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EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF SELF CURING CONCRETE USING POLYETHYLENE GLYCOL WITH PARTIAL REPLACEMENT OF RIVER SAND BY M SAND

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Abstract

Concrete is the most generally utilized material because of its quality, lastingness and sturdiness. The water is being utilized as a part of making solid, its utilization is high in the curing practice. Inadequate curing can severely affect the durability and strength of the concrete. Self-curing or internal curing is a method that provides extra moisture inside the concrete for effective hydration of cement and decreases self-desiccation. The hydration of cement takes place due to the availability of additional internal water through internal reservoirs like light weight aggregate, super absorbent polymers and shrinkage reducing admixture.
The investigation is aimed towards the production of concrete that are equal or superior to traditional form of curing through the addition of self-curing admixture without compromising the strength In this present study, concrete cubes, cylinder and prism were casted to examine the effect of PEG on compressive strength of cube, split tensile strength of cylinder and flexural strength of prism with different proportions of Polyethylene glycol 400 in the order of 0,0.5 %,1% &1.5 % by weight of cement for M 30 grade of concrete and river sand is replaced by M sand in the ratio of 30% ,40% &50 % . From the test results, it was found that 40% M sand and 1% PEG 400 as optimum percentage.

Keywords: Self-curing; Polyethylene Glycol; M Sand: Compressive strength; Split tensile strength; Flexural strength.

1. Introduction

Concrete is the most familiar construction material used in the construction industry globally which requires more water for its production. The property of concrete mainly depends on hydration of cement and microstructure of the hydrated cement. Proper curing is essential to aid the hydration of cement(Gopala Krishna Sastry and Kumar 2018). Improper curing may affect the quality of the concrete (Bashandy, Meleka, and Hamad 2017). Self-curing is the process by which the cement hydrates within the concrete so that no external sources are needed for curing such as water curing (Memon et al. 2018). Self-curing supplies redundant moisture which is more than sufficient for hydration of cement and reduces self-desiccation. Self-curing agents reduces the evaporation of water during hydration of cement (Gopala Krishna Sastry and Kumar 2018). Self-curing concrete reduces autogenous shrinkage and which is responsible for early age cracking(Nduka et al. 2018). Self-curing technique can be adopted in order to ensure the availability of additional internal water for hydration of cement and also mitigates the effect of water loss to surroundings.(Sri Rama Chand et al. 2015)

2. Polyethylene Glycol

Polyethylene glycol (PEG), also identified as Polyethylene

Oxide (PEO) or Polyoxyethylene (POE), is the commercially available Polyether that is used as self-curing agents. PEG, PEO or POE denotes an Oligomer or polymer of Ethylene Oxide. PEG denotes to Oligomers and Polymers of molecular mass below 20,000 g/mol, PEO denotes to Polymers with a molecular mass above 20,000 g/mol, and POE denotes to a Polymer of any molecular mass. PEG and PEO is produced by polymerization of Ethylene Oxide and is available with a molecular weights from 300 g/mol to 10,000,000 g/mol.

Poly Ethylene Glycols (PEGs) are group of water-soluble polymers formed by the extra response of Ethylene Oxide (EO) with Mono Ethylene Glycols (MEG) or diethylene glycol. The summed-up equation for polyethylene glycol is: H(OCH2CH2) n OH, where n: Average number of rehashing ethylene oxide gatherings.

3. Literature review

Ole Mejlhede Jensen, et al, 2001, presents a survey on different methods of achieving internal curing in concrete. Substance with physically adsorbed water such as bentonite clay and super absorbent polymers are reviewed. Perlite, pumice, expanded clay clinker, Stalite, Diatomaceous earth are substances with physically held water. Of all the techniques available internal curing is achieved by incorporating super absorbent polymers and lightweight aggregates only.

Dieb A.S, 2007 studied about the water retention on the concrete mix incorporating self-curing agent. Weight losss with time denotes that water retention in self-curing concrete mix is greater when compared to conventional concrete mixes. Self-curing concrete exhibits better hydration with time under drying condition compared to conventional concrete. transport of water through self-curing concrete is lesser compared to air-cured conventional concrete. Water sorptivity and water permeability of self-curing concrete also decreases with age which indicates the lower permeable pores because of continuous cement hydration.

