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Experimental study on replacement of fine aggregate in concrete with dissimilar curing conditions

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ABSTRACT

The nation over, Scarcity of natural sand, water, and craftsmanship is at the zenith in the construction sectors. The construction industries are now inquiring other substitutes. This paper synthesized answers from the literature review and an experimental study carried out as per Indian Standards to compare the Strength properties of the concrete by natural sand, manufactured sand and quarry dust with different curing methods for the conventional M20 grade concrete. The parameters of the research comprise the curing periods [7 and 28 days] and curing methods [Standard moist curing, Air-Shade curing, wet-gunny bag curing, water sprinkling method, membrane wax-based curing, membrane resin-based curing and self-curing with SAP 0.3% & 0.4%]. The result shows that compressive and tensile strength properties were higher in self-curing with SAP 0.3% and air-shade curing shows the least value n both strength properties.

1. Introduction

Over the top, mining on the river beds to encounter the increasing demand for sand from the construction industry has prompted serve natural disparity [1]. The bigger issue is mining done under the guise of waterway bed. The natural sand available now is coarse and contains more amounts of clay, silt and other organic matters which affect the strength and durability of the concrete [2]. In Tamil Nadu, India, scarcity of natural sand, water, and its volatile price escalation is a noteworthy reason for concern in the real estate and infrastructure sectors, especially in the major cities. Overcome this crisis [3]; alternatives have come up for the industry to bank on of which manufactured sand or M-sand and quarry dust, both observed to be the most reasonable one to supplant river sand [4]. Compared to the natural sand, the manufactured sand has a better superior consistency high Strength concrete with redeemable significance instrument. In concrete [5], Curing is the prime key factor for the life of the concrete structures. Curing guarantees additionally to maintain an adequate temperature of concrete in its first ages, as this directly influences the rate of hydration of cement and eventually the strength improvement of concrete or mortars. With improper curing, the hydration will not take place, and the resulting concrete may not get the expected strength and durability [6]. The advancement in the chemical and construction sectors have lead the way for development of new construction chemicals and techniques in curing of concrete such as Membrane curing compounds, Self curing agents, Water proofing compounds.

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2. Experimental details

2.1. Materials used

2.1.1. Cement

53 grade of OPC used in this entire investigation. The cement tested for physical properties by IS: 4031-1988 [7] and IS 12269-2013 [8].

2.1.2. Aggregates

Fine aggregate used in this research is natural sand, manufactured sand, and quarry dust. The physical property determined under IS 2386-2016 [9]. The angular shape coarse aggregate of size is 20 mm and below. The physical properties of coarse aggregate determined under IS: 2386-1963.

2.1.3. Water

In this investigation for mixing and curing of concrete potable water is used.

2.1.4. Membrane curing compound

In this investigation, the internationally recognized ASTM C 309 - Type 1 Class A standard used for Water based concrete curing. It obtained from Labcare scientific, Coimbatore (Table 1).

2.1.5. Super absorbent polymer

The SAPs added at the rate of 0.3 and 0.4 wt % of cement (Table 2).

2.2. Mix proportions

(Table 3)

3. Test results and discussion

3.1. Compressive strength

The test is carried out on 0.15 × 0.15 x 0.15 m size cubes, as per IS: 516- 1959. The specimens kept in deferent curing conditions for seven and 28 days. Finally, the samples tested in dry condition with grit present on the surface. The average of three test values was taken as the representatives of the compressive strength of the sample as noted and shown in Fig. 1.

Table 1
Properties of ASTM C 309.

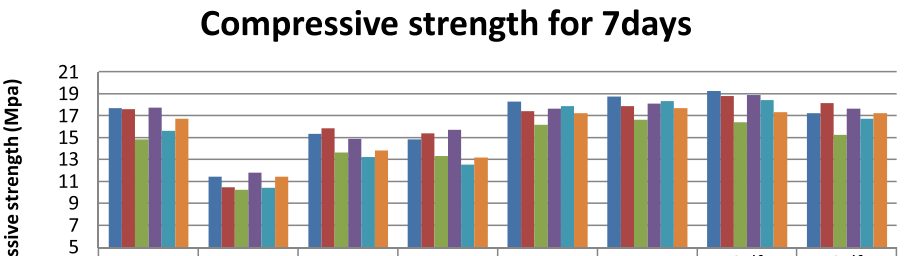
Specific gravity	1.00
Drying time	less than 4 hours
Moisture retention properties equalling	0.55 Kg/M^2 in 72 hours

Table 2
Properties of SAP.

