

EXPERIMENTAL STUDY OF SELF-CURING CONCRETE

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Article Received: 11-11-19

Accepted: 24-02-20

Published: 27-03-20

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ABSTRACT

The study aim was to make comparison between self-curing and traditional concrete qualities in terms of hardness and water absorption. The study was experimental in nature and made use of material including Portland Pozzolana cement, fine aggregate, and angular coarse aggregate. The three grades of concrete were used in the experiment including M10, M20, and M30 based on cube and cylinder format. The tests involved in the study included non-destructive test, compression and split tensile strength test, and water absorption test. The findings show that overall, self-curing concrete shows better performance compare to the sprinkler or fully cured concrete. Thus, the study makes recommendation that traditional concrete may be replaced with the self-curing concrete.

Keywords: Self-Curing, Traditional, Concrete, Experiment.

INTRODUCTION

There is increased usage of concrete and it leads to the rapid increase in concrete technology. Internal curing of concrete is a new concept and has gained increased popularity (Mather, 2001; Shetty, 2000). The idea of internal curing concrete is that such concrete maintains good level of moisture contents within itself during its early stages which enable development of desired properties (IS 456:2000). This maintenance of moisture leads during the early stages leads to the

higher level of performance, durability, and hardness of such concrete. However, because of some difficulties such as lack of enough water, the good curing is not achievable all the times. identification of self-curing agent is the prime concern of many researchers. One solution is the polyethylene-glycol which enable minimum water evaporation due to the decreased surface tension of the water (Bentz, Lura, & Roberts, 2005). This enable greater water retention and curing. Generally, water-soluble polymers or polyethylene Glycol are considered as self-curing concrete agent. In this study, we investigate Polyethylene Glycol and its use as self-curing concrete. The study is experimental in nature and details are provided below.

EXPERIMENT DETAILS

Material

Portland Pozzolana cement is used in the study along with fine aggregate obtained from river bed, and angular coarse aggregate with maximum size of 25 mm. All material used in the study are fulfilling the standard requirements.

Table 1: Concrete Mixes Involving Self-Curing Agent for One Cube of Size 175 * 175 mm

Grade of Concrete	Cement (Kg)	Sand (Kg)	Coarse Aggregate (Kg)	Water (lt)	PEG (ml)
M10	1.9	2.78	6.78	0.98	7.34
M20	2.7	3.98	3.54	1.18	7.97
M30	4.5	4.23	3.35	1.43	10.89

Table 2: Concrete Mixes Involving Self-Curing Agent for One Cylinder of Size 200 * 350 mm

Grade of Concrete	Cement (Kg)	Sand (Kg)	Coarse Aggregate (Kg)	Water (ml)	PEG (ml)
M10	1.7	1.87	5.45	879	5.45
M20	2.43	1.56	5.23	900	3.45
M30	3.56	1.88	5.11	960	5.75

We used two separate concrete mixes with same w/c ratio. We added self-curing agent in one of the mix, while, the other mix remained unadded. The compacting factor value and the slump value for the both types of concrete are provided in table 3.

Table 3: Slump and Compacting Factor Tests Results

Grade of Concrete	Designation	W/C	Slump (mm)	Compacting Factor
M10	Conventional Concrete	0.4	120	0.89
M10	Self-Curing Concrete	0.4	175	0.85
M20	Conventional Concrete	0.6	80	0.70
M20	Self-Curing Concrete	0.6	85	0.80
M30	Conventional Concrete	0.35	100	0.95
M30	Self-Curing Concrete	0.35	20	0.80

Non-Destructive Test

For establishing the compressive strength of the concrete, Schmidt rebound hammer test is conducted. The test was performed while keeping rebound hammer in vertical position with 175 mm cube specimen.

Compression and Split Tensile Strength

Cube of 175 by 175 mm size and cylinder of 175 diameter belonging to the self-curing and the conventional concrete were casted. We used a steel tamping rod of about 18 mm diameter and 700 mm length for blowing each layer with 30 blows. The conventional based specimen was permitted to get dry for 24 hours after casting. As per the requirements, the water was sprinkled at regular time interval for both the cubes and the cylinder. For self-curing specimen, no external curing such as sprinkling was used. The strength related tests were performed for both types of specimen after 3, 7, and 28 days passed.

Water Absorption Test

90 days curing time was used for immersing the cylinder after casting. The specimens were later dried for 24 hours at the temperature of about 100 centigrade until the mass get to the constant level which was used to calculate the dry weight of the cylinder. Later, this was kept in hot water at about 9- centigrade for 4 hours and its weight was taken as the wet weight of the cylinder labelled as W2. The percentage of the water absorption was taken as the W1 deducted from W1 and divided by W1.

Water Sorptivity Test/Durability Test

Water sorptivity test was conducted for measuring the rate of water absorption. Cylinder of 100 mm and 50 mm height were used for both the conventional and self-curing concrete. These specimens were dried for 24 hours at the 100 centigrade and left to cool in dry conditions for another 24 hours. The test was conducted by placing one circular surface of the specimen to be in contact with water at 5 mm depth. The rest of the part of the specimen was coated with high quality water proofer for creating unidirectional flow pattern through the concrete specimen. These tests were conducted on both type of samples at the age of 28 days for assessing the absorption rate of the water at interval of 30 minutes, 60 minutes, 90 minutes, and 120 minutes, 150 minutes, and 180 minutes.

RESULTS

The results are as follows;

Table 4: NDT for 3 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	14	11	10
Cylinder	12	10	9

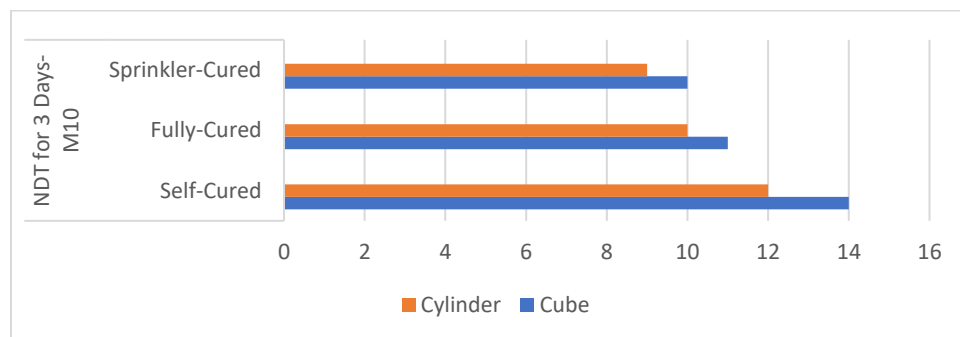


Figure 1: NDT for 3 Days- M10

For NDT test for M10 at the age of 3 days, the test statistics for cube for self-cured is 14, fully-cured is 11, and sprinkler-cured is 10. The test statistics for cylinder for cube for self-cured is 12, fully cured is 10, and sprinkler-cured is 9.

Table 5: NDT for 3 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	15	13	11
Cylinder	13	12	9

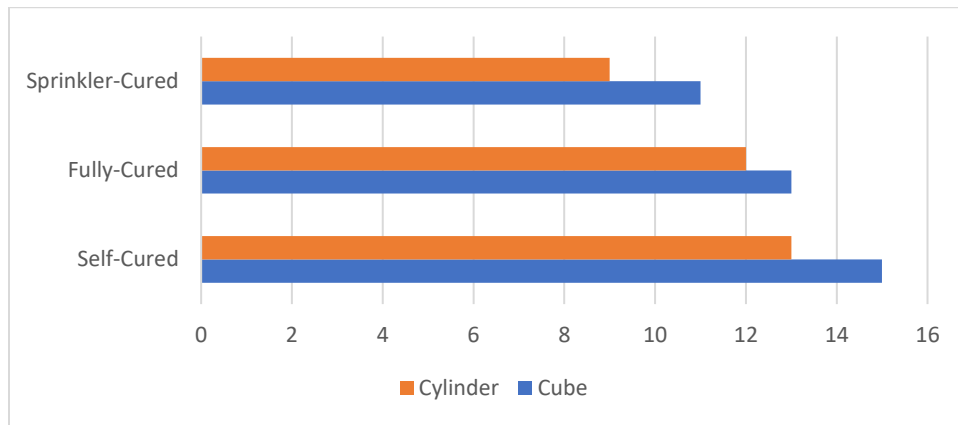


Figure 2: NDT for 3 Days- M20

For NDT test for M20 at the age of 3 days, the test statistics for cube for self-cured is 15, fully-cured is 13, and sprinkler-cured is 11. The test statistics for cylinder for cube for self-cured is 13, fully cured is 12, and sprinkler-cured is 9.

