



Application of destructive testing, compression, and split tensile strength on a material based on polyethylene glycol

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Abstract

The objective of this study was to compare the properties of self-curing concrete with those of conventional concrete, focusing on strength and water absorption. Conducted as an experimental investigation, the study utilized materials such as Portland Pozzolana cement, fine aggregates, and angular coarse aggregates. Three concrete grades—M10, M20, and M30—were tested using cube and cylinder specimens. The research involved various assessments, including non-destructive testing, compression and split tensile strength evaluations. The results indicated that self-curing concrete exhibited superior performance compared to sprinkler or fully cured conventional concrete. Consequently, the study suggests that self-curing concrete could serve as an effective alternative to traditional concrete.

Keywords: Self-Curing, Conventional Concrete, Strength, Experiment.

INTRODUCTION

The growing demand for concrete has led to rapid advancements in concrete technology. Internal curing is a relatively new approach that has gained significant attention (Mather, 2001; Shetty, 2000). This method ensures that concrete retains sufficient moisture during its early stages, facilitating the development of desirable properties (IS 456:2000). Maintaining adequate moisture during the initial curing phase enhances the concrete's strength, durability, and overall performance. However, effective curing is not always achievable due to challenges such as water scarcity. Identifying suitable self-curing agents remains a key area of research. One promising solution is polyethylene glycol, which minimizes water evaporation by reducing surface tension (Bentz, Lura, & Roberts, 2005). This property enhances water retention, leading to improved curing efficiency. In general, water-soluble polymers,

including polyethylene glycol, are recognized as effective self-curing agents. This study explores the use of polyethylene glycol in self-curing concrete through an experimental approach, as outlined in the following sections.

EXPERIMENT DETAILS

Material

Portland Pozzolana cement was utilized in this study, along with fine aggregate sourced from a riverbed and angular coarse aggregate with a maximum size of 25 mm. All materials used complied with standard specifications.

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	2.1	3.13	7.56	0.97	8.32
M20	2.6	4.13	4.65	1.23	7.97
M30	4.6	4.25	4.23	1.27	11.25

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	2.3	1.89	5.35	950	5.35
M20	2.7	1.67	5.35	990	3.50
M30	4.7	1.66	5.22	995	5.65

We prepared two distinct concrete mixes, both with the same water-to-cement (w/c) ratio. A self-curing agent was incorporated into one of the mixes, while the other mix was left without any additive. The corresponding compacting factor and slump values for both concrete types are presented in Table 3.

Table 3

Slump and Compacting Factor Tests Results

Grade of Concrete	Designation	W/C	Slump (mm)	Compacting Factor
M10	Conventional Concrete	0.3	120	0.80
M10	Self-Curing Concrete	0.3	185	0.80
M20	Conventional Concrete	0.6	85	0.75
M20	Self-Curing Concrete	0.6	90	0.70
M30	Conventional Concrete	0.40	900	0.75
M30	Self-Curing Concrete	0.40	25	0.85

Non-Destructive Test

To determine the compressive strength of the concrete, the Schmidt rebound hammer test was conducted. The test was carried out with the rebound hammer positioned vertically on a 190 mm cube specimen.

Compression and Split Tensile Strength

Cubes with dimensions of 175 mm x 175 mm and cylinders with a 150 mm diameter were cast for both self-curing and conventional concrete. An 25 mm diameter steel tamping rod, 700 mm in length, was used to compact each layer with 50 blows. The conventional specimens were allowed to dry for 48 hours after casting. In accordance with the procedure, water was sprinkled at regular intervals on both the cubes and the cylinders. For the self-curing specimens, no external curing, such as sprinkling, was applied. Strength-related tests were conducted on both types of specimens after 4, 8, and 30 days.

Water Absorption Test

The cylinder specimens were cured by immersion for 120 days after casting. After curing, the specimens were dried at approximately 100°C for 36 hours until their mass stabilized, which was then used to determine the dry weight of the cylinder. The cylinders were subsequently

submerged in hot water at around 120°C for 6 hours, and their weight was recorded as the wet weight (W2). The water absorption percentage was calculated by subtracting the dry weight (W1) from the wet weight (W2), and then dividing the result by the dry weight (W1).