Particle size	1 mm(Average)
Density	1.08
Bulk density	0.85
Form	Dry– Crystalline white powder / granules
Water absorption	150 g for 1 g

Table 3
Mix proportions of Fine aggregate.

Mix \ Fine aggregete	Natural sand (%)	Manufactured sand (%)	Quarry dust (%)
Mix-A	100	–	–
Mix-B	–	100	–
Mix-C	–	–	100
Mix-AB	50	50	–
Mix-AC	50	–	50
Mix-BC	–	50	50



	Standard Moist curing	Air-Shade curing	Wet-gunny bag curing	Water-Sprink Curing	Resin-based curing	Wax-based curing	Self curing (Sap-0.3%)	Self curing (Sap-0.4%)
Mix-A	17.72	11.45	15.34	14.86	18.28	18.74	19.26	17.22
Mix-B	17.63	10.5	15.86	15.42	17.43	17.89	18.82	18.14
Mix-C	14.85	10.23	13.64	13.33	16.2	16.66	16.43	15.28
Mix-AB	17.73	11.8	14.89	15.73	17.67	18.13	18.9	17.65
Mix-AC	15.65	10.42	13.22	12.56	17.89	18.35	18.46	16.72
Mix-BC	16.75	11.45	13.84	13.2	17.24	17.7	17.32	17.25

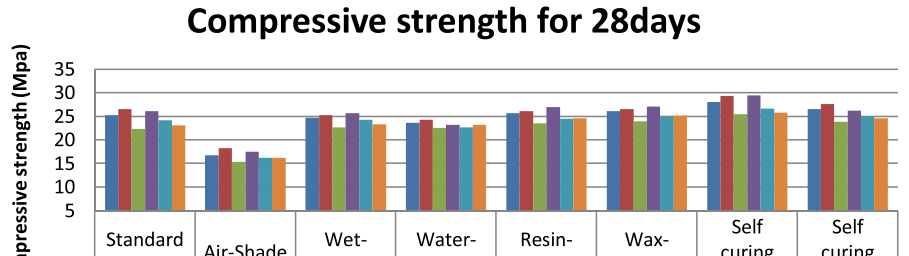
Fig. 1. Compressive strength of concrete for 7 days with different curing conditions.

Compressive strength of Self-curing with (SAP 0.3%) mix-A increased slightly by 8.7% than Standard moist curing and 68.2% than Air-shaded curing. In all mix proportions, air-shaded curing shows the least compressive strength compared to other methods.

Concrete mixes with partially (Mix-AB) and fully (Mix-B) replaced with M-sand showing a significant strength improvement for 28days in all curing conditions. Compare to all curing conditions, compressive strength of self-curing with (SAP-0.3%) shows a rose of approximately 11% than Standard Moist curing, 14% than wet gunny bag curing, 9.5% than resin based curing and 7.6% than wax based curing (Figs. 2–4).

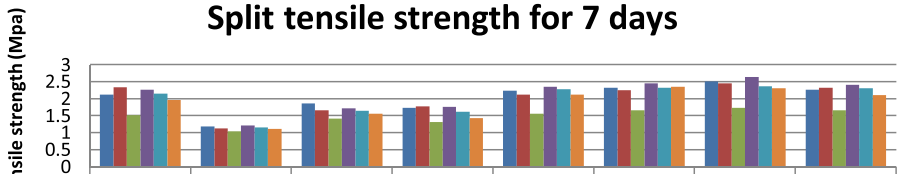
3.2. Split tensile strength of concrete

Tensile strength results clearly showing that both natural and manufacturing sand concrete in all curing conditions were roughly equal. Tensile strength of Self-curing with (SAP 0.3%) mix-A increased slightly by 12.3% than Standard moist curing Air shaded curing shows a least tensile strength compare to other coring conditions.