Table 6: NDT for 3 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	16	14	10
Cylinder	14	12	8

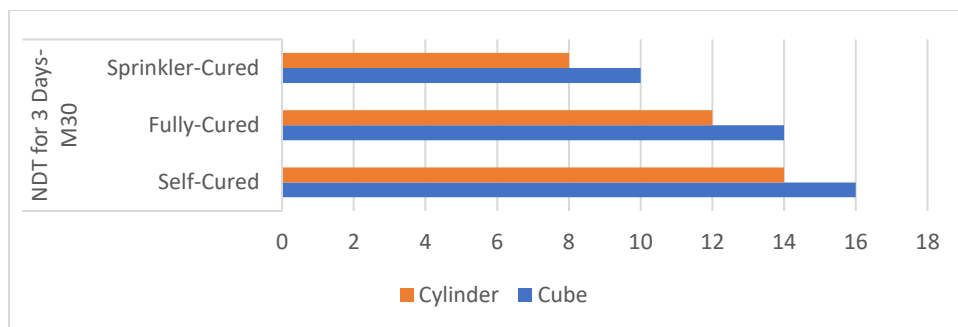


Figure 3: NDT for 3 Days- M30

For NDT test for M30 at the age of 3 days, the test statistics for cube for self-cured is 16, fully-cured is 14, and sprinkler-cured is 10. The test statistics for cylinder for cube for self-cured is 14, fully cured is 12, and sprinkler-cured is 8.

Table 7: NDT for 7 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	22	20	18
Cylinder	20	19	16

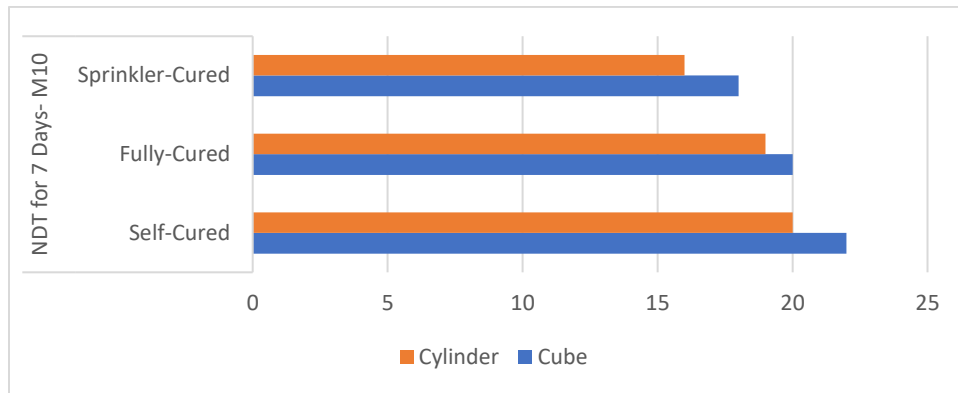


Figure 4: NDT for 7 Days- M10

For NDT test for M10 at the age of 7 days, the test statistics for cube for self-cured is 22, fully-cured is 20, and sprinkler-cured is 18. The test statistics for cylinder for cube for self-cured is 20, fully cured is 19, and sprinkler-cured is 16.

Table 8: NDT for 7 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	24	20	26
Cylinder	22	19	22

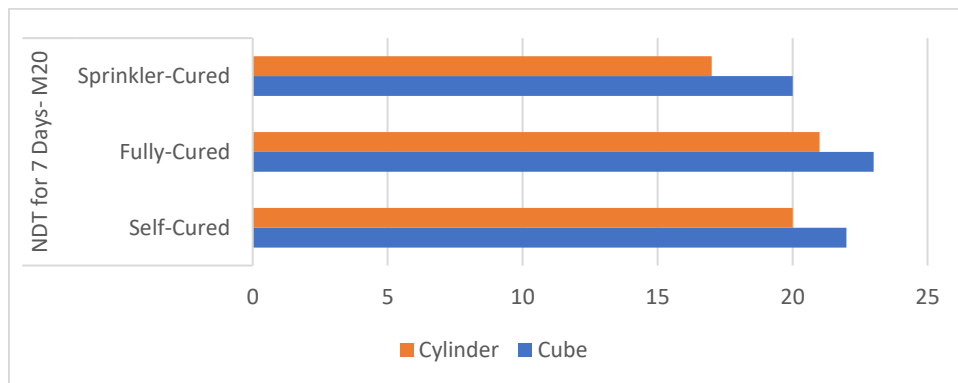


Figure 5: NDT for 7 Days- M20

For NDT test for M20 at the age of 7 days, the test statistics for cube for self-cured is 24, fully-cured is 20, and sprinkler-cured is 26. The test statistics for cylinder for cube for self-cured is 22, fully cured is 19, and sprinkler-cured is 22.

Table 9: NDT for 7 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	16	14	10
Cylinder	14	12	8

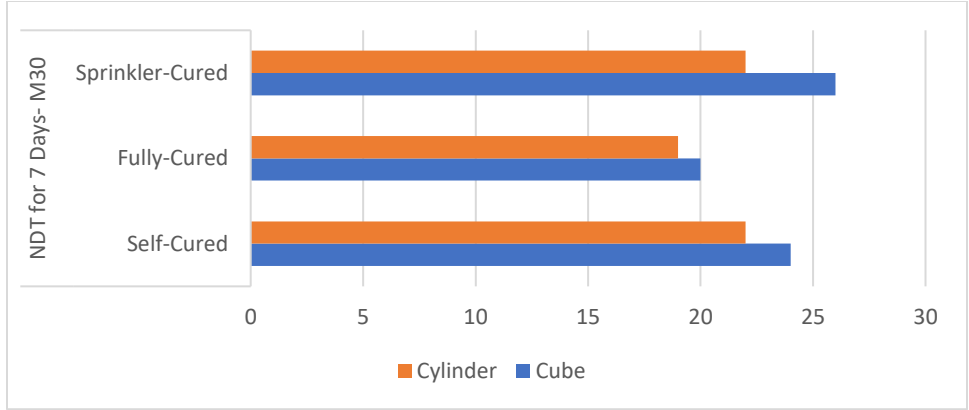


Figure 6: NDT for 7 Days- M30

For NDT test for M30 at the age of 7 days, the test statistics for cube for self-cured is 16, fully-cured is 14, and sprinkler-cured is 10. The test statistics for cylinder for cube for self-cured is 14, fully cured is 12, and sprinkler-cured is 8.