M.V.Jagannadha Kumar, et.al, 2012 , studied the strength of self-curing concrete with Polyethylene Glycol as a self-curing agent. Increase in percentage of PEG 400 dosage shows increase in workability factors such as slump and compaction factor. It is concluded that the increase in strength was found at 1% addition of PEG 400 for M20 grade of concrete and 0.5% addition of PEG in case of M 40 grade of concrete compared to conventional mix. Self-cured concrete strength is comparable with conventionally water cured concrete

Madduru Sri Rama Chand et.al, 2016 examined the effect of paraffin wax as self-curing agent in self-compacting concrete with different parameters such as curing type, concrete grade (mix proportions), molecular weight and dosage of paraffin wax. It is concluded that compressive strength of self-cured concrete is approximately same as like that of conventionally cured specimens. Also, self-curing agents facilitates better hydration and improves the strength and durability properties of self-compacting concrete.

Gopala krishna sastry et.al, 2018 studied the influence of self-curing agents such as Poly Ethylene Glycol (PEG), Poly Vinyl Alcohol (PVA) and Super Absorbent Polymer (SAP) on M25 grade of concrete. The effect of self-curing agents on strength parameters such as compressive strength, split tensile strength and flexural strength were studied and it is concluded that maximum compressive strength was obtained with PEG 4000 whereas tensile and flexural strength was observed with the use of PEG 6000.it is found that PEG was the most effective self-curing agent compared to Poly Vinyl Alcohol) and Super Absorbent Polymer.

Sudharson G et.al, 2021 studied the effect of self-curing agent PEG 400 on fresh and hardened properties of M 30 grade of concrete and compared with conventional concrete. It is concluded that the increases in dosage of PEG increases the workability of concrete. Compressive strength, split tensile strength and Flexural Strength of self-cured concrete is found to be higher when compared with conventional concrete. Also, the performance of the concrete can be improved with the addition PEG as a self-curing agent.

4. Research significance

Self-curing is the process by which the cement hydrates internally inside the concrete and no external source needed for curing. Frequently concrete under goes extensive self-desiccation, autogenous shrinkage and other properties of concrete can be affected due to improper curing. Self-curing agents such as porous lightweight aggregates, chemicals admixtures, polymers, natural fibers and pozzolanic has ability to withstand high amount of water which reduces the evaporation of water during cement hydration (Memon et al, 2018). The main aim of this investigation is to study the mechanical characteristics of concrete i.e., compressive strength, split tensile strength & flexural strength by varying the percentage of PEG from 0% to 1.5% in the order of 0.5% by weight of cement and fine aggregate is replaced by M sand at 30% ,40%, 50% for M30 grade of concrete.

5. Experimental program

The effect of PEG as a self-curing agent on strength properties of concrete is studied for M30 grade of concrete with different dosage of PEG such as 0.5%,1%,1.5% by weight of cement and by replacing the river sand with M sand at 30%, 40%, 50% and compared with the concrete with conventional water curing.

5.1. Materials used

5.1.1 Cement

Cement utilized as a part of the examination was 53 grade ordinary Portland cement affirming IS: 12269: 2013.The physical properties of cement were tested as per IS 4031-1988 and tabulated in table 1

Table 1 Properties of Cement

Properties	Result
Fineness of cement	1%
Consistency of cement	33%
Initial setting time	90 min
Final setting time	320 min

5.1.2 Fine Aggregate

5.1.2.1 River Sand

Sand or stone dust and its size is limited to 4.75mm gauge, i.e., passing through 4.75mm IS sieve but retained on 75-micron sieve according to the IS: 383–2016 code recommendations are used for the experiment. The properties of sand used in this experiment is tabulated in table 2

Table 2 Properties of River Sand

Properties	Result
Specific gravity	2.67
Bulk density	1765.02 kg/m3
Particle size distribution	zone II

5.1.2.2 M sand

Manufactured sand is a purpose-made crushed fine aggregate and is produced from a suitable source material. The quality of the river sand depends normally on its source but mostly it varies a lot. Therefore, it is essential to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. The physical properties of M sand were tested as per IS: 383: 2016 and tabulated in the table 3

Table 3 Properties of M Sand

Properties	Result
Specific gravity	2.61
Bulk density	1789.12 kg/m3
Particle size distribution	zone II

5.1.3 Coarse aggregate:

Crushed stones of size 20mm is used as a coarse aggregate. The coarse aggregate satisfying the properties according to IS: 383-2016 was used. The physical properties of coarse aggregate were tested as per IS: 383: 2016 and tabulated in table 4

Table 4 Properties of Coarse Aggregate

Properties	Result
Specific gravity	2.83
Bulk density	1812.5 kg/m3

5.1.4 Water

Potable water is used for the experimental work for preparing the concrete and it should be free from sugar, salt, organic matter etc. confirming to IS 456:2000.

