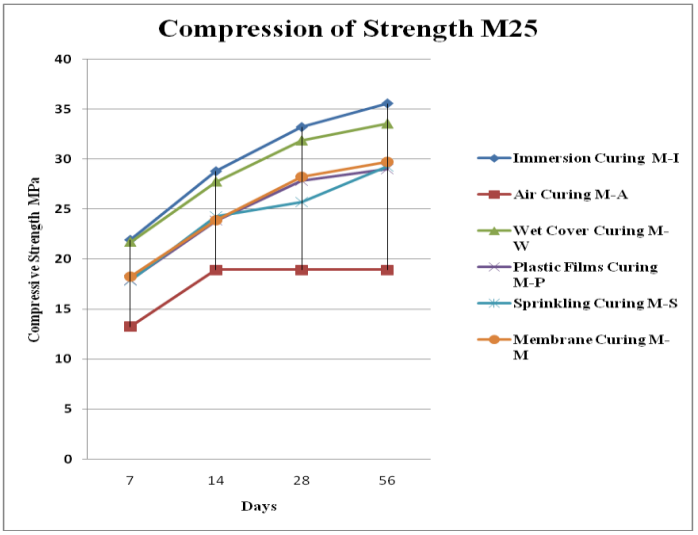

Figure.1. Showing the Compression of strength M25 with age

Table.4. Test results of Compressive Strength and compression of strength with reference to immersion curing for M30 grade of concrete

Grade M30									
Method	Symbol	Days							
		7	%age Compressive strength with reference to immersion curing	14	%age Compressive strength with reference to immersion curing	28	%age Compressive strength with reference to immersion curing	56	%age Compressive strength with reference to immersion curing
Immersion Curing	M-IF	26.98	66.98%	37.22	92.40%	40.28	100.00%	41.74	103.62%
Air Curing	M-AF	16.23	40.29%	18.88	46.87%	21.06	52.28%	21.06	52.28%
Wet Covering Curing	M-WF	26.58	65.99%	34.02	84.46%	38.48	95.53%	39.42	95.53%
Plastic Films Curing	M-PF	23.56	58.49%	30.1	74.73%	32.46	80.59%	35.92	80.59%
Sprinkling Curing	M-SF	20.24	50.25%	25.88	64.25%	31.26	77.61%	32.46	77.61%
Membrane Curing	M-MF	21.54	53.48%	28.5	70.75%	32.52	80.73%	33.02	81.98%

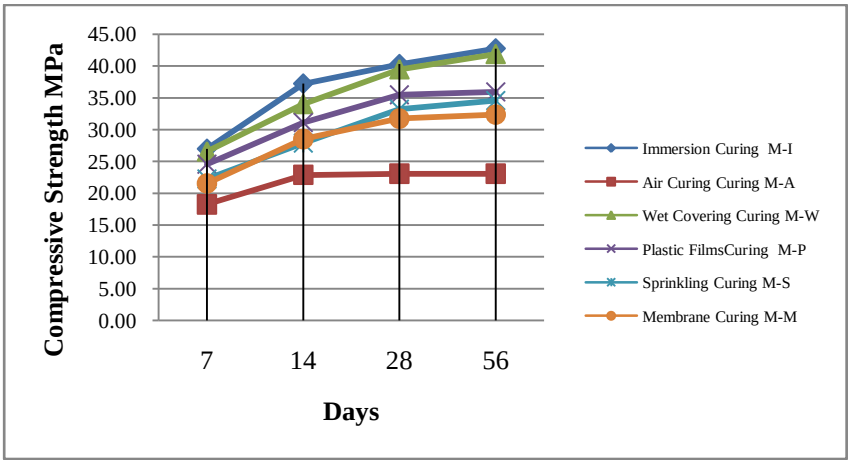

Figure.2. Showing Compression of strength M30 with age

3.2 Flexural Strength

The results of compressive strength obtained at different ages for M25 and M30grade of concrete, with different method of curing at different age have been presented as below.

