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# Influence of Different Curing Methods on the Performance of M30 Grade Concrete

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**ABSTRACT:** This paper presents an experimental investigation on influence of different curing methods on the performance of M30 grade concrete. Different curing methods such as air curing, pond curing, intermittent curing, gunny bags curing, chemical curing and using Super Absorbent Polymer(SAP) by 0.3% of weight of cement are considered. Crushed stone sand and slag sand are used as fine aggregate in 75:25 proportion. Slump and compacting factor tests are performed to know the workability of fresh concrete. Compressive strength and flexure tensile strength of hardened concrete are determined for concrete specimens cured by different curing methods. Durability in terms of carbonation resistance on hardened concrete is also performed as per IS 516 (Part 5/Sec 3, 2021) codal provisions. Depending upon the site conditions and availability of potable water, curing methods such as pond curing, intermittent curing, gunny bags curing, chemical curing and SAP curing can be adopted in site to achieve the expected strength and durability requirements.

**KEYWORDS:** Curing methods, Compressive strength, Flexural tensile strength, Carbonation resistance

## I. INTRODUCTION

The basic construction material used in industry is concrete which is a mixture of cement, aggregates (fine and coarse) and admixtures. River sand is the prime material used for the preparation of mortar and concrete and it plays a major role in mix design. Construction industry is facing non-availability or shortage of river sand due to erosion of river. In order to prevent the excess river erosion and harm to the environment, new alternative materials for river sand such as crushed stone sand, slag sand, copper slag, recycled concrete aggregate etc. are recommended by IS 383 (2016) codal provisions for use in concrete works.

Curing of concrete plays a major role in strength and durability of concrete. Properly cured concrete will have adequate amount of moisture for hydration, strength development and volume stability. When cement, aggregates, water and admixtures are mixed together, heat is produced due to exothermic process. The reaction between active components of cement (i.e.  $C_3A$ ,  $C_3S$ ,  $C_2S$  and  $C_4AF$ ) and water is known as hydration of cement.  $C_3S$  gives strength development for the first week of hardening and  $C_2S$  for successive stages of strength development. During hydration of cement,  $C_3S$  and  $C_2S$  react with water to form CSH (Calcium Silicate Hydrate) gel and CH (Calcium Hydroxide). CSH gel is responsible for the strength development and mechanical properties of concrete. CH maintains high pH value in concrete which resists the corrosion of reinforcement. Curing of concrete can be done by different means such as pond curing, intermittent curing, gunny bags curing, air curing, chemical curing, using Super Absorbent Polymer (SAP) etc.

In the present study, an attempt has been made to investigate the strength and durability characteristics of M30 grade concrete cured by different methods such as air curing, pond curing, intermittent curing, gunny bags curing, chemical curing and using SAP at 0.3%.

## II. EXPERIMENTAL PROGRAM

### Materials Used:

Cement used conforms to Ordinary Portland Cement (OPC) of 43 grade conforming to IS 269 (2015). Crushed stone sand obtained from a local quarry and slag sand obtained from JSW Steel Limited, Vijayanagara are used as fine aggregates. Both the fine aggregates conform to grading zone II of IS 383 (2016). Coarse aggregate passing through 20 mm IS sieve and retained on 4.75 mm IS sieve procured from a local quarry and conforming to IS 383 (2016) specifications is used. Conplast SP430 DIS procured from FOSROC Chemicals (India) Pvt. Ltd. is used as a superplasticizer.

**Curing Methods:** Different types of curing methods adopted in the present study are as shown in Table 1.

**Table 1: Different types of curing methods adopted in present study**

Sl. No.	Curing methods	Remarks
1	Air curing	–
2	Pond curing	–
3	Intermittent curing	–
4	Gunny bags curing	–
5	Chemical curing compounds	Procured from FOSROC Chemicals (India) Pvt. Ltd.
6	Super Absorbent Polymer (SAP) – 0.3% by weight of cement	Procured from Alchemy Substances, Bangalore, India

#### Concrete Mix Design :

M30 grade concrete is designed as per IS 10262 (2019) codal provisions for moderate exposure condition with a slump of 75 mm. Crushed stone sand and slag sand are considered in the mix design in 75: 25 proportion. Table 2 shows the mix design proportions of M30 grade concrete.