5.1.5 Polyethylene Glycol

Polyethylene glycol is non-lethal, unscented, unbiased, greasing up, non-unstable and non- disturbing, is utilized as a part of an assortment of pharmaceuticals. The physical properties of Polyethylene glycol obtained from the manufacturer is given in table 5

Table 5 Physical Properties of PEG 400

Properties	Result
Appearance	Clear liquid or white solid.
Odour	Mild odour.
Solubility	Soluble in water.
Density	1.1 to 1.2 (increases as molecular weight increases)
Boiling Point	Min. 250°C (1013 hPa)
Vapor Pressure (mm Hg)	Vapor pressure is very low; as molecular weight increases, vapor pressure decreases

6. Mixing and proportioning

All the dry constituents like cement, fine aggregates (both river sand and M sand) are mixed dry until thorough blending is attained. Coarse aggregate is added and mixed till uniform distribution of mix is attained. Two third of water is added to the concrete mix and polyethylene glycol is added with the remaining one third of water and is mixed continuously until the mixture attains homogeneous and desired consistency. The PEG is added at 0%, 0.5%, 1%, 1.5% by the weight of cement and river sand is replaced by 30%, 40% and 50% M Sand and are tested for Compressive strength, Split tensile Strength and Flexural Strength of concrete specimens with and without PEG. M30 grade of concrete is designed as per IS 10269:2009. The various mix combination is shown in Table 6.

Table 6. Various mix combination

Mix ID	Mix
A1	30% M sand
A2	30% M sand + 0.5% PEG
A3	30% M sand+ 1.0 % PEG
A4	30% M sand + 1.5% PEG
B1	40% M sand
B2	40% M sand + 0.5% PEG
B3	40% M sand+ 1.0 % PEG
B4	40% M sand + 1.5% PEG
C1	50% M sand
C2	50% M sand + 0.5% PEG
C3	50% M sand+ 1.0 % PEG
C4	50% M sand + 1.5% PEG

7. Experimental Work

The test specimens were cast in cast-iron moulds. The inside the mould was coated with oil to facilitate the easy removal of specimens. Hand mixing was done and the dry mix was prepared by mixing cement, rivers sand, M sand, coarse aggregate. The self-curing agent was added along with water and then added to the dry mix. The constituents were mixed homogenously. Specimens used in this work were cubes, cylinders, and beams. 150mmx150mmx150mm cubes used for compressive strength, 150mm Diameter and 300mm Height cylinders for split tensile strength, 500mmx100mmx100mm beams used for calculating flexural strength.

Totally 36 no's of cubes, 36 no's of cylinders and 36 no's of prism were casted and tested for compressive strength of cube, split tensile strength of cylinder and flexural strength of prism at the age of 28 days. The tests are carried out as per IS 516- 1959.

7.1 Compressive strength test

The cube specimens were tested on compression testing machine. The size of the cube specimen was 150mmx150mmx150mm. Place the specimen centrally on the compression testing machine and load was applied continuously and uniformly on the surface perpendicular to the direction of tamping. The load is increased and the maximum load at which the specimen fails is recorded.

Compressive strength was computed using the following formula,

Compressive strength = (LOAD (P) / AREA (A) x 1000

Where, P = Load in KN
A = Area of the cube surface = 150mm x150 mm.
The test results are tabulated in Table 7

Table 7 Strength test results

S. No	Mix		Average Compressive Strength (N/mm^2)	Average Split Tensile Strength (N/mm^2)	Average Flexural Strength (N/mm^2)
	Percentage replacement of river sand with M sand	Percentage addition of PEG by weight of cement	28 days	28 days	28 days
1	30	0	31.76	3.4	5.4
2		0.5	29.72	3.2	5.2
3		1	22.8	3.3	4.96
4		1.5	18.76	2.9	4.1
5	40	0	34.75	3.51	6.66
6		0.5	29.5	2.9	5.7
7		1	34.8	3.5	6.67
8		1.5	30.88	2.7	4.83
9	50	0	33.4	3.3	5.6
10		0.5	19.61	2.8	4.92
11		1	27.83	3	4.97
12		1.5	23.10	2.6	3.95