Water Sorptivity Test/Durability Test

A water sorptivity test was performed to assess the rate of water absorption. Cylinders with dimensions of 1000 mm in diameter and 50 mm in height were used for both conventional and self-curing concrete. The specimens were dried for 48 hours at 120°C and then allowed to cool in dry conditions for an additional 36 hours. For the test, one circular surface of the specimen was placed in contact with water at a 10 mm depth, while the rest of the specimen was coated with a high-quality water proofer to ensure a unidirectional flow of water through the concrete. The test was carried out on both types of specimens at 30 days of age, with measurements taken at intervals of 50,100, 150, 200 minutes to evaluate the water absorption rate.

RESULTS

The results are as follows;

Table 4
NDT for 5 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	16	10	9
Cylinder	11	09	8

For the NDT test on M10 concrete at 5 days of age, the test results for the cubes were as follows: self-cured specimens had a value of 16, fully-cured specimens had a value of 10, and sprinkler-cured specimens had a value of 9. For the cylinders, the results were: self-cured specimens had a value of 11, fully-cured specimens had a value of 09, and sprinkler-cured specimens had a value of 8.

Table 5
NDT for 5 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	15	10	09
Cylinder	13	10	09

For the NDT test on M20 concrete at 5 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 15, fully-cured specimens recorded a value of 10, and sprinkler-cured specimens recorded a value of 09. For the cylinders, the results were: self-cured specimens recorded a value of 13, fully-cured specimens recorded a value of 10, and sprinkler-cured specimens recorded a value of 9.

Table 6
NDT for 5 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	17	14	09
Cylinder	14	12	7

For the NDT test on M30 concrete at 5 days of age, the test results for the cubes were as follows: self-cured specimens showed a value of 17, fully-cured specimens showed a value of 14, and sprinkler-cured specimens showed a value of 09. For the cylinders, the results were: self-cured specimens showed a value of 14, fully-cured specimens showed a value of 12, and sprinkler-cured specimens showed a value of 7.

Table 7
NDT for 10 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	22	21	17
Cylinder	19	18	15

For the NDT test on M10 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens showed a value of 22, fully-cured specimens showed a value of 21, and sprinkler-cured specimens showed a value of 17. For the cylinders, the results were: self-cured specimens showed a value of 19, fully-cured specimens showed a value of 18, and sprinkler-cured specimens showed a value of 15.

Table 8
NDT for 10 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	28	22	21
Cylinder	20	18	20

For the NDT test on M20 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 28, fully-cured specimens recorded a value of 22, and sprinkler-cured specimens recorded a value of 21. For the cylinders, the results were: self-cured specimens recorded a value of 20, fully-cured specimens recorded a value of 18, and sprinkler-cured specimens recorded a value of 20.

Table 9
NDT for 10 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	20	13	12
Cylinder	15	11	9

For the NDT test on M30 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 20, fully-cured specimens recorded a value of 13, and sprinkler-cured specimens recorded a value of 12. For the cylinders, the results were: self-cured specimens recorded a value of 15, fully-cured specimens recorded a value of 11, and sprinkler-cured specimens recorded a value of 9.

Table 10
NDT for 30 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	48	36	39
Cylinder	33	32	33

For the NDT test on M10 concrete at 28 days of age, the test results for the cubes were as follows: self-cured specimens showed a value of 48, fully-cured specimens showed a value of 36, and sprinkler-cured specimens showed a value of 39. For the cylinders, the results were: self-cured specimens showed a value of 33, fully-cured specimens showed a value of 32, and sprinkler-cured specimens showed a value of 33.

Table 11
NDT for 30 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	50	36	42
Cylinder	40	38	40

For the NDT test on M20 concrete at 30 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 50, fully-cured specimens recorded a value of 36, and sprinkler-cured specimens recorded a value of 42. For the cylinders, the results were: self-cured specimens recorded a value of 40, fully-cured specimens recorded a value of 38, and sprinkler-cured specimens recorded a value of 40.

Table 12
NDT for 30 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	47	40	36
Cylinder	43	35	32

For the NDT test on M30 concrete at 30 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 47, fully-cured specimens recorded a value of 40, and sprinkler-cured specimens recorded a value of 36. For the cylinders, the results were: self-cured specimens recorded a value of 43, fully-cured specimens recorded a value of 35, and sprinkler-cured specimens recorded a value of 32.

