

Effects of Different Types of Curing on Strength of Concrete

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ABSTRACT: This experimental work was carried out to investigate the effect of concrete strength in terms of compressive and split tensile strength for M20 grade of normal strength concrete and M40 grade of medium strength concrete as per 10262:1999 by adopting Immersion curing, Wet gunny bags curing and Accelerated warm water curing as per IS 9013:1978. Traditionally, quality of concrete in construction works is calculated in terms of its 28 days compressive strength. This procedure requires 28 days of moist curing before testing, which is too long a period to be of any value for either concrete construction control or applying timely corrective measures. What is essentially needed for assessing quality of controlled concrete is an acceptance test which can supply results, within about 24 hours after casting. With the assistance of reliable test methods employing accelerated curing techniques, it is now possible to test the compressive strength of concrete within a short period and thereby the test results of compressive strength and split tensile strength having good agreement with the specified strength at 28 days. The results of the investigations demonstrate that superior strength is achieved by Immersion curing than the other two types of curing. But the strength achieved in Accelerated curing within 24 hours is nearly to Immersion curing. So, Accelerated curing can be used for curing, also it is very much useful in prefabrication industry.

KEYWORDS: Accelerated warm water curing, Normal strength concrete, Medium strength concrete, Split tensile strength, Compressive Strength and Wet gunny bags

I. INTRODUCTION

Concrete is a construction material which has been widely used in construction industry. Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. This process results in concrete with increased strength and decreased permeability. Curing is also a key player in mitigating cracks. Traditionally, quality of concrete in construction works is calculated in terms of its 28 days compressive strength. If after 28 days, the quality of concrete is found to be dubious, it would have considerably hardened by that time and also might have been buried by subsequent construction. The need for having a reliable and fast method for evaluating controlled concrete in the field using accelerated curing technique was recognized by Cement and Concrete Sectional Committee and further the Committee decided to evolve a standard method of determining the strength of concrete cured by accelerated curing methods. Accelerated curing is any method by which high early age strength is achieved in concrete. These techniques are especially useful in the prefabrication industry, wherein high early age strength enables the removal of the formwork within 24 hours, thereby reducing the cycle time, resulting in cost-saving benefits.

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II. MATERIAL TEST RESULTS

Table 1: Material test results

Test Description	Results
Specific Gravity of Cement	3.15
Fineness of Cement	3%
Consistency of Cement	30%
Initial setting time of Cement	37 minutes
Final setting time of Cement	5 hours 45 minutes
Specific Gravity of Fine aggregate	2.68
Loose Bulk density of Fine aggregate	1480 kg/m ³
Rodded Bulk Density of Fine aggregate	1635 kg/m ³
Specific Gravity of Coarse aggregate	2.71
Loose Bulk density of Coarse aggregate	1450 kg/m ³
Rodded Bulk Density of Coarse aggregate	1700 kg/m ³

III. MIX PROPORTION

Silica fume, also known as microsilica is an [amorphous](#) polymorph of [silicon dioxide](#), [silica](#). It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 (undensified) to 600 kg/m³. The specific gravity of silica fume is generally in the range of 2.2 to 2.3.

Conplast SP430 : For this experimental work, a super plasticizer by the name CONPLAST SP430 has been used for obtaining workable concrete at low w/b ratio. CONPLAST SP430 complies with BIS: 9103-1999 and BS: 5075-part3 and ASTM C494. Super plasticizer molecules and cement grains are oppositely charged and hence repel each other. This increases the mobility and hence makes the concrete flow. Super plasticizers enable savings in cement for a given strength and ideal for pumping concrete, casting heavily reinforced concrete members, and the precast elements of concrete.

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Table 2: Mix Proportion

Mix	Cement	Silica fume	Fine aggregate	Coarse aggregate	Water	Super plasticizer
M20	1	-	1.58	2.51	0.45	-
M40	1	0.1	1.9	3.16	0.36	0.02

IV. EXPERIMENTAL SETUP

After the specimens have been made, they shall be left to stand undisturbed in their moulds in a place free from vibration at a temperature of $27 \pm 2^{\circ}\text{C}$ for at least one hour, prior to immersion in the curing tank. The time between the addition of water to the ingredients and immersion of the test specimens in the curing tank shall be at least 1 hour 30 minutes but shall not exceed 3 hour and 30 minutes.