Table .5. Test results of flexural Strength and compression of strength with reference to immersion curing for M25 grade of concrete

Table Showing Flexural Strength of Beams							
Grade M25							
Method	Symbol	Days					
		7	%age flexural strength with reference to immersion curing	28	%age flexural strength with reference to immersion curing	56	%age flexural strength with reference to immersion curing
Immersion Curing	M-IF	2.84	73.58%	3.86	100.00%	4.10	106.22%
Air Curing Curing	M-AF	1.53	39.64%	1.68	43.52%	1.68	43.52%
Wet Covering Curing	M-WF	2.36	61.21%	3.58	92.75%	3.98	92.75%
Plastic Films Curing	M-PF	2.27	58.82%	3.44	89.12%	3.84	89.12%
Sprinkling Curing	M-SF	2.17	56.25%	3.29	85.23%	3.88	85.23%
Membrane Curing	M-MF	2.23	57.79%	3.38	87.56%	3.84	99.48%

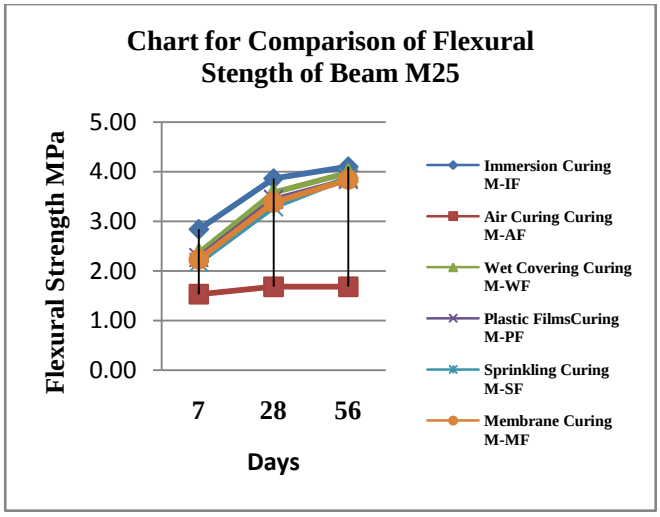

Figure.3. showing compression of Flexural strength M25 with age

Table.6. Test results of flexural Strength and compression of strength with reference to immersion curing for M30 grade of concrete

Table Showing Flexural Strength of Beams							
Grade M30							
Method	Symbol	Days					
		7	%age flexural strength with reference to immersion curing	28	%age flexural strength with reference to immersion curing	56	%age flexural strength with reference to immersion curing
Immersion Curing	M-IF	3.84	87.87%	**4.37**	100.00%	4.56	104.35%
Air Curing	M-AF	1.56	35.70%	1.96	44.85%	2.01	46.00%
Wet Covering Curing	M-WF	2.86	65.45%	4.12	94.28%	4.30	94.28%
Plastic Films Curing	M-PF	2.54	58.12%	3.92	89.70%	4.02	89.70%
Sprinkling Curing	M-SF	2.84	64.99%	3.30	75.51%	3.76	75.51%
Membrane Curing	M-MF	3.02	69.11%	3.38	77.35%	3.58	81.92%