Compressive Strength for 5 Days, 10 Days, and 30 Days for M10, M20, and M30

Table 13
Compressive Strength for 5 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	10	13	12
Cylinder	09	09	08

For the compressive strength test, the test results for the cubes were as follows: self-cured specimens had a value of 10, fully-cured specimens had a value of 13, and sprinkler-cured specimens had a value of 12. For the cylinders, the results were: self-cured specimens had a value of 09, fully-cured specimens had a value of 09, and sprinkler-cured specimens had a value of 08.

Table 14
Compressive Strength for 5 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	15	12	14
Cylinder	12	08	13

For the compressive strength test on M20 concrete at 5 days of age, the test results for the cubes were as follows: self-cured specimens had a value of 15, fully-cured specimens had a value of 12, and sprinkler-cured specimens had a value of 14. For the cylinders, the results were: self-cured specimens had a value of 12, fully-cured specimens had a value of 08, and sprinkler-cured specimens had a value of 13.

Table 15
Compressive Strength for 5 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	20	22	21
Cylinder	18	18	13

For the compressive strength test on M30 concrete at 5 days of age, the test results for the cubes were as follows: self-cured, fully-cured, and sprinkler-cured specimens all had a value of 20, 22, and 21 respectively. For the cylinders, the results were: self-cured and fully-cured specimens each had a value of 18, while sprinkler-cured specimens had a value of 13.

Table 16
Compressive Strength for 10 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	14	17	17
Cylinder	15	15	11

For the compressive strength test on M10 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens had a value of 14, fully-cured specimens had a value of 17, and sprinkler-cured specimens had a value of 17. For the cylinders, the results were: self-cured and fully-cured specimens both had a value of 15, while sprinkler-cured specimens had a value of 11.

Table 17
Compressive Strength for 10 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	29	29	31
Cylinder	24	23	30

For the compressive strength test on M20 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens had a value of 29, fully-cured specimens had a value of 29, and sprinkler-cured specimens had a value of 31. For the cylinders, the results were: self-cured specimens had a value of 24, fully-cured specimens had a value of 23, and sprinkler-cured specimens had a value of 30.

Table 18
Compressive Strength for 10 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	31	27	30
Cylinder	29	25	26

For the compressive strength test on M30 concrete at 10 days of age, the test results for the cubes were as follows: self-cured specimens had a value of 31, fully-cured specimens had a value of 27, and sprinkler-cured specimens had a value of 30. For the cylinders, the results were: self-cured specimens had a value of 29, fully-cured specimens had a value of 25, and sprinkler-cured specimens had a value of 26.

Table 19
Compressive Strength for 30 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	42	44	51
Cylinder	36	39	45

For the compressive strength test on M10 concrete at 30 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 42, fully-cured specimens recorded a value of 44, and sprinkler-cured specimens recorded a value of 51. For the cylinders, the results were: self-cured specimens recorded a value of 36, fully-cured specimens recorded a value of 39, and sprinkler-cured specimens recorded a value of 45.

Table 20
Compressive Strength for 30 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	44	47
Cylinder	38	36	42

For the compressive strength test on M20 concrete at 30 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 44, fully-cured specimens recorded a value of 44, and sprinkler-cured specimens recorded a value of 47. For the cylinders, the results were: self-cured specimens recorded a value of 38, fully-cured specimens recorded a value of 36, and sprinkler-cured specimens recorded a value of 42.

Table 21
Compressive Strength for 30 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	44	50	51
Cylinder	44	43	47

For the compressive strength test on M30 concrete at 30 days of age, the test results for the cubes were as follows: self-cured specimens recorded a value of 44, fully-cured specimens recorded a value of 50, and sprinkler-cured specimens recorded a value of 51. For the cylinders, the results were: self-cured specimens recorded a value of 44, fully-cured specimens recorded a value of 43, and sprinkler-cured specimens recorded a value of 47.

Split Tensile Strength for Cylinder for 5 Days, 10 Days, and 30 Days, for M10, M20, and M30

Table 22
Split Tensile Strength for Cylinder 5 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	0.6	0.8	1.1
Cylinder	0.6	0.6	0.6

For the split strength test of M10 concrete at 5 days of age, the test statistics for the cubes are as follows: 0.6 for self-cured, 0.8 for fully-cured, and 1.1 for sprinkler-cured. For the cylinders, the test statistics are 0.6 for self-cured, 0.6 for fully-cured, and 0.6 for sprinkler-cured.