Table 10: NDT for 28 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	36	38
Cylinder	40	34	34

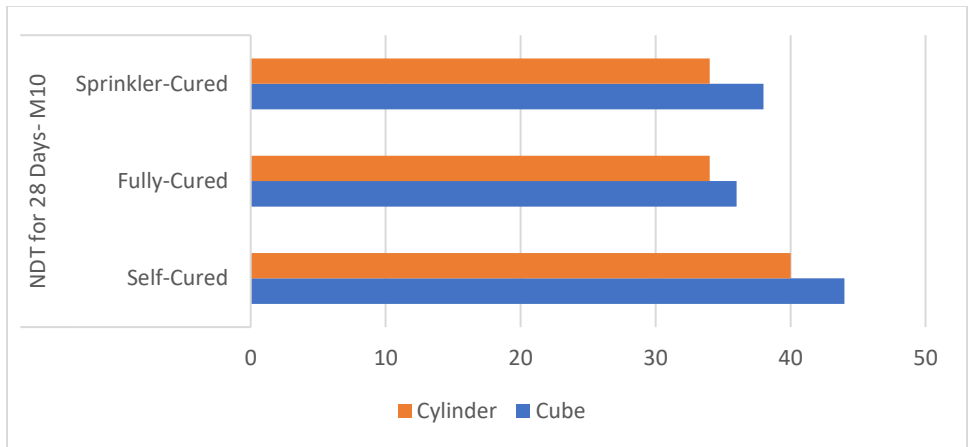


Figure 7: NDT for 28 Days- M10

For NDT test for M10 at the age of 28 days, the test statistics for cube for self-cured is 44, fully-cured is 36, and sprinkler-cured is 38. The test statistics for cylinder for cube for self-cured is 40, fully cured is 34, and sprinkler-cured is 34.

Table 11: NDT for 28 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	38	42
Cylinder	40	32	40

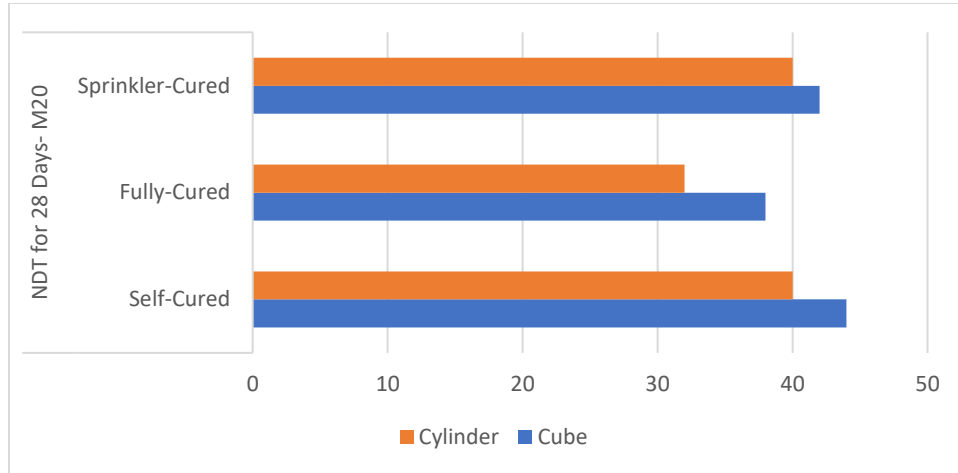


Figure 8: NDT for 28 Days- M20

For NDT test for M20 at the age of 28 days, the test statistics for cube for self-cured is 44, fully-cured is 38, and sprinkler-cured is 42. The test statistics for cylinder for cube for self-cured is 40, fully cured is 32, and sprinkler-cured is 40.

Table 12: NDT for 28 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	46	44	40
Cylinder	42	40	38

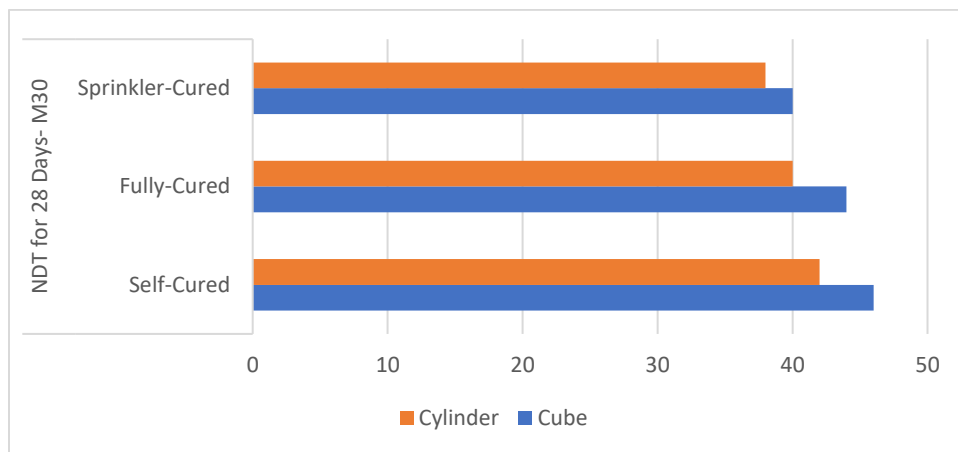


Figure 9: NDT for 28 Days- M30

For NDT test for M30 at the age of 28 days, the test statistics for cube for self-cured is 46, fully-cured is 44, and sprinkler-cured is 40. The test statistics for cylinder for cube for self-cured is 42, fully cured is 40, and sprinkler-cured is 38.

Compressive Strength for 3 Days, 7 Days, and 28 Days for M10, M20, and M30

Table 13: Compressive Strength for 3 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	10	12	12
Cylinder	10	10	8

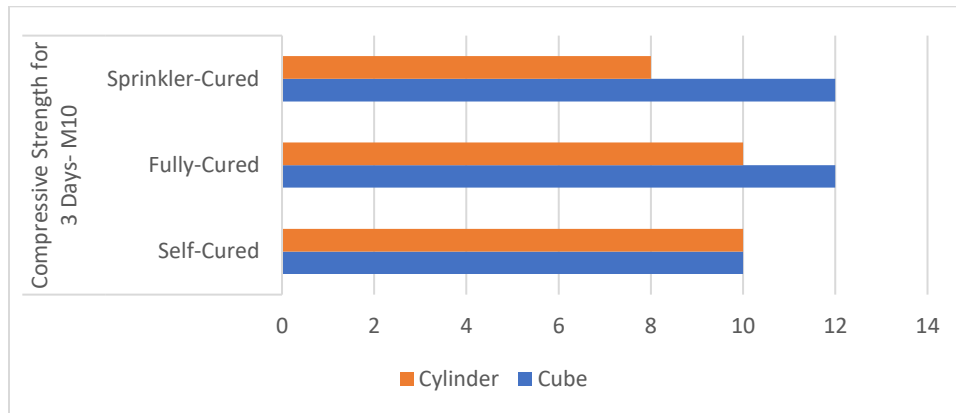


Figure 10: Compressive Strength for 3 Days- M10

For compressive strength test for M10 at the age of 3 days, the test statistics for cube for self-cured is 10, fully-cured is 12, and sprinkler-cured is 12. The test statistics for cylinder for cube for self-cured is 10, fully cured is 10, and sprinkler-cured is 8.

Table 14: Compressive Strength for 3 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	14	12	14
Cylinder	12	10	12

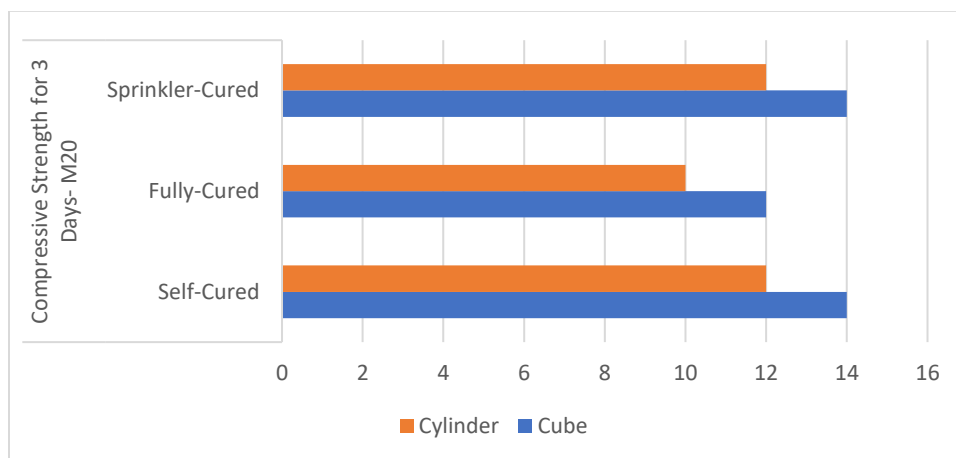


Figure 11: Compressive Strength for 3 Days- M20

For compressive strength test for M20 at the age of 3 days, the test statistics for cube for self-cured is 14, fully-cured is 12, and sprinkler-cured is 14. The test statistics for cylinder for cube for self-cured is 12, fully cured is 10, and sprinkler-cured is 12.

