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Effect of Curing Methods on Strength and Durability Properties 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. Slump and compacting factor tests are performed to know the workability of fresh concrete.***
Compressive strength of hardened concrete is 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 and 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

A. 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 is used as fine aggregates conforming 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.

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1) Curing Methods: Different types of curing methods adopted in the present study are as shown in Table1.

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

2) 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. 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 (kg/m^3)	375
2	Coarse aggregate (kg/m^3)	1090
3	Crushed stone sand (kg/m^3)	685
4	w/c ratio	0.48
5	Super-plasticizer (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 strength 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	73	0.83

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.

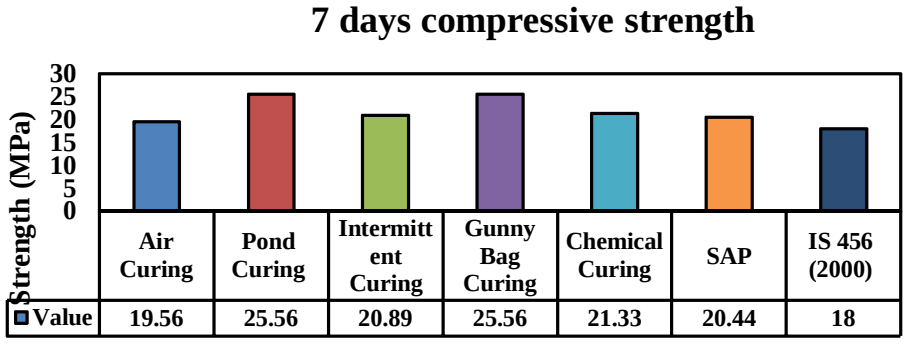


Fig. 1 : 7 days compressive strength

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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.

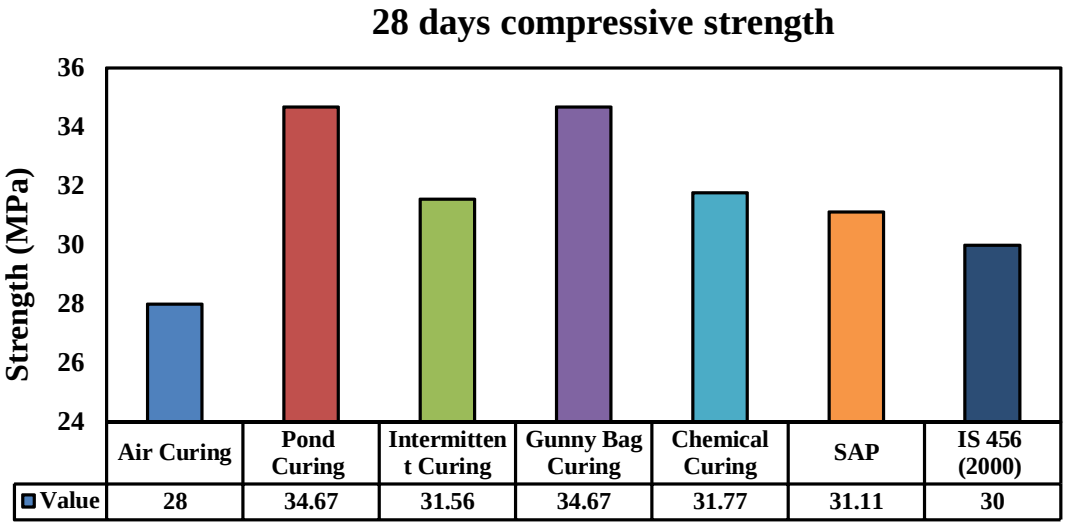
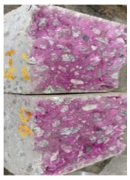


Fig. 2 : 28 days compressive strength

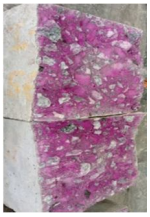
To measure the durability of concrete in terms of carbonation resistance, concrete cube specimens are cured for 28 days by different curing methods and are exposed to the laboratory environment for 56 days. Figure 3 shows the photographic record of exposed concrete cube specimens surface sprayed with 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.