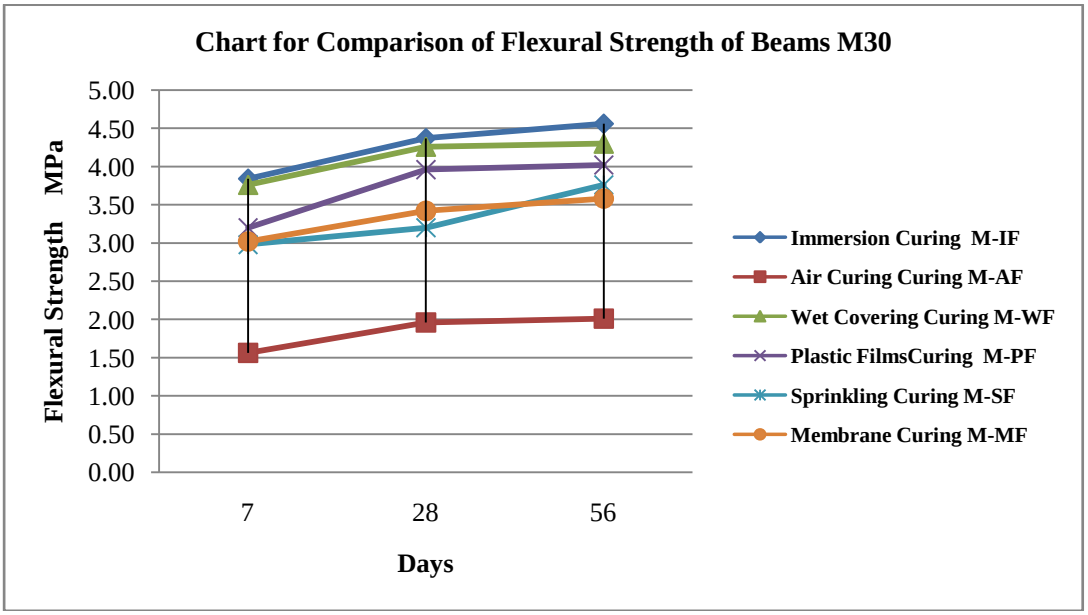

Figure.4. showing compression of Flexural strength M25 with age

Split Tensile Strength

Table.7. Test results of split tensile Strength and compression of strength with reference to immersion curing for M25 grade of concrete

Table Showing Split Tensile Strength of Cylinder							
Grade M25							
Method	Symbol	Days					
		7	%age split tensile strength with reference to immersion curing	28	%age split tensile strength with reference to immersion curing	56	%age split tensile strength with reference to immersion curing
Immersion Curing	M-IF	2.44	72.62%	**3.36**	100.00%	3.79	112.80%
Air Curing	M-AF	1.10	32.74%	1.42	42.26%	1.49	44.35%
Wet Covering Curing	M-WF	2.03	60.36%	3.12	92.86%	3.78	92.86%
Plastic Films Curing	M-PF	1.96	58.42%	3.02	89.88%	3.14	89.88%
Sprinkling Curing	M-SF	1.83	54.55%	2.82	83.93%	3.14	83.93%
Membrane Curing	M-MF	1.89	56.10%	2.90	86.31%	3.36	100.00%

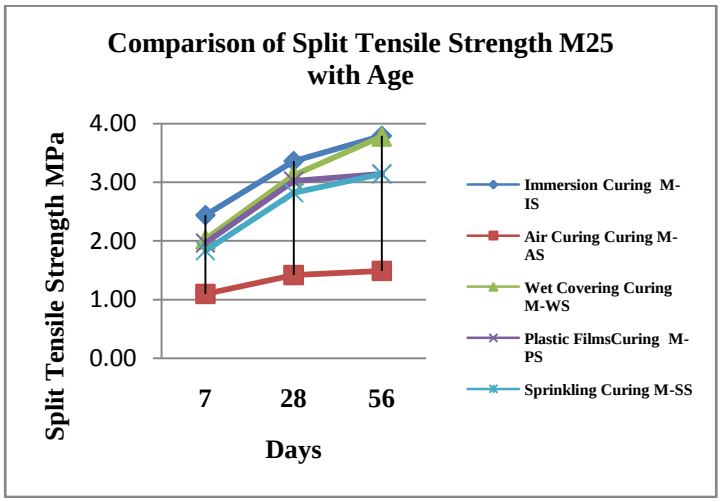

Figure.5. showing compression of split tensile strength M25 with age

Table.7. Test results of split tensile Strength and compression of strength with reference to immersion curing for M25 grade of concrete

Table Showing Split Tensile Strength of Cylinder							
Grade M30							
Method	Symbol	Days					
		7	%age split tensile strength with reference to immersion curing	28	%age split tensile strength with reference to immersion curing	56	%age split tensile strength with reference to immersion curing
Immersion Curing	M-IF	3.04	78.76%	**3.86**	100.00%	4.10	106.22%
Air Curing	M-AF	1.48	38.34%	1.60	41.45%	1.68	43.52%
Wet Covering Curing	M-WF	2.74	70.98%	3.56	92.23%	3.66	92.23%
Plastic Films Curing	M-PF	2.40	62.18%	3.52	91.19%	3.60	91.19%
Sprinkling Curing	M-SF	2.32	60.10%	3.48	90.16%	3.44	90.16%
Membrane Curing	M-MF	2.42	62.69%	3.74	96.89%	3.84	99.48%