Table 15: Compressive Strength for 3 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	16	16	16
Cylinder	14	12	12

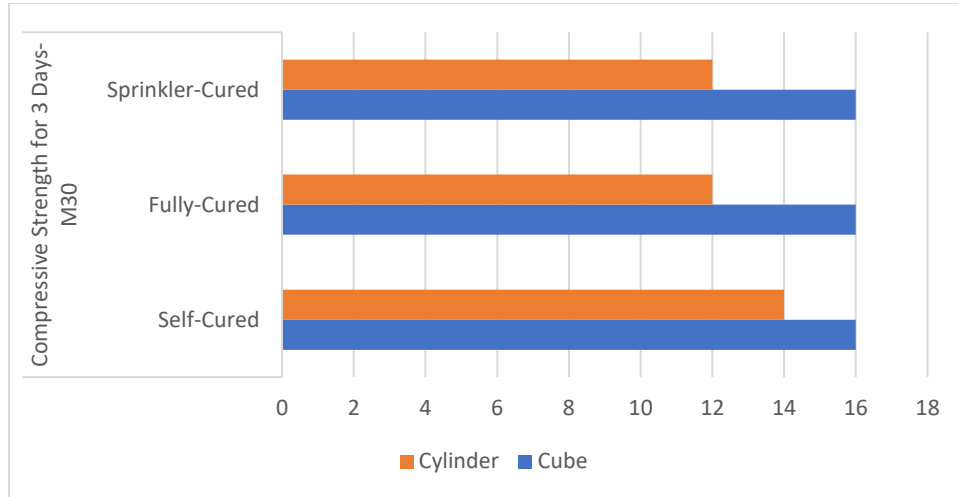


Figure 12: Compressive Strength for 3 Days- M30

For compressive strength test for M30 at the age of 3 days, the test statistics for cube for self-cured is 16, fully-cured is 16, and sprinkler-cured is 16. The test statistics for cylinder for cube for self-cured is 14, fully cured is 14, and sprinkler-cured is 12.

Table 16: Compressive Strength for 7 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	14	16	18
Cylinder	14	14	16

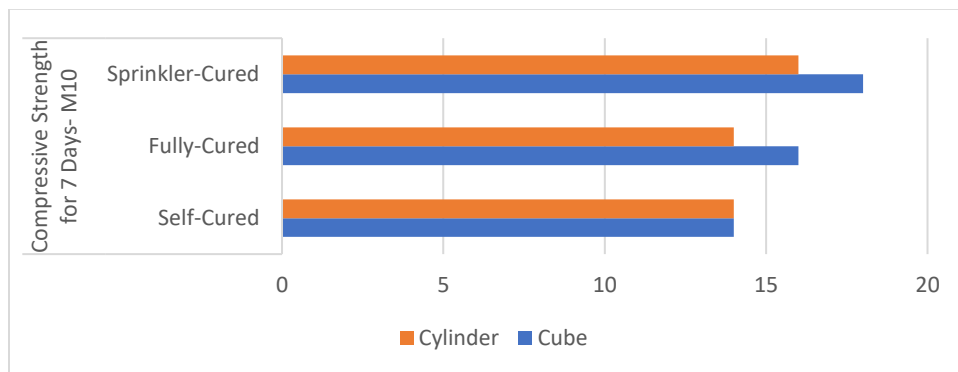


Figure 13: Compressive Strength for 7 Days- M10

For compressive strength test for M10 at the age of 7 days, the test statistics for cube for self-cured is 14, fully-cured is 16, and sprinkler-cured is 18. The test statistics for cylinder for cube for self-cured is 14, fully cured is 14, and sprinkler-cured is 16.

Table 17: Compressive Strength for 7 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	28	30	32
Cylinder	24	26	28

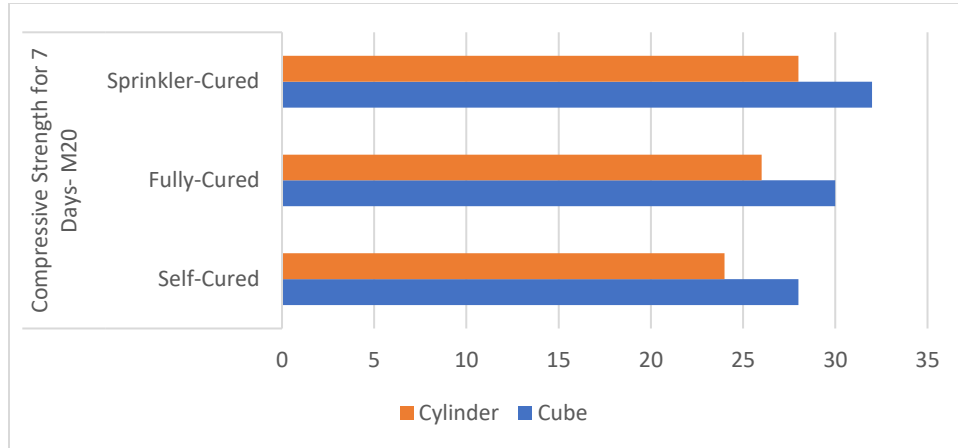


Figure 14: Compressive Strength for 7 Days- M20

For compressive strength test for M20 at the age of 7 days, the test statistics for cube for self-cured is 28, fully-cured is 30, and sprinkler-cured is 32. The test statistics for cylinder for cube for self-cured is 24, fully cured is 26, and sprinkler-cured is 28.

Table 18: Compressive Strength for 7 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	32	28	30
Cylinder	30	26	26

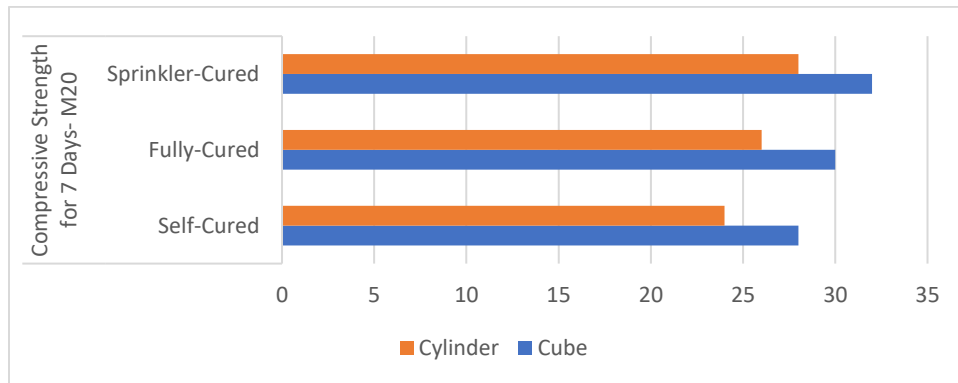


Figure 15: Compressive Strength for 7 Days- M30

For compressive strength test for M30 at the age of 7 days, the test statistics for cube for self-cured is 32, fully-cured test is 28, and sprinkler-cured is 30. The test statistics for cylinder for cube for self-cured is 30, fully cured is 26, and sprinkler-cured is 26.