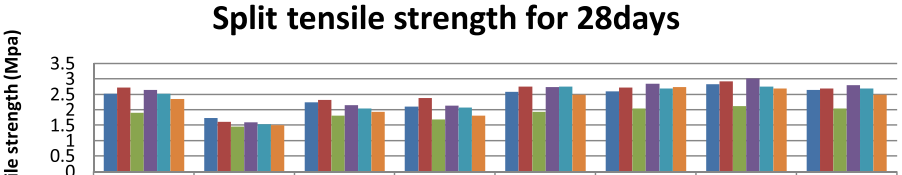
	Standard Moist curing	Air-Shade curing	Wet-gunny bag curing	Water-Sprink Curing	Resin-based curing	Wax-based curing	Self curing (Sap-0.3%)	Self curing (Sap-0.4%)
Mix-A	25.26	16.73	24.72	23.67	25.67	26.13	28.12	26.56
Mix-B	26.52	18.26	25.23	24.32	26.12	26.58	29.36	27.67
Mix-C	22.36	15.36	22.65	22.54	23.56	24.02	25.46	23.87
Mix-AB	26.12	17.54	25.72	23.23	26.95	27.12	29.52	26.21
Mix-AC	24.22	16.23	24.34	22.65	24.52	24.98	26.72	25.11
Mix-BC	23.12	16.21	23.33	23.28	24.67	25.13	25.8	24.64

Fig. 2. Compressive strength of concrete for 28 days with different curing.



	Standard Moist curing	Air-Shade curing	Wet-gunny bag curing	Water-Sprink Curing	Resin-based curing	Wax-based curing	Self curing (Sap-0.3%)	Self curing (Sap-0.4%)
Mix-A	2.12	1.19	1.86	1.73	2.24	2.32	2.52	2.27
Mix-B	2.34	1.13	1.67	1.78	2.12	2.26	2.45	2.32
Mix-C	1.52	1.04	1.42	1.31	1.56	1.67	1.74	1.67
Mix-AB	2.27	1.22	1.72	1.76	2.36	2.46	2.64	2.42
Mix-AC	2.16	1.16	1.65	1.62	2.28	2.32	2.37	2.31
Mix-BC	1.96	1.12	1.56	1.43	2.12	2.36	2.31	2.11

Fig. 3. Split tensile strength of concrete for 7days with different curing conditions.



	Standard Moist curing	Air-Shade curing	Wet-gunny bag curing	Water-Sprink Curing	Resin-based curing	Wax-based curing	Self curing (Sap-0.3%)	Self curing (Sap-0.4%)
Mix-A	2.52	1.73	2.24	2.11	2.58	2.6	2.83	2.65
Mix-B	2.72	1.61	2.32	2.38	2.76	2.72	2.92	2.7
Mix-C	1.91	1.46	1.81	1.69	1.94	2.05	2.12	2.05
Mix-AB	2.65	1.6	2.15	2.14	2.74	2.84	3.02	2.8
Mix-AC	2.53	1.54	2.05	2.07	2.76	2.7	2.75	2.69
Mix-BC	2.36	1.5	1.94	1.81	2.5	2.74	2.69	2.49

Fig. 4. Split tensile strength of concrete for 7days with different curing conditions.

4. Conclusion

- In all curing conditions, Compression and tensile strength of concrete with M-sand are on par with conventional natural sand concrete.
- Concrete mixes with quarry dust (Mix-C, Mix-AC & Mix-BC) showing lower strength values in all curing conditions.
- It found that the most suitable one to replace river sand is M-sand. Compared to the river sand, the M-sand has a better quality. Thus the illegal extraction and price tag of natural sand can be significantly reduced.
- Dissimilar curing systems have different effects on the strength properties of concrete.
- Among the curing systems employed in this investigation, self-curing with SAP 0.3% produced the uppermost strength for 7 and 28 days. Air-shade curing produced the lowest strength value among the curing systems examined. Membrane curing for concrete is the answer to many problems faced due to deficit of proper curing and water scarcity.

Conflict of interest

The author declares that there is no potential conflict of interest.

Acknowledgement

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