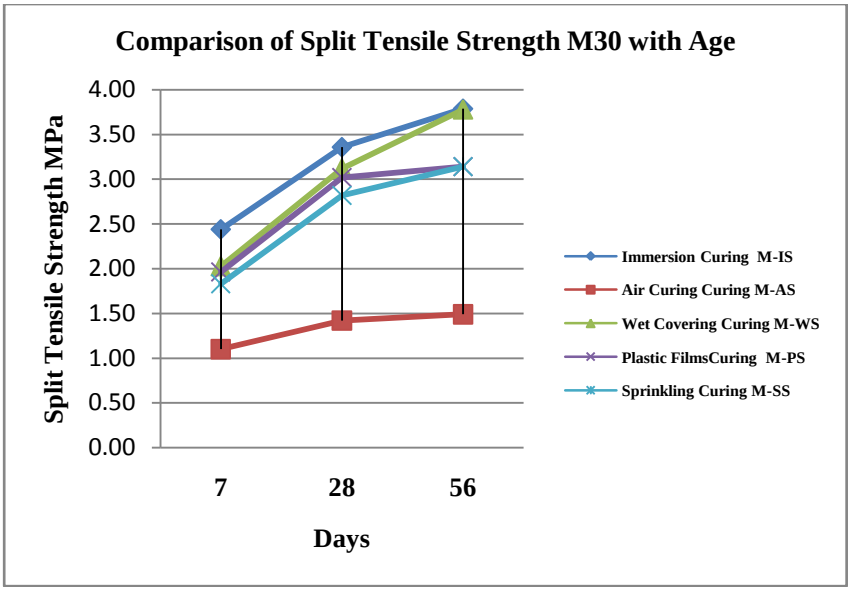

Figure.6. showing compression of split tensile strength M0 with age

The above table show experimental results of different that immersion curing is best one and air curing should be avoid at all. By wet cover curing method the strength achieved is as per design strength. By plastic sheet method and membrane curing method desired strength achieved .The efficiency of sprinkling method can be improved by increasing the number of sprinkling.

4. DISCUSSION OF RESULTS AND CONCLUSION

1. The strength of concrete is affected considerably by method of curing and age of concrete for M25 and M30 grade of concrete.
2. Immersion curing is the best method of curing in which curing is possible from all direction, however immersion curing conditions may not be practically possible at site of work and immersion curing conditions are possible in laboratory only.
3. Ponding is good on flat surfaces, where all top surfaces are filled with water and gives better results i.e. up to desired design strength. Ponding is not suitable for all kinds of in-situ construction.
4. Ponding is good on flat surfaces, where all top surfaces are filled with water and gives better results i.e. up to desired design strength. Ponding is not suitable for all kinds of in-situ construction.
5. Wet covering curing method gives good results .By wet cover curing; the desired results up to design strength are achievable. In this method covering or burlap should be wet all the times of curing period .It is the more practical and economical method used for vertical members and sloping surface.
6. Use of membrane curing or curing compounds resulted in achieving strength of 80 to 90 % of curing of immersion method. The efficiency of membrane curing can be improved by application of membrane in two layers as has been applied and tested in the present project. Compound or membrane is found cost effective as compared to conventional wet curing method using waste jute bags /waste burlaps.
7. Wrapped curing or plastic films is less effective as compared to wet curing and membrane curing, it can also be applied to any kind of simple and complex shaped but is slightly cost effective. Wrapped curing or plastic films is less effective as there are chances of moisture loss due to damage, uncovering due to wind, theft etc
8.Air curing should not be done because it does not give 50%strength of desired design strength so, as far as possible air curing should be avoided
9. Sprinkling curing (2 times a day) does not give satisfactory desired design strength, however the efficiency may be improved by increasing the number of sprinkling.

5. RECOMMENDATIONS

1. On the basis of results it can be observed that concrete should be cured for the period as specified in design so that desired design strength of concrete may be attained.
2.On the basis of results it can be observed that concrete should be cured for the period as specified in design so that desired design strength of concrete may be attained.
3.For large projects membrane curing is best and application of membrane (thickness and layers) should as per design so that desired design strength can achieved.
4.Plastics film can be used to cover flat surface such as roof etc in small area (local construction) where there is shortage of water.
5.Sprinkling (2 times morning and evening) is not sufficient and does not gives desired design strength, but it efficiency can be improved by increasing the number of application and use of burlap
6.Air curing should be avoided at all.
7.In addition to above, self curing method should be adopted for high rise buildings/ structure where curing is practically difficult.
8.Depending upon the method of curing adopted or method to be adopted as per the site condition, the designer should make necessary incorporation while designing the concrete mix at the design stage so that expected decrease in strength because of curing method to be adopted can be taken care of. V.

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