Table 19: Compressive Strength for 28 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	42	44	50
Cylinder	38	40	46

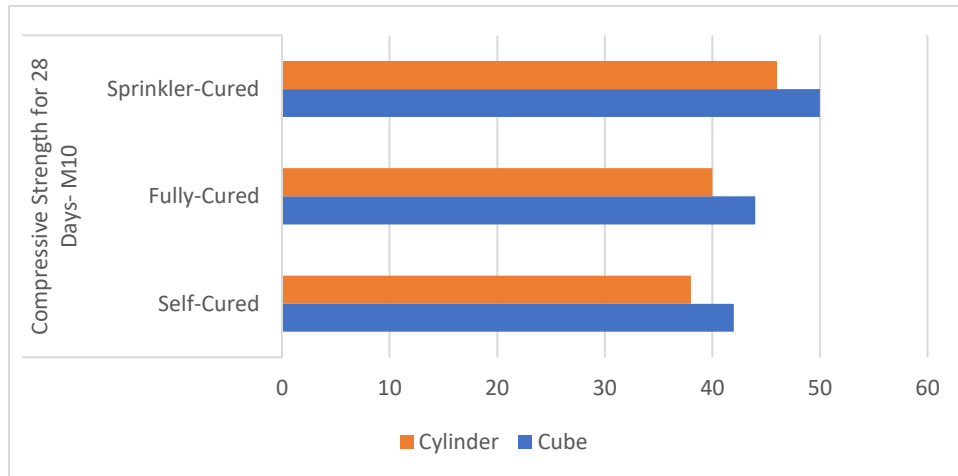


Figure 16: Compressive Strength for 28 Days- M10

For compressive strength test for M10 at the age of 28 days, the test statistics for cube for self-cured is 42, fully-cured is 44, and sprinkler-cured is 50. The test statistics for cylinder for cube for self-cured is 38, fully cured is 40, and sprinkler-cured is 46.

Table 20: Compressive Strength for 28 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	44	48
Cylinder	38	36	42

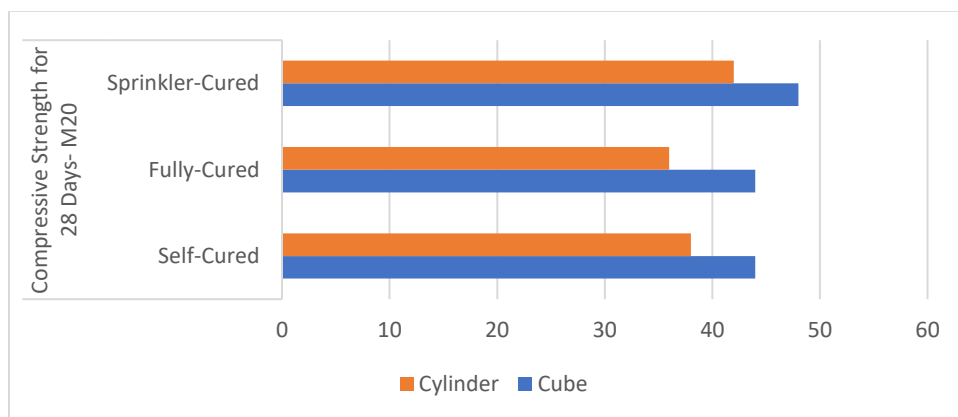


Figure 17: Compressive Strength for 28 Days- M20

For compressive strength test for M20 at the age of 28 days, the test statistics for cube for self-cured is 44, fully-cured is 44, and sprinkler-cured is 48. The test statistics for cylinder for cube for self-cured is 38, fully cured is 36, and sprinkler-cured is 42.

Table 21: Compressive Strength for 28 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	48	50
Cylinder	46	44	46

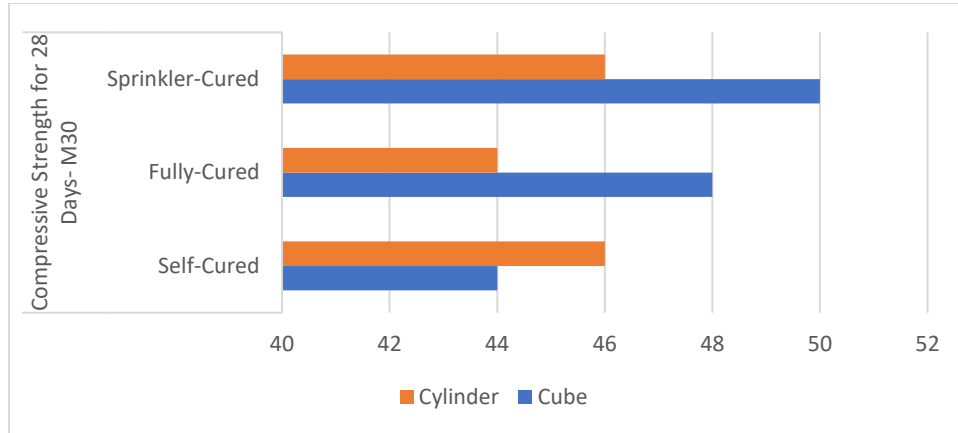


Figure 18: Compressive Strength for 28 Days- M30

For compressive strength test for M30 at the age of 28 days, the test statistics for cube for self-cured is 44, fully-cured is 48, and sprinkler-cured is 50. The test statistics for cylinder for cube for self-cured is 46, fully cured is 44, and sprinkler-cured is 46.

Split Tensile Strength for Cylinder for 3 Days, 7 Days, and 28 Days, for M10, M20, and M30

Table 22: Split Tensile Strength for Cylinder 3 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	0.8	0.8	1
Cylinder	0.6	0.6	0.8

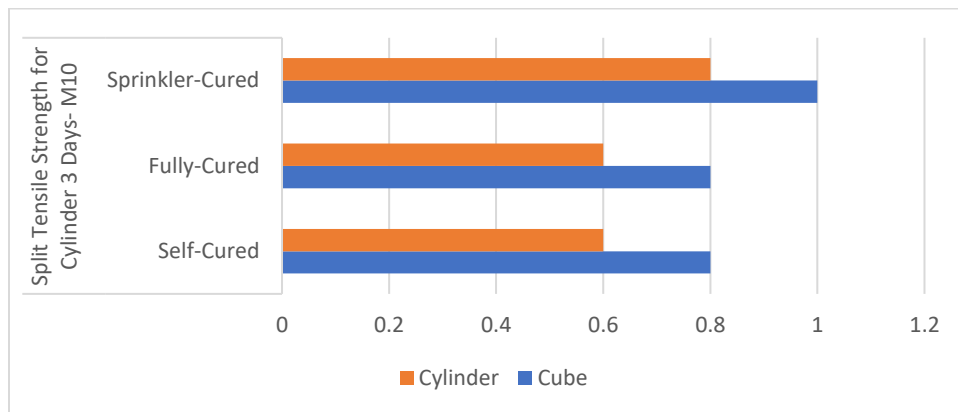


Figure 19: Split Tensile Strength for Cylinder 3 Days- M10

For split strength test for M10 at the age of 3 days, the test statistics for cube for self-cured is 0.8, fully-cured is 0.8, and sprinkler-cured is 1. The test statistics for cylinder for self-cured is 0.6, fully cured is 0.6, and sprinkler-cured is 0.8.