**Table 2: Mix proportion for M30 grade concrete**

Sl. No.	Ingredient	Value
1	Cement ( $\text{kg/m}^3$ )	375
2	Coarse aggregate ( $\text{kg/m}^3$ )	1090
3	Crushed stone sand ( $\text{kg/m}^3$ )	511
4	Slag sand ( $\text{kg/m}^3$ )	180
5	w/c ratio	0.48
6	Super-plasticizer ( $\text{kg/m}^3$ )	3.75

Workability of fresh concrete in terms of slump and compacting factor tests are conducted as per IS 1199–Part 2 (2018). Compressive and flexural tensile strengths on hardened concrete specimens is conducted as per IS 516 (Part 1/Sec 1, 2021). Also Carbonation depth test of hardened concrete is conducted as per IS 516 (Part 5/Sec 3, 2021).

### III.RESULTS AND DISCUSSION

Table 3 shows the tests carried out on fresh concrete to measure the workability.

**Table 3: Test results of fresh concrete**

Mix	Slump (mm)	Compacting Factor
M30	72	0.82

Figure 1 shows the 7 days compressive strength of cube specimens cured by different methods. Minimum compressive strength as specified by IS 456 (2000) is achieved by concrete cube specimens when cured by all the curing methods.

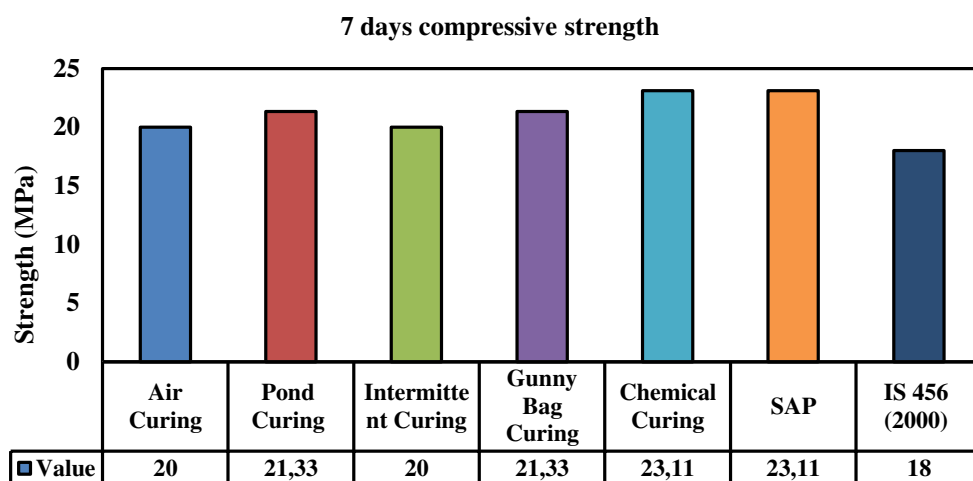


Fig. 1. 7 days compressive strength

Figure 2 shows the 28 days compressive strength of cube specimens cured by different methods. Air curing method fails to achieve the expected minimum compressive strength of 30 MPa. However, minimum compressive strength as specified by IS 456 (2000) is achieved by concrete cube specimens cured by all the other curing methods.