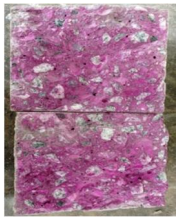
(i) : Air curing



(ii) : Pond curing



(iii) : Intermittent curing



(iv) : Gunny bags curing



(v) : Chemical curing



(vi) : SAP

Fig. 3 : Photographic record of exposed concrete surface sprayed with Phenolphthalein solution

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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. 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) 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.

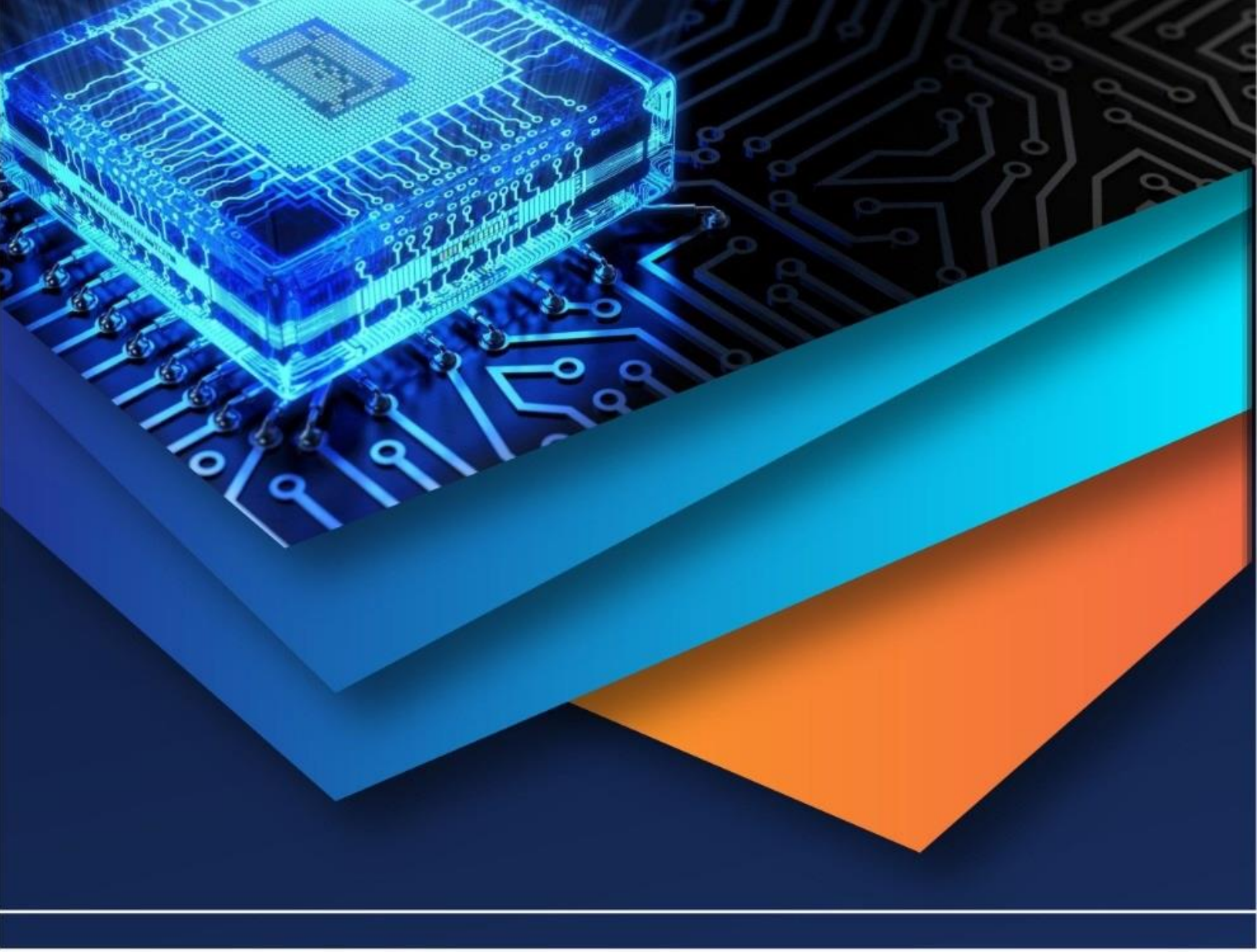
A. Concluding Remarks

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.

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