Table 23: Split Tensile Strength for Cylinder 7 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.2	1.4	1.6
Cylinder	1.2	1	1.2

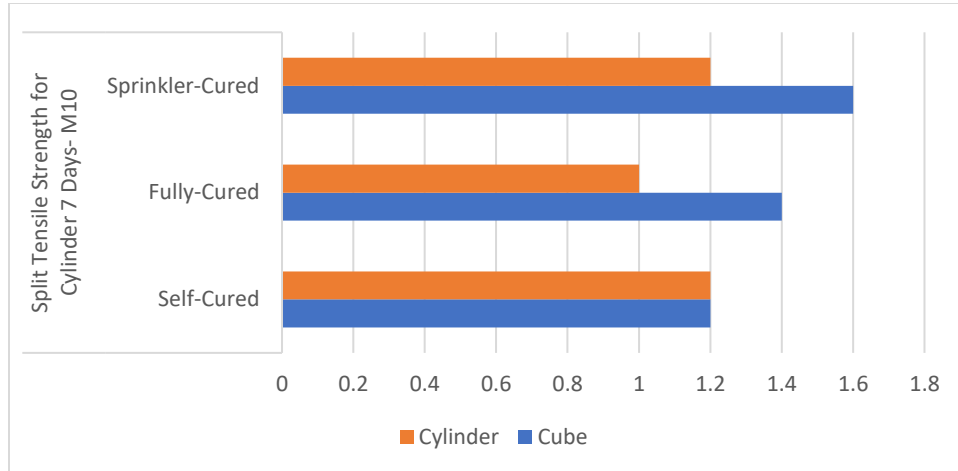


Figure 20: Split Tensile Strength for Cylinder 7 Days- M10

For split strength test for M10 at the age of 7 days, the test statistics for cube for self-cured is 1.2, fully-cured is 1.4, and sprinkler-cured is 1.6. The test statistics for cylinder for self-cured is 1.2, fully cured is 1, and sprinkler-cured is 1.2.

Table 24: Split Tensile Strength for Cylinder 28 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	3.2	3.4	3.6
Cylinder	2.8	3	3.2

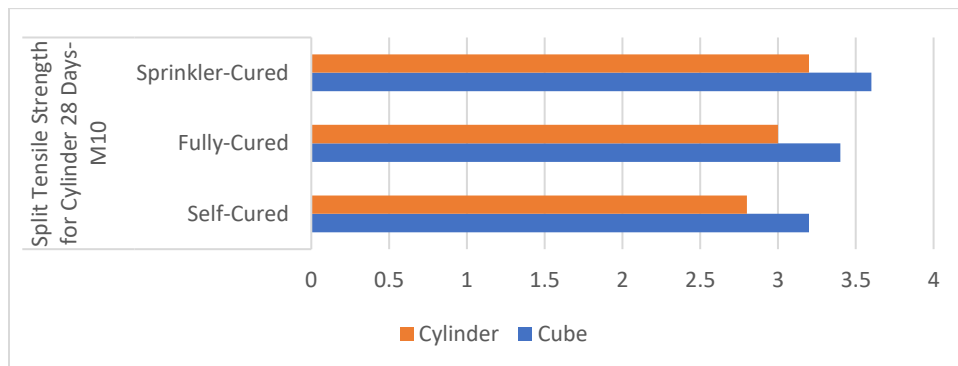


Figure 21: Split Tensile Strength for Cylinder 28 Days- M10

For split strength test for M10 at the age of 28 days, the test statistics for cube for self-cured is 3.2, fully-cured is 3.4, and sprinkler-cured is 3.6. The test statistics for cylinder for self-cured is 2.8, fully cured is 3, and sprinkler-cured is 3.2.

Table 25: Split Tensile Strength for Cylinder 3 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.2	0.8	1
Cylinder	0.8	0.8	1

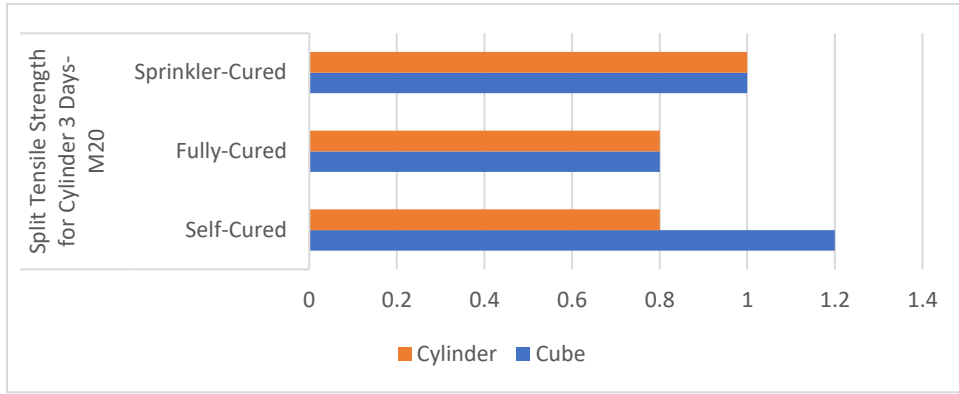


Figure 22: Split Tensile Strength for Cylinder 3 Days- M20

For split strength test for M20 at the age of 3 days, the test statistics for cube for self-cured is 1.2, fully-cured is 0.8, and sprinkler-cured is 1. The test statistics for cylinder for self-cured is 0.8, fully cured is 0.8, and sprinkler-cured is 1.

Table 26: Split Tensile Strength for Cylinder 7 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.6	1.2	1.2
Cylinder	1.4	1	1

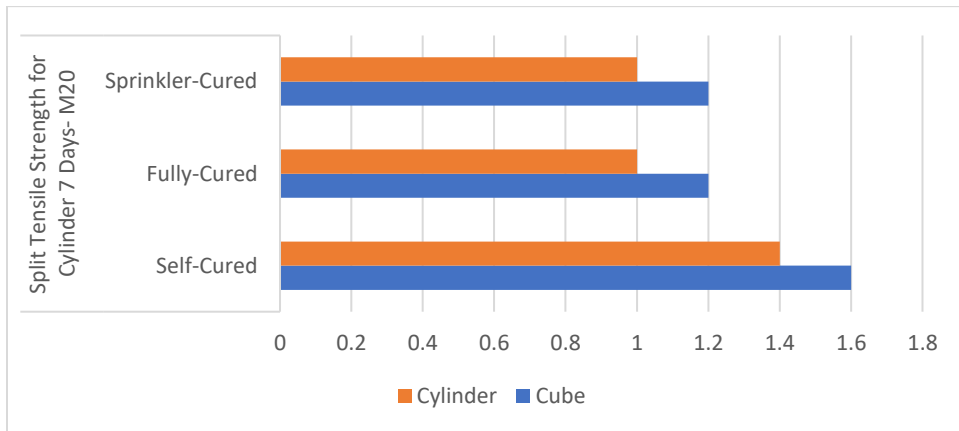


Figure 23: Split Tensile Strength for Cylinder 7 Days- M20

For split strength test for M20 at the age of 7 days, the test statistics for cube for self-cured is 1.6, fully-cured is 1.2, and sprinkler-cured is 1.2. The test statistics for cylinder for self-cured is 1.4, fully cured is 1, and sprinkler-cured is 1.