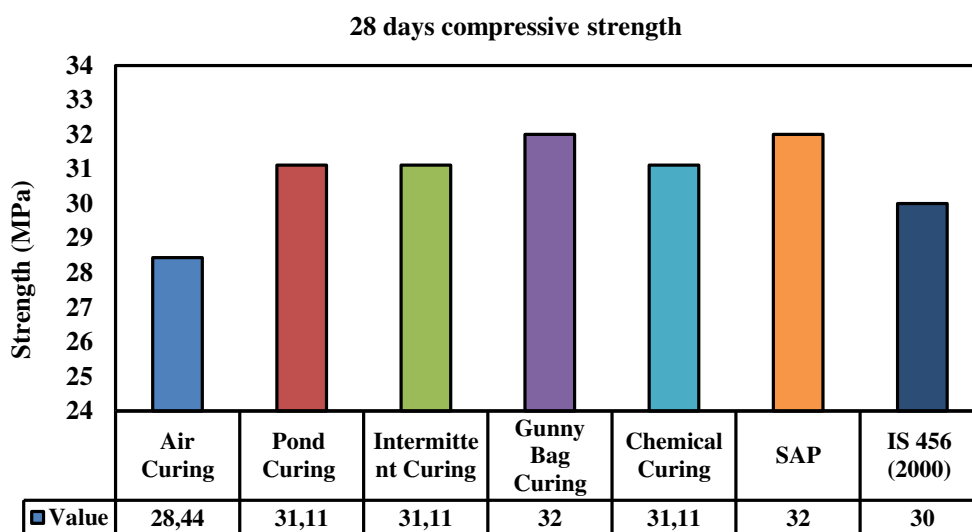


Fig. 2. 28 days compressive strength

Figure 3 shows the 56 days compressive strength of cube specimens cured by different methods. Concrete specimens cured by all the methods show increase in compressive strength at 56 days. Silica content in slag sand and favourable temperature in the laboratory facilitated the air cured concrete specimens to attain the expected strength of 30 MPa.

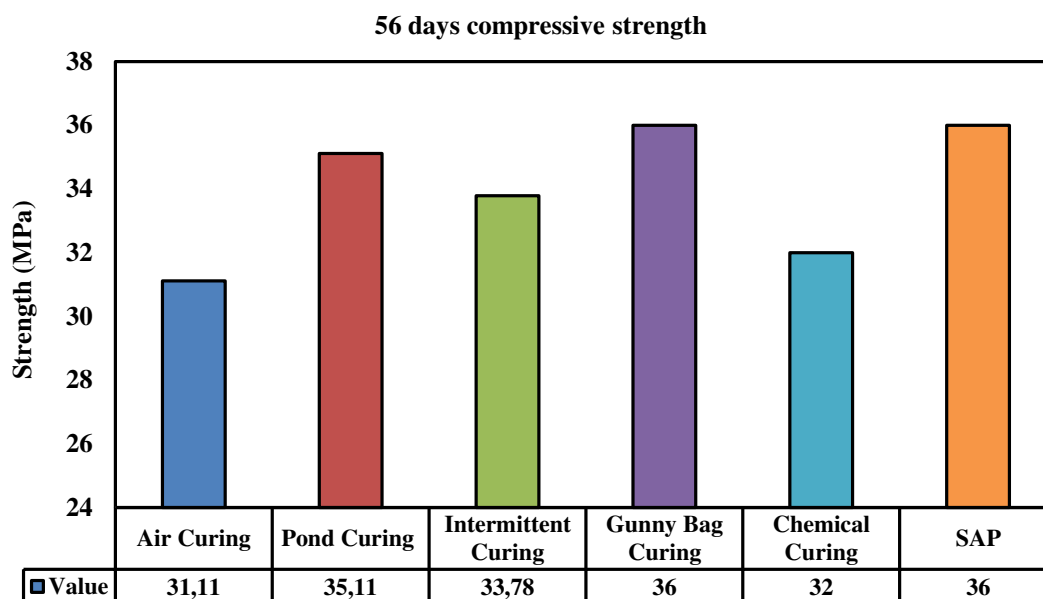


Fig. 3 : 56 days compressive strength

Figure 4 shows the 28 days flexural tensile strength of beam specimens cured by different methods. Considering 28 days flexural strength results, air curing method fails to achieve the expected minimum flexural strength of 3.83 MPa as per IS 456 (2000). Whereas concrete beam specimens cured by all the other methods conform to minimum flexural strength requirement.