The test results of Compressive strength of cube at 28 days is graphically represented in Fig 1

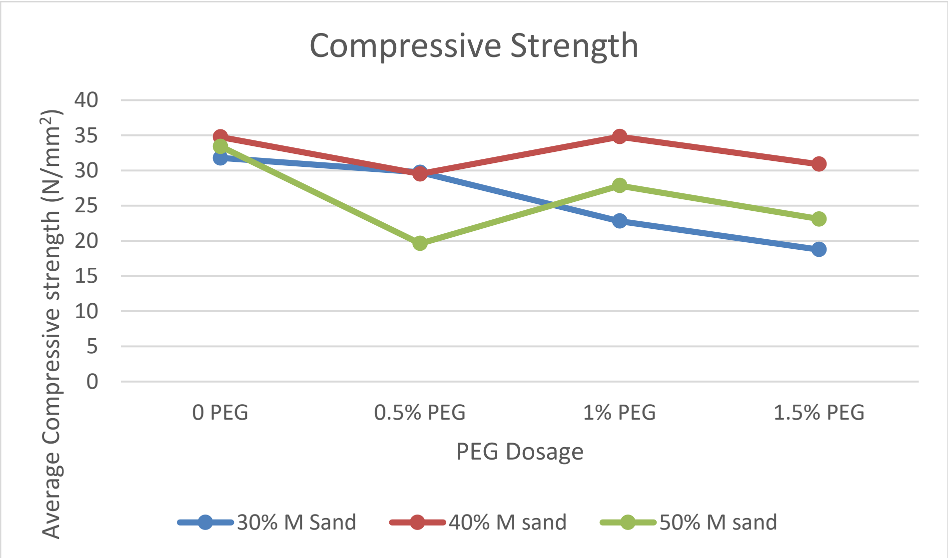

Fig 1 Compressive strength of cubes at 28days

At 0.5% addition of PEG the compressive strength of self-curing concrete decreases compared to concrete without PEG in all the three cases with 30%, 40% and 50% replacement of river sand with M sand. But in the case of 40% M sand and 1% PEG addition, the compressive strength of self-cured concrete shows comparative strength compared to 0.5% and 1.5% dosage of PEG.

7.2.2 Split tensile strength test

The cylinder specimens are tested in a compression testing machine. The load is increased continuously at a constant rate until the specimen breaks down. The size of the cylinder specimen is of 150 mm diameter and 300 mm length. Apply the load continuously and record the maximum load carried by the specimen. Split tensile strength was computed using the following formula,

Split tensile strength = (2P/ ΠDL)

Where, P = Load in KN

Π = 3.142

D = Diameter of cylindrical Specimen = 150 mm

L = Length of cylindrical Specimen = 300 mm

The test results of Split tensile strength of cylinder at 28 days is graphically represented in Fig 2