Table 27: Split Tensile Strength for Cylinder 28 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.4	2.2	2.2
Cylinder	2.2	2	2.2

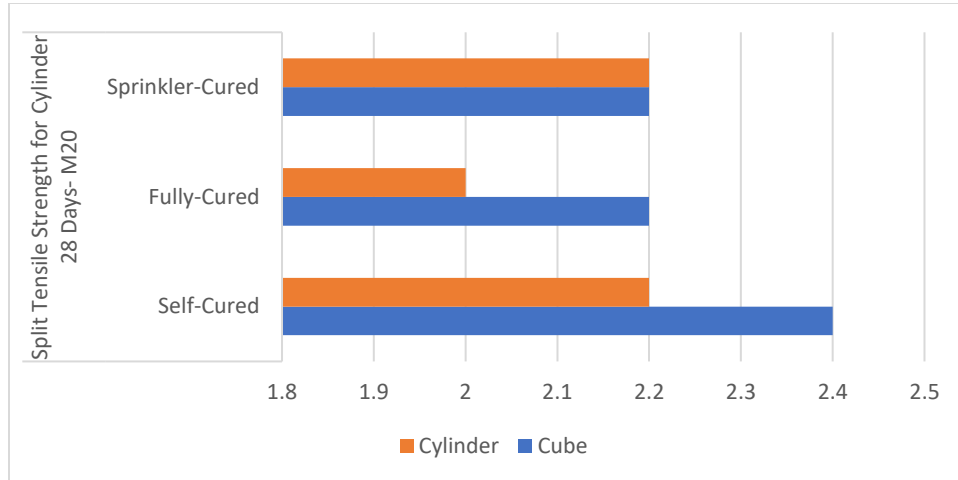


Figure 24: Split Tensile Strength for Cylinder 28 Days- M20

For split strength test for M20 at the age of 28 days, the test statistics for cube for self-cured is 2.4, fully-cured is 2.2, and sprinkler-cured is 2.2. The test statistics for cylinder for self-cured is 2.2, fully cured is 2, and sprinkler-cured is 2.2.

Table 28: Split Tensile Strength for Cylinder 3 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.6	2.4	2.8
Cylinder	2.2	2.2	2.4

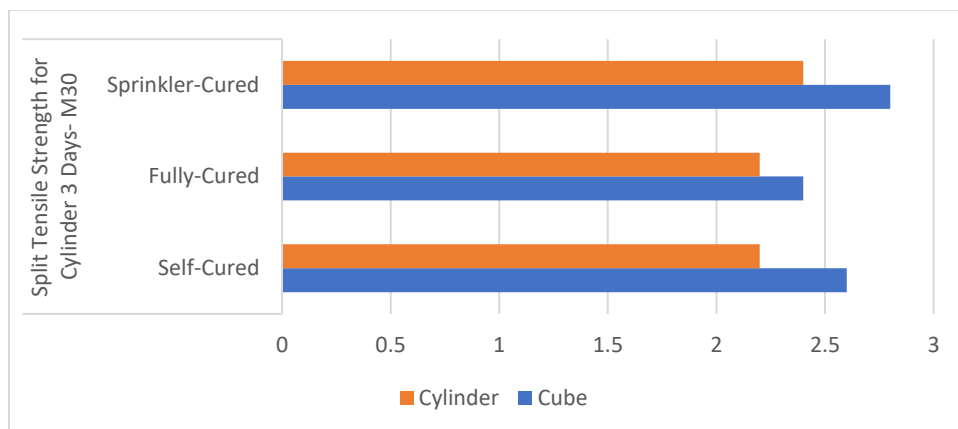


Figure 25: Split Tensile Strength for Cylinder 3 Days- M30

For split strength test for M30 at the age of 3 days, the test statistics for cube for self-cured is 2.6, fully-cured is 2.4, and sprinkler-cured is 2.8. The test statistics for cylinder for self-cured is 2.2, fully cured is 2.2, and sprinkler-cured is 2.4.

Table 29: Split Tensile Strength for Cylinder 7 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.8	2.8	2.8
Cylinder	2.2	2.4	2.2

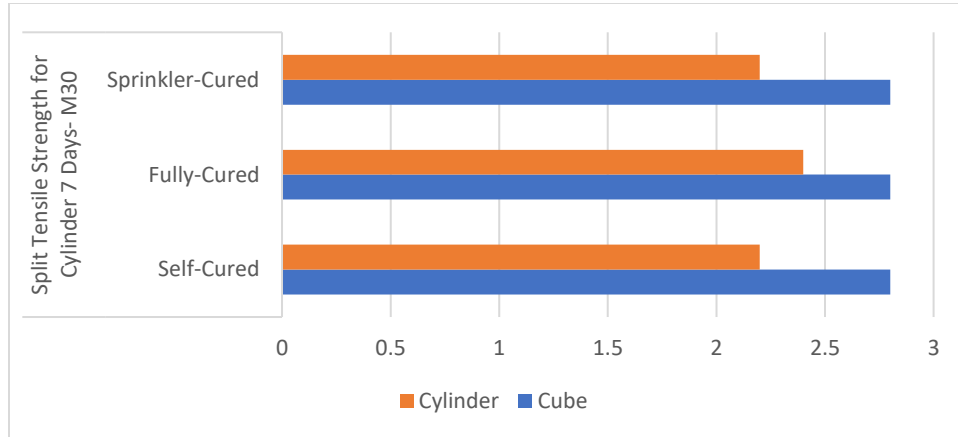


Figure 26: Split Tensile Strength for Cylinder 7 Days- M30

For split strength test for M30 at the age of 7 days, the test statistics for cube for self-cured is 2.8, fully-cured is 2.8, and sprinkler-cured is 2.8. The test statistics for cylinder for self-cured is 2.2, fully cured is 2.4, and sprinkler-cured is 2.2.

Table 30: Split Tensile Strength for Cylinder 28 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.8	2.4	2.8
Cylinder	2.2	2	2.2

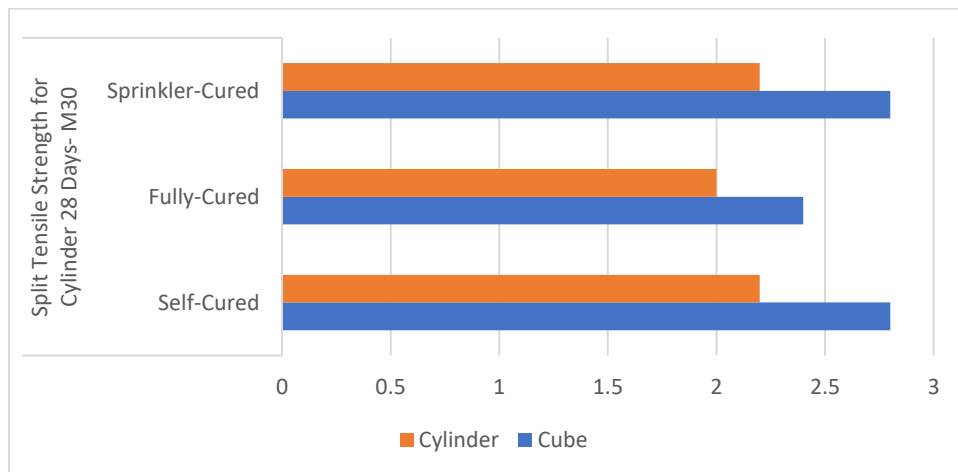


Figure 27: Split Tensile Strength for Cylinder 28 Days- M30

For split strength test for M30 at the age of 28 days, the test statistics for cube for self-cured is 2.8, fully-cured is 2.4, and sprinkler-cured is 2.8. The test statistics for cylinder for self-cured is 2.2, fully cured is 2, and sprinkler-cured is 2.2.