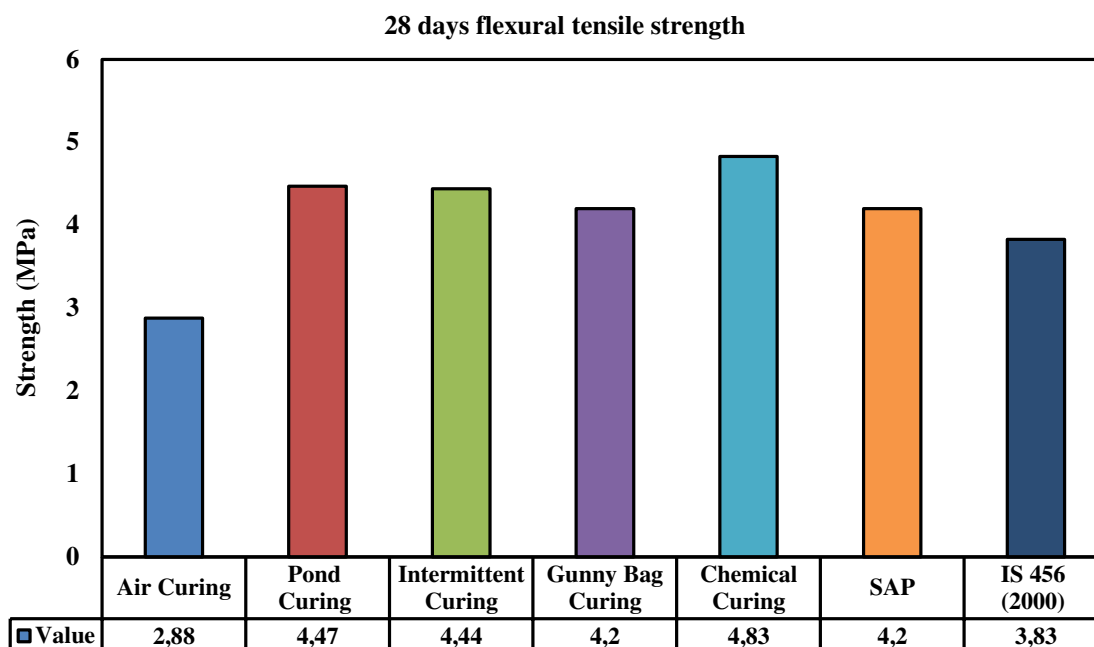


Fig. 4: 28 days flexural tensile strength

To measure the durability of concrete in terms of carbonation resistance, concrete cube specimens are cured for 28 days by different curing methods and exposed to the laboratory environment for 56 days. Figure 5 shows the photographic record of exposed concrete cube specimens surface sprayed with Phenolphthalein solution. No signs of carbonation



attack is observed in concrete cube specimens cured by all the methods for 28 days and then exposed to laboratory environment for 56 days. However, a more detailed investigation on carbonation resistance of concrete is required by exposing the concrete samples to different carbon dioxide levels in an accelerated carbonation chamber.



(a) : Air curing



(b) : Pond curing



(c) : Intermittent curing



(d) : Gunny bags curing



(e) : Chemical curing



(f) : SAP

**Fig. 5: Photographic record of exposed concrete surface sprayed with Phenolphthalein solution**

#### IV. CONCLUSIONS

The present study reports the influence of different curing methods such as air curing, pond curing, intermittent curing, gunny bags curing, chemical curing and using Super Absorbent Polymer (SAP) by 0.3% of weight of cement on the performance of M30 grade concrete which is designed as per IS 10262 (2019) guidelines. Crushed stone sand and slag sand are used as fine aggregates in 75:25 proportion. Important conclusions drawn are as follows:

1. At the age of 7 days, minimum compressive strength as specified by IS 456 (2000) is achieved by the concrete specimens cured by all the methods.
2. Considering 28 days compressive strength results, air curing method fails to achieve the expected minimum compressive strength of 30 MPa. However, minimum compressive strength as specified by IS 456 (2000) is achieved by concrete cube specimens cured by all the other curing methods.
3. Concrete specimens cured by all the methods show increase in compressive strength at 56 days. Silica content in slag sand and favourable temperature in the laboratory facilitated the air cured concrete specimens to attain the expected strength of 30 MPa.



4. Considering 28 days flexural strength results, air curing method fails to achieve the expected minimum flexural strength of 3.83 MPa as per IS 456 (2000). Whereas concrete beam specimens cured by all the other methods conform to minimum flexural strength requirement.
5. When tested as per IS 516 (Part 5/Sec 3, 2021), no signs of carbonation attack is observed in concrete cube specimens cured by all the methods for 28 days and then exposed to laboratory environment for 56 days. However, a more detailed investigation on carbonation resistance of concrete is required by exposing the concrete samples to different carbon dioxide levels in an accelerated carbonation chamber.

**Concluding remarks:** Depending upon the site conditions and availability of potable water, concrete with 25% slag sand and cured by different methods such as pond curing, intermittent curing, gunny bags curing, chemical curing and SAP curing can be adopted in site to achieve the expected strength and durability requirements.

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