The specimen in their moulds shall be gently lowered into the curing tank and shall remain totally immersed at $55 \pm 2^{\circ}\text{C}$ for a period of not less than 19 hours 50 minutes. The specimens shall be removed from the water, marked for identification, removed from the moulds and immersed in the cooling tank at $27 \pm 2^{\circ}\text{C}$ before the completion of 20 hours 10 minutes from the start of immersion in the curing tank. They shall remain in the cooling tank for a period of not less than 1 hour. After that the specimens shall be tested while still wet, not more than 2 hours from the time of immersion in the cooling tank.

V. RESULT AND DISCUSSION

In this experimental work a total number of 42 cubes and 42 cylinders were cast and tested. Out of these, 36 cubes and 36 cylinders were tested for Immersion curing and wet gunny bags curing respectively. Out of which, 18 cubes and 18 cylinders were cast and tested for normal strength of concrete (M20) and medium strength of concrete (M40) through Immersion and wet gunny bags curing method. Remaining 6 cubes and 6 cylinders were tested for Accelerated warm water curing method.

Table 3: Test Result for Compressive Strength

Curing methods		Immersion curing (N/mm^2)			Wet gunny bag curing (N/mm^2)			Accelerated curing (N/mm^2)
Curing (in days)		7	14	28	7	14	28	1
Grade of concrete	M20	13.88	18.67	24.6	12.5	17.7	23.2	22.43
	M40	26.83	33.83	43.6	25.56	32.2	41.3	40.7

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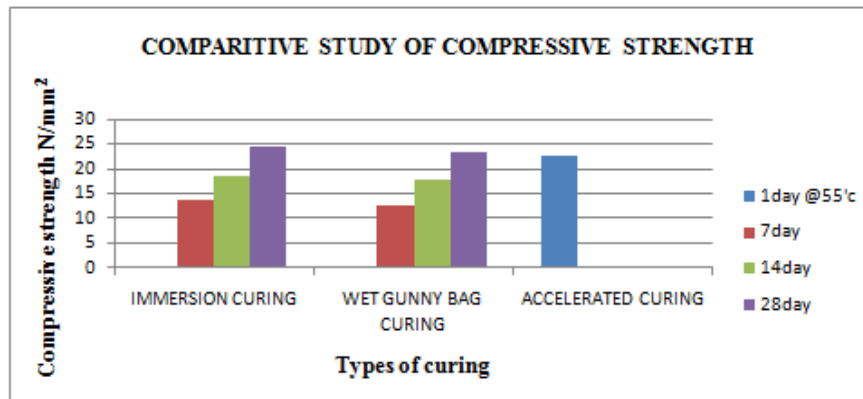


Fig 1:Effect of three types of curing on compressive strength of concrete for M20 grade of concrete

From Figure 1, it can be concluded that the compressive strength of concrete cubes by Immersion curing method was achieved that 56.42% and 74.8% of 28 days strength at 7 days and 14 days respectively for M20 grade of concrete. The compressive strength of concrete cubes by wet gunny bags curing method was achieved that 53.8% and 76.2% of 28 days strength at 7 days and 14 days respectively for M20 grade of concrete.

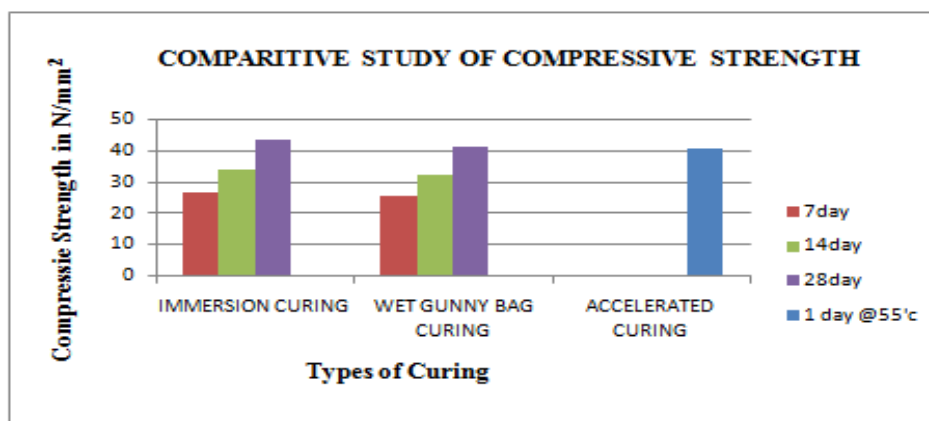


Fig 2:Effect of three types of curing on compressive strength of concrete for M40 grade of concrete

From Figure 2, it can be concluded that the compressive strength of concrete cubes by immersion curing method was achieved that 61.5% and 77.5% of 28 days strength at 7 days and 14 days respectively for M40 grade of concrete. The compressive strength of concrete cubes by Wet gunny bags curing method was achieved that 61.8% and 77.8% of 28 days strength at 7 days and 14 days respectively for M40 grade of concrete.