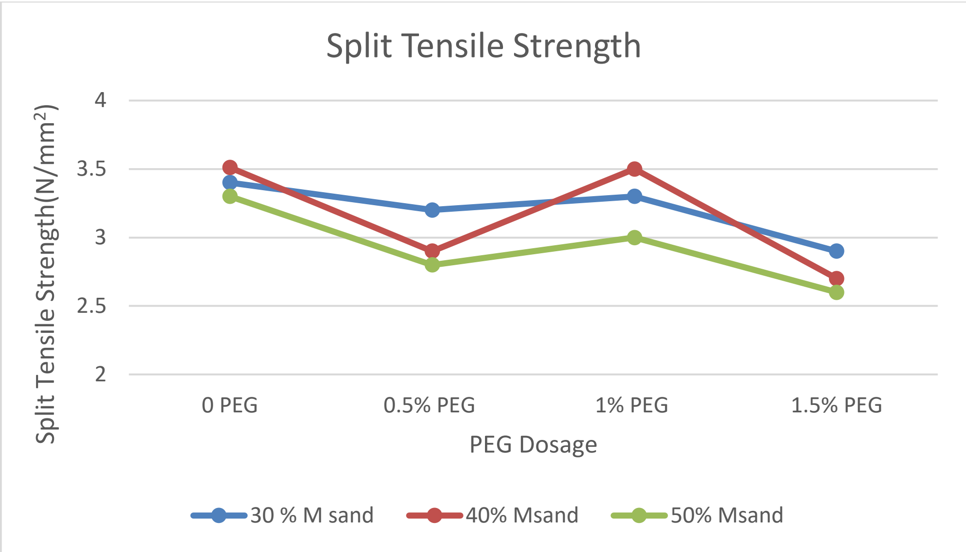

Fig 2. Split tensile strength of concrete at 28 days

The Split tensile strength of concrete for 0.5% addition of PEG decreases compared to concrete without PEG with 30%, 40% and 50% replacement of river sand with M sand. But in the case of 40% M sand and 1% PEG addition, the compressive strength of self-cured concrete shows same strength compared to 0.5% and 1.5% dosage of PEG.

7.2.3 Flexural strength test

Flexural strength of the concrete was measured by the prism specimens of size 100mm x 100mm x 400mm and tested as per IS: 516-1959. The testing machine is provided with two steel rollers of 38mm in diameter on which the specimen is placed and these rollers are kept at the distance of 40mm from centre to centre. The loading arrangement is symmetrical two-point loading. Flexural strength was computed using the following formula,

Flexural strength = [(PL /BD^2) x 1000]

Where, P = Load in KN

L = Effective length of beam = 400 mm

B = Width of the beam specimen = 100 mm

D = Depth of the beam specimen = 100 mm

The test results of flexural strength of prism are represented graphically in Figure 3

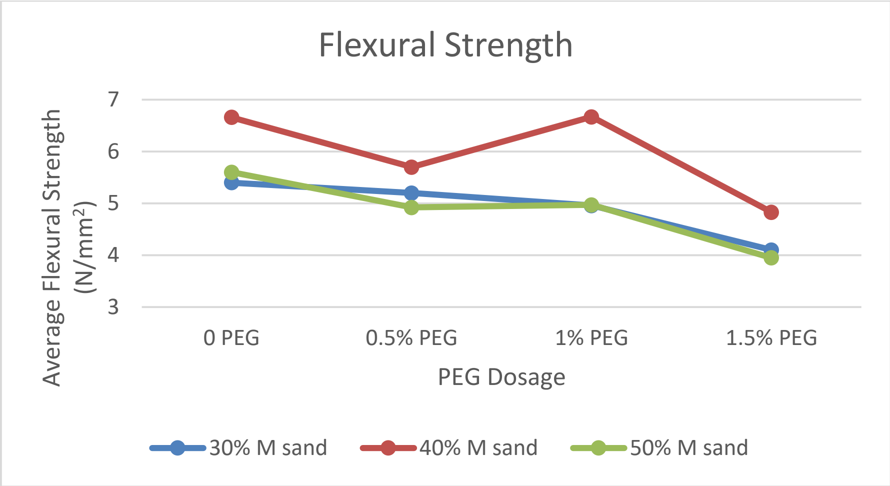

Fig 3 Flexural strength of concrete at 28 days

Flexural strength of self-cured concrete is approximately equal to the Flexural strength of conventionally cured concrete in case of 40% replacement of river sand with M sand and addition of 1% PEG after that increased addition of PEG dosages reduces the flexural strength.

8. Conclusion

Based on the experimental study carried out on self-curing concrete considering the replacement of river sand by M sand and with varying dosages of PEG 400, the following observations were made

1. In most cases, the conventional mix obtained greater results than mix with PEG but in case of 40%M sand with 1% PEG gets nearly equal strength.
2. Increase in dosage of PEG above 1%, slight reduction in strength is found.
3. When 40% of river sand is replaced by M sand, the strength was found to be increased when compared to 30% & 50% replacements.
4. The optimum dosage of PEG is found to be 1% and replacements of river sand by M sand is 40% for M30 grade of concrete.