Table 31: Water Absorption for M10

	Time (Minutes)					
	30	60	90	120	150	180
Sprinkler	0.02	0.05	0.06	0.07	0.08	0.09
Full Curing	0.03	0.05	0.07	0.08	0.09	0.09
Self-Curing	0	0.01	0.02	0.03	0.04	0.05

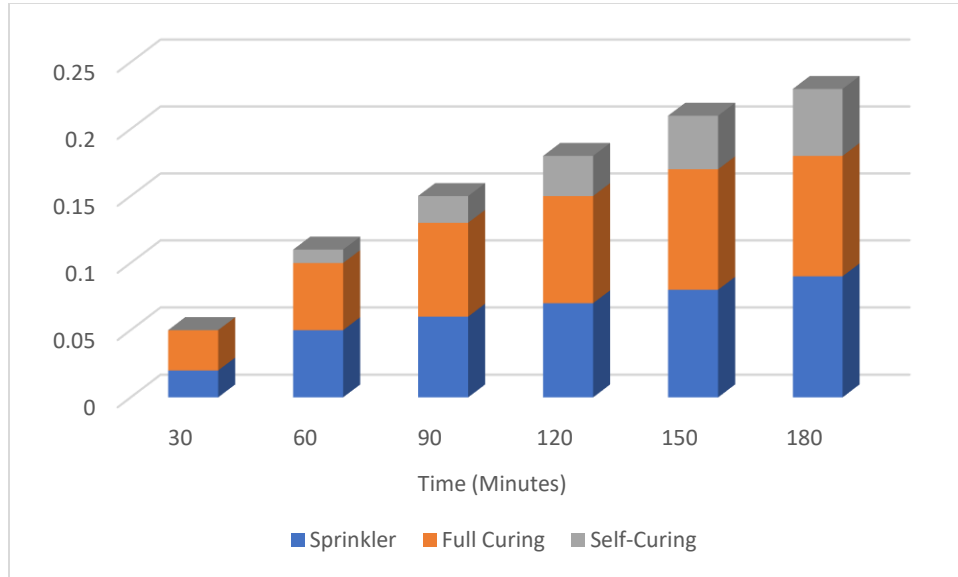


Figure 28: Water Absorption for M10

For water absorption test for M10, the test statistics is as follows. For sprinkler, after 30 minutes is 0.02; after 60 minutes is 0.05; after 90 minutes is 0.06; after 120 minutes is 0.07; after 150 minutes is 0.08; and after 180 minutes is 0.09. For full-curing, after 30 minutes is 0.03; after 60 minutes is 0.05; after 90 minutes is 0.07; after 120 minutes is 0.08; after 150 minutes is 0.09; and after 180 minutes is 0.09. For self-curing, after 30 minutes is 0; after 60 minutes is 0.01; after 90 minutes is 0.02; after 120 minutes is 0.03; after 150 minutes is 0.04; and after 180 minutes is 0.05.

Table 32: Water Absorption for M20

	Time (Minutes)					
	30	60	90	120	150	180
Sprinkler	0.03	0.04	0.05	0.06	0.07	0.08
Full Curing	0	0.01	0.02	0.04	0.05	0.07
Self-Curing	0	0	0.01	0.02	0.03	0.04

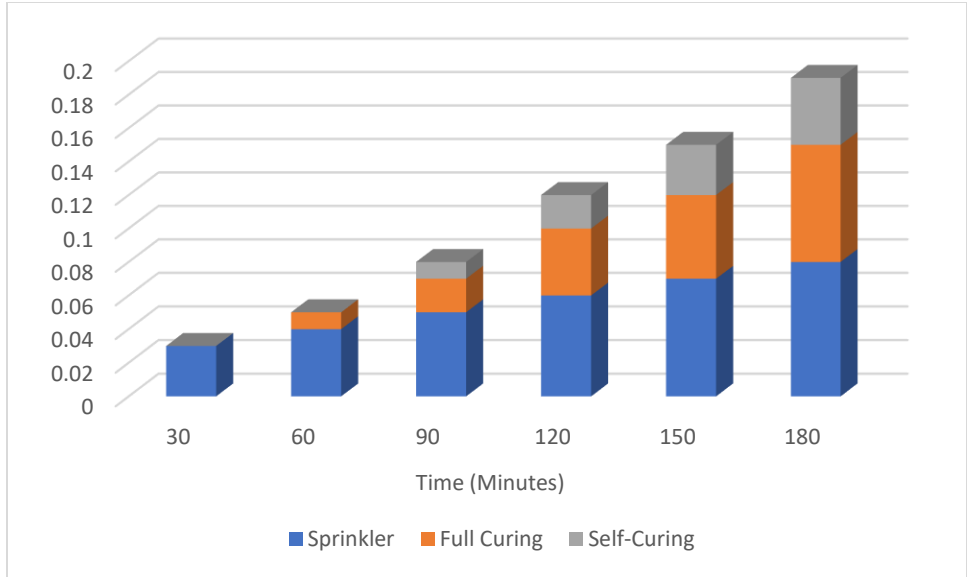


Figure 29: Water Absorption for M20

For water absorption test for M20, the test statistics is as follows. For sprinkler, after 30 minutes is 0.03; after 60 minutes is 0.04; after 90 minutes is 0.05; after 120 minutes is 0.06; after 150 minutes is 0.07; and after 180 minutes is 0.08. For full-curing, after 30 minutes is 0; after 60 minutes is 0.01; after 90 minutes is 0.02; after 120 minutes is 0.04; after 150 minutes is 0.05; and after 180 minutes is 0.07. For self-curing, after 30 minutes is 0; after 60 minutes is 0; after 90 minutes is 0.01; after 120 minutes is 0.02; after 150 minutes is 0.03; and after 180 minutes is 0.04.

Table 33: Water Absorption for M30

	Time (Minutes)					
	30	60	90	120	150	180
Sprinkler	0	0.01	0.03	0.04	0.05	0.07
Full Curing	0	0	0.02	0.03	0.04	0.05
Self-Curing	0	0.01	0.02	0.03	0.04	0.05

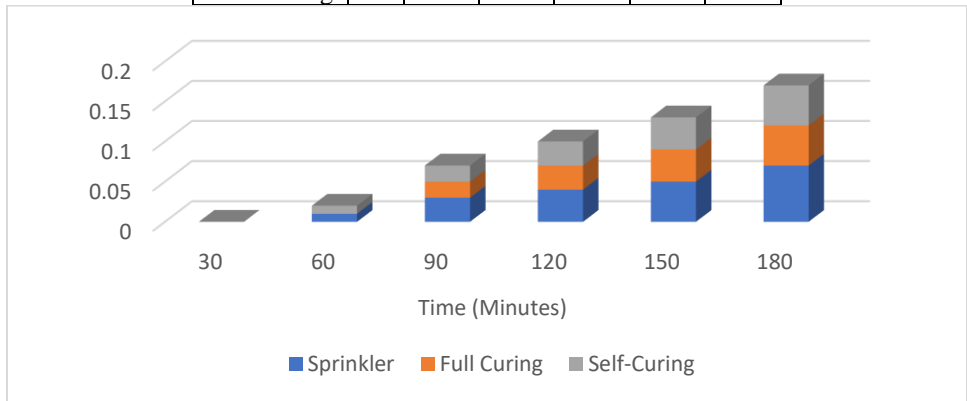


Figure 30: Water Absorption for M30

For water absorption test for M30, the test statistics is as follows. For sprinkler, after 30 minutes is 0; after 60 minutes is 0.01; after 90 minutes is 0.03; after 120 minutes is 0.04; after 150 minutes is 0.05; and after 180 minutes is 0.07. For full-curing, after 30 minutes is 0; after 60 minutes is 0; after 90 minutes is 0.02; after 120 minutes is 0.03; after 150 minutes is 0.04; and after 180 minutes is 0.05. For self-curing, after 30 minutes is 0; after 60 minutes is 0.01; after 90 minutes is 0.02; after 120 minutes is 0.03; after 150 minutes is 0.04; and after 180 minutes is 0.05.

CONCLUSION

The results of NDT test, compression and split tensile strength test, and water absorption test based on the 3 days, 7 days, and 28 days for 3 graded material shows that overall self-curing concrete shows better absorption and strength compared to the sprinkler and fully cured concrete. Furthermore, the comparison also shows that cube shows better strength for all samples compare to the cylinder. Our results confirm the previous studies finding which shows that self-curing concrete is superior in quality and possess desirable qualities such as hardness, durability, and better performance. Thus, this study recommends making greater use of self-curing concrete compare to the traditional concrete.

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