From the test results it was observed that the compressive strength of concrete by Immersion curing method yield maximum strength when compared to the other curing methods. Since, the Immersion curing method can't be directly applied in practice it is reliable to compare with only wet gunny bags curing method. The results indicate that the strength of concrete obtained from Wet gunny bags curing was 1.03% and 1.01% higher than Accelerated curing and 1.06% and 1.05% lesser than results obtained from Immersion curing for M20 and M40 grade of concrete respectively.

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Table 4: Test Result for Split Tensile Strength

Curing methods		Immersion curing(N/mm ²)			Wet gunny bag curing (N/mm ²)			Accelerated curing (N/mm ²)
Curing (in days)		7	14	28	7	14	28	1
Grade of concrete	M20	0.87	1.26	1.63	0.71	1.16	1.54	1.51
	M40	1.61	1.95	2.47	1.49	1.82	2.35	2.28

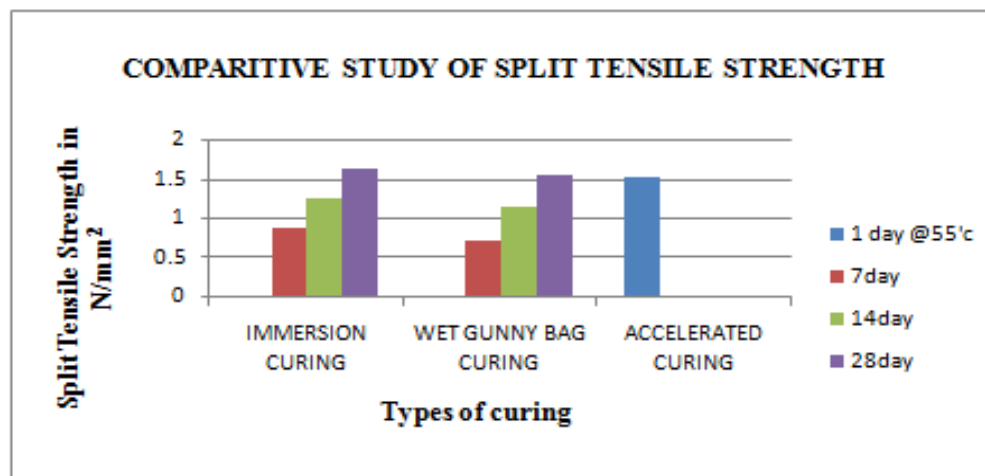


Fig 3: Effect of three types of curing on split tensile strength of concrete for M20 grade of concrete

From Figure 3, it can be concluded that the split tensile strength of concrete cylinders by Immersion curing method was achieved that 53% and 77.3% of 28 days strength at 7 days and 14 days respectively for M20 grade of concrete. The compressive strength of concrete cubes by wet gunny bags curing method was achieved that 46% and 75.3% of 28 days strength at 7 days and 14 days respectively. After 28 days it was seen that the strength achieved by Immersion curing and Accelerated curing was 1.06% higher and 0.98% lesser than Wet gunny bag curing respectively for M20 grade of concrete.

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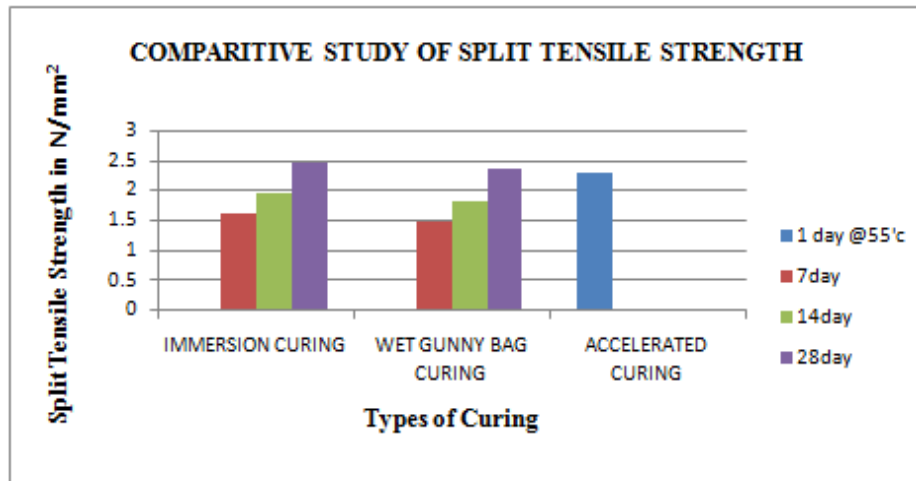