References

1. BASHANDY, ALAA A., NAGEH N. MELEKA, AND MOHAMED M. HAMAD. 2017. Comparative Study on the Using of PEG and PAM as Curing Agents for Self-Curing Concrete, Challenge Journal of Concrete Research Letters 8 (1), p.1-10
2. LAVANYA PRABHA, S., GOPALAKRISHNAN, M., NEELAMEGAM, M.: Development of high-strength nano-cementitious composites using copper slag, ACI Materials Journal, 2020, 117(4), pp. 37–46.
3. MOHAN, A , VIJAYAN, D.S. , REVATHY, J., PARTHIBAN, D., VARATHARAJAN, R.: Evaluation of the impact of thermal performance on various building bricks and blocks: A review, Environmental Technology and Innovation, 2021, 23, 101577(2021)
4. NDUKA, DAVID O., JOHN O. AMEH, OPEYEMI JOSHUA, AND RAPHEAL OJELABI. 2018. Awareness and Benefits of Self-Curing Concrete in Construction Projects: Builders and Civil Engineers Perceptions, Buildings, 8 (8)
5. GOPALAKRISHNAN, R., MOHAN, A., SANKAR, L. P., & VIJAYAN, D. S. (2020). Characterisation On Toughness Property Of Self-Compacting Fibre Reinforced Concrete. In Journal of Environmental Protection and Ecology (Vol. 21, Issue 6, pp. 2153–2163).
6. LAVANYA PRABHA, S., DATTATREYA, J.K., NEELAMEGAM, M., SESHAGIRI RAO, M.V., Investigation of bolted RPC plate under direct tension, Journal of Structural Engineering (Madras), 2009, 36(5), pp. 333–341
7. SRI RAMA CHAND, MADDURU, PANCHARATHI RATHISH KUMAR, PALLAPOTHU SWAMY NAGA RATNA GIRI, GARJE RAJESH KUMAR, AND MUPPARISETTY V. KRISHNA RAO. 2015. Influence of Paraffin Wax as a Self-Curing Compound in Self-Compacting Concretes, Advances in Cement Research, September, p. 1–11.
8. MOHAN, A., TABISH HAYAT, M.: Characterization of mechanical properties by preferential supplant of cement with GGBS and silica fume in concrete, Materials Today: Proceedings, 2020, 43, pp. 1179–1189.
9. JENSEN, OLE MEJLHEDE, AND PER FREIESLEBEN HANSEN. 2001. Water-Entrained Cement-Based Materials - I. Principles and Theoretical Background, Cement and Concrete Research 31 (4), p. 647–54.
10. DHARMAR, S., GOPALAKRISHNAN, R., MOHAN, A.: Environmental effect of denitrification of structural glass by coating TiO2, Materials Today: Proceedings, 2020, 45, pp. 6454–6458
11. KIRUTHIKA, C., LAVANYA PRABHA, S., NEELAMEGAM, M.: Different aspects of polyester

polymer concrete for sustainable construction Materials Today: Proceedings, 2020, 43, pp. 1622–1625
12. PRABHA, S.L., SURENDAR, M., NEELAMEGAM, M.: Experimental investigation of eco-friendly mortar using industrial wastes ,Journal of Green Engineering, 2019, 9(4), pp. 626–637
13. M. THOLKAPIYAN, A.MOHAN, VIJAYAN.D.S: A survey of recent studies on chlorophyll variation in Indian coastal waters, IOP Conf. Series: Materials Science and Engineering 993 (2020) 012041, 1-6.
14. GOPALA KRISHNA SASTRY, K. V.S., AND PUTTURU MANOJ KUMAR. 2018. Self-Curing Concrete with Different Self-Curing Agents, IOP Conference Series: Materials Science and Engineering 330 (1).
15. MEMON, RUHAL PERVEZ, ABDUL RAHMAN ABDUL, ABDULLAH ZAWAWI AWANG, GHASAN FAHIM HUSEIEN, AND UROOSA MEMON. 2018. A Review: Mechanism, Materials and Properties of Self-Curing Concrete, ARPN Journal of Engineering and Applied Sciences 13 (24), p. 9397–9409.
16. KUMAR, JAGANATH, AND KODUKULA JAGANNADHA RAO. 2012. Strength Characteritics of Self Curing Concrete 1 (1), p. 51–57.
17. CHAND, MADDURU SRI RAMA, PANCHARATHI RATHISH KUMAR, PALLAPOTHU SWAMY NAGA RATNA GIRI, GARJE RAJESH KUMAR, AND MUPPARISETTY V.KRISHNA RAO. 2016. Influence of Paraffin Wax as a Self-Curing Compound in Self-Compacting Concretes, Advances in Cement Research 28 (2), p. 110–20.
18. SUDHARSON, G, M KALPANA, D ANBURAJA, AND M G PRATHAP. 2021. PEG 400 Effect on Properties of Self Curing Concrete, IOP Conference Series: Materials Science and Engineering 1026 (1), p. 012014.