Table 23

Split Tensile Strength for Cylinder 10 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.3	1.5	1.7
Cylinder	1.2	1.2	1.1

For the split strength test of M10 concrete at 10 days of age, the test statistics for the cubes are 1.3 for self-cured, 1.5 for fully-cured, and 1.7 for sprinkler-cured. For the cylinders, the test statistics are 1.2 for self-cured, 1.2 for fully-cured, and 1.1 for sprinkler-cured.

Table 24

Split Tensile Strength for Cylinder 30 Days- M10

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	3.2	3.5	3.6
Cylinder	2.7	3.1	2.9

For the split strength test of M10 concrete at 30 days of age, the test statistics for the cubes are 3.2 for self-cured, 3.5 for fully-cured, and 3.6 for sprinkler-cured. For the cylinders, the test statistics are 2.7 for self-cured, 3.1 for fully-cured, and 2.9 for sprinkler-cured.

Table 25

Split Tensile Strength for Cylinder 5 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.3	0.9	1.1
Cylinder	0.8	0.8	1.1

For the split strength test of M20 concrete at 5 days of age, the test statistics for the cubes are 1.3 for self-cured, 0.9 for fully-cured, and 1.1 for sprinkler-cured. For the cylinders, the test statistics are 0.8 for self-cured, 0.8 for fully-cured, and 1.1 for sprinkler-cured.

Table 26

Split Tensile Strength for Cylinder 10 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	1.6	1.2	1.2
Cylinder	1.4	1.1	1

For the split strength test of M20 concrete at 10 days of age, the test statistics for the cubes are 1.6 for self-cured, 1.2 for fully-cured, and 1.2 for sprinkler-cured. For the cylinders, the test statistics are 1.4 for self-cured, 1.1 for fully-cured, and 1 for sprinkler-cured.

Table 27

Split Tensile Strength for Cylinder 30 Days- M20

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.4	2.3	2
Cylinder	2.4	2.1	1.9

For the split strength test of M20 concrete at 30 days of age, the test statistics for the cubes are 2.4 for self-cured, 2.3 for fully-cured, and 2 for sprinkler-cured. For the cylinders, the test statistics are 2.4 for self-cured, 2.1 for fully-cured, and 1.9 for sprinkler-cured.

Table 28

Split Tensile Strength for Cylinder 5 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.7	2.4	2.8
Cylinder	2.2	2.2	2.1

For the split strength test of M30 concrete at 5 days of age, the test statistics for the cubes are 2.7 for self-cured, 2.4 for fully-cured, and 2.8 for sprinkler-cured. For the cylinders, the test statistics are 2.2 for self-cured, 2.2 for fully-cured, and 2.1 for sprinkler-cured.

Table 29

Split Tensile Strength for Cylinder 10 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.8	2.9	2.6
Cylinder	2.2	2.2	2.1

For the split strength test of M30 concrete at 10 days of age, the test statistics for the cubes are 2.8 for self-cured, 2.9 for fully-cured, and 2.6 for sprinkler-cured. For the cylinders, the test statistics are 2.2 for self-cured, 2.2 for fully-cured, and 2.1 for sprinkler-cured.

Table 30

Split Tensile Strength for Cylinder 30 Days- M30

	Self-Cured	Fully-Cured	Sprinkler-Cured
Cube	2.8	2.4	2.9
Cylinder	2	1.9	1.8

For the split strength test of M30 concrete at 30 days of age, the test statistics for the cubes are 2.8 for self-cured, 2.4 for fully-cured, and 2.9 for sprinkler-cured. For the cylinders, the test statistics are 2 for self-cured, 1.9 for fully-cured, and 1.8 for sprinkler-cured.

CONCLUSION

The results of the non-destructive test (NDT), compression and split tensile strength tests, and water absorption tests conducted at 5, 10, and 30 days for the three concrete grades indicate that self-curing concrete demonstrates superior absorption and strength compared to sprinkler and fully cured concrete. Additionally, the comparison reveals that cube specimens exhibit higher strength than cylindrical specimens across all samples. Our findings align with previous research, confirming that self-curing concrete offers enhanced quality, including greater hardness, durability, and overall performance. Therefore, this study recommends increased adoption of self-curing concrete as a preferable alternative to traditional concrete.

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