Fig 4: Effect of three types of curing on split tensile strength of concrete for M40 grade of concrete

From Figure 4, it can be concluded that the split tensile strength of concrete cylinders by Immersion curing method was achieved that 65.2% and 78.9% of 28 days strength at 7 days and 14 days respectively for M20 grade of concrete. The compressive strength of concrete cubes by wet gunny bags curing method was achieved that 63.4% and 77.4% of 28 days strength at 7 days and 14 days respectively. After 28 days it was seen that the strength achieved by Immersion curing and Accelerated curing was 1.05% higher and 0.97% lesser than Wet gunny bag curing respectively for M40 grade of concrete.

VI. CONCLUSION

In this experimental work a total number of 42 cubes and 42 cylinders were cast and tested. Out of these, 36 cubes and 36 cylinders were tested for Immersion curing and wet gunny bags curing respectively. Out of which, 18 cubes and 18 cylinders were cast and tested for normal strength of concrete (M20) and medium strength of concrete (M40) through Immersion and wet gunny bags curing method. Remaining 6 cubes and 6 cylinders were tested for Accelerated warm water curing method

a. From the experimental test results the following conclusions were made,

- II. The Immersion curing and Wet gunny bag curing attained an average compressive strength of 24.6 N/mm² and 23.2 N/mm² respectively for M20 grade of concrete at the age of 28 days. At same age, the Immersion curing and Wet gunny bag curing attained an average compressive strength of 43.6 N/mm² and 41.3 N/mm² respectively for M40 grade of concrete.
- III. At the age of 28 days by Immersion curing and Wet gunny bag curing attained an average split tensile strength of 1.63 N/mm² and 1.54 N/mm² respectively for M20 grade of concrete. In case of M40 grade the average split tensile strength of 2.47 N/mm² by Immersion curing and 2.35 N/mm² by Wet gunny bags curing respectively.
- IV. The average compressive strength of concrete cubes with Accelerated warm water curing method equivalent to 28 days was found to be 22.43 N/mm² for M20 grade
- V. The average compressive strength of concrete cubes with Accelerated warm water curing method was 40.7 N/mm² for M40 grade of concrete.
- VI. The average split tensile strength of cylinder specimens by Accelerated warm water curing method which is equal to 28 days of curing was calculated as 1.51 N/mm² for M20 grade of concrete.
- VII. The average split tensile strength of cylinder specimens by Accelerated warm water curing method was 2.28 N/mm² for M40 grade of concrete.

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- VIII. From the experimental values it can be concluded that the optimum strength of concrete for compressive and split tensile strength was achieved by adopting immersion curing method for both normal and medium strength concrete.
- IX. But as immersion curing is not practically possible the strength is being compared with Wet gunny bags curing which is practically done in the site.
- X. The variation in average compressive strength of concrete for a normal strength of M20 grade by Immersion curing was observed to be 1.06% higher than Wet gunny bags curing. The results of Accelerated curing was found to be 0.96% lesser than Wet gunny bags curing. The variations in average split tensile strength by Immersion curing was observed to be 1.06% higher and by Accelerated curing 0.98% lesser when compared with Wet gunny bags curing method.
- XI. The variation in average compressive strength of concrete for a medium strength of concrete of M40 by Immersion curing was observed to be 1.06% higher than Wet gunny bags curing and by Accelerated curing it was 0.98% lesser than Wet gunny bags curing. The variations in average split tensile strength by Immersion curing was observed to be 1.05% higher and by Accelerated curing 0.97% lesser when compared with Wet gunny bags curing method.
- XII. Though M20 and M40 grade of concrete results in lesser percentage by Accelerated warm water method of curing compared to Wet gunny bag curing method, the results obtained by this Accelerated warm water method was higher than 1.12% and 1.02% of required value for both M20 and M40 grade of concrete.
- XIII. Since the variation in results, while compared to all three methods of curing are very close to the actual value and also the result of Accelerated warm water method of curing can be obtained within 24 hours, it is strongly recommended to use in prefabrication industry to obtain quick results and reduce the expenses.

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