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Mechanical properties of Polypropylene Fibre reinforced concrete for M25 mixes.

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ABSTRACT
This paper focuses on experimental study in the behaviour of polypropylene fibre reinforced concrete. The polypropylene (PP) fibres were mixed into the concrete in the form of reinforcement into the concrete with uniform orientation of the fibres. By adding polypropylene(PP) fibre in concrete the crack formation reduces. Polypropylene (PP) fibre is also heat resistant that is advantageous over polyethylene fibre.The tests on the concrete were conducted after adding polypropylene (PP) fibres into the concrete in different contents, i.e.; 1.5%, 1.75%, 1.85% of the cement mass. Polypropylene is one of the cheapest and abundantly available polymers. Chemical inertness makes the polypropylene fibers resistant to most chemicals. In this paper the relationship between cube compressive strength and cylinder split tensile strength for conventional and polypropylene fibre reinforced concrete were established and compared with standards. The study prompted the substantial improvement in compressive and tensile strength for concrete mixes reinforced with polypropylene fibres. Use of polypropylene (PP) fibre and E waste in M25 concrete increases the flexible strength, prevents the crack an also increases the impact strength of concrete.Positioned on test results obtained 1.5% of polypropylene (PP) fibre addition found to be optimal percentage of polypropylene (PP) fibers. The optimal percentage of polypropylene (PP) fibre 1.5% is used in the experiment. M25 grade of concrete achievement is assessed with respect to slump test, compressive strength, split tensile strength and flexural strength.
KEY WORDS :- polypropylene (PP) fibre reinforced concrete, compressive strength, fibre, tensile strength, flexural strength.

1. Introduction :-

Concrete with modified mechanical properties is termed as Fibre reinforced concrete and is normally used now a days. Fibres are introduced in concrete to make it fibre reinforced concrete (FRC). The fibres used may be natural, artificial, or waste(Nagarkar P, 1987) [2][6]. Fibre used increases the flexible strength, prevents the crack an also increases the impact strength of concrete(3. Hannant, 1998) [3][8]. By preventing or keeping the crack small in concrete therefore increases the durability of concrete and prevents it from entering the outsidechemicals and hence prevents the concrete from wear also. .There are different types of fibres that can used in the FRC like glass fibres, steel fibres, coconut fibres, polymer fibres(polypropylene fibres)(Kumar, 2016)[31][32][18]. FRC increases various properties of concrete like compressive strength, flexible strength, flexural strength, ductility, high impact loading and higher winding resistance. Dynamic resistance, increases the structural reliability, interruption the crack propagation in the hardened concrete (post-cracking effect) elastic modulus, loss control. The capability of fibre is to diminish cracks at maximum strain and increases its stiffness also continuity which reduces transport of sharp material into concrete(Manjunath, 2016)[32][5][16]. Addition of polypropylene fibres decreases the unit weight of concrete and increases its strength. While as the purpose of steel reinforcement in the concrete is to enhance load bearing capacity while fibre in concrete help crack establishment(Priti A. Patel., 2012) [8][5]13]. FRC is used as light weight Concrete because of its less self-weight. Aspect rate is the parameter that describes fibres and is defined as length by borderline rate of fibre. Generally aspect rate lies between 40 to 160 but it may vary that's depending on fibre type(Kale, 2013) [25][4][10]. Researchers have

studied cement concrete and polypropylene (PP) fibre reinforced concrete and have investigated the effect of fibres on the mechanical properties of concrete. However considering the polypropylene (PP) fibres by 1.5%, 1.75%, 1.85% of the cement mass in M25 grade of concrete is an innovative approach(mohd auqib, 2023)[21]. The objective of study is to analyse and determine the effects of polypropylene fibres (PPF) on various grades of concrete and to make a comparative study of compressive and split tensile strength of various grades of concrete using PP fibres.

2. Experimental program

2.1 Materials

A. Cement

Cement is a general term for all types of bonds, but in a more precise sense, it refers to the binders used in construction and civil engineering organizations. Ordinary Portland cement of 43 grade having specific gravity 2.7 is used. The cement has been tested for various properties as per IS: 4031[22] part 5 and there by confirming to various specifications of IS: 12269[24].

Figure 1 Cement sample.

Table 1 Physical properties of cement

S.no	Name of test	Result obtained	IS: 12269-1987 specification
1	Initial setting time	45 minutes	30 minutes
2	Final setting time	487 minutes	600 max
3	Soundness	2.52	10mm (max)
4	Specific gravity	2.7	-
5	Consistency	32%	-
6	Fineness	96%	225 m^2/kg (min)
7	Compressive strength		
	7 days	44 Mpa	37 Mpa
	8 days	62 Mpa	53 Mpa

B. Coarse Aggregate

Crushed angular aggregate of size 20mm having specific gravity 2.7 and fineness modulus of 4.05 confirming to IS: 383[25] is used.

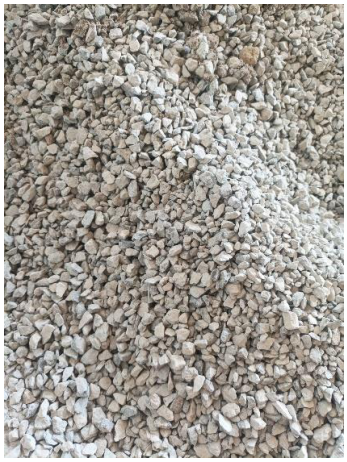


Figure 2 Coarse aggregate sample.

Table 1.2Results of sieve analysis of coarse aggregate

S no	Sieve analysis	Percentage retained (%)	Percentage cumulative (%)	Percentage passing (%)	Limits as per IS code
1	40mm	0	0.0	100	100
2	20mm	8	8.00	92	85-100
3	10mm	83.32	91.32	8.68	0-20
4	4.75mm	2.48	93.8	6.2	0.5
5	Pan	6.2	100	0	-

Table 1.2.1Coarse aggregate test results

S no	Properties	Results	Limits as per IS code
1	Specific gravity	2.62	2.6-2.8
2	Fineness modulus	2.98	2.9-3.2

C. Fine Aggregate

Natural sand is used with maximum size 4.75mm as a fine aggregate. Sand used in this study is of zone2.

Figure 3 Fine aggregate sample.

Table 1.3Sieve analysis of fine aggregate

S no	Sieve size (mm)	Percentage retained (%)	Cumulative percentage retained (%)	Percentage of passing (%)	Limits as per IS code
1	4.75 mm	-		98.90	90-100
2	2.36mm	-	4.60	95.40	75-100
3	1.18 mm	31.20	35.80	64.20	55-90
4	600 micron	19.90	55.70	44.30	35-59
5	300 micron	26.20	81.90	18.10	8-30
6	150 micron	10.30	92.20	7.80	0-10
7	Pan	7.80	10.00	-	-

Table 1.3.1Fine aggregates test results

S no	Properties	Results	Limits as per IS code
1	Specific gravity	2.45	2.3-2.7
2	Fineness modulus	1.12	1-3.37

D. Polypropylene (PP) fibres

Polypropylene (PP) fibre are used and these are cutted into the pieces of size 30 to 35 mm.

Figure 4 Polypropylene sample.

Table 1.4Properties of polypropylene (PP) fibre

Length of fibre	30-35mm
Width of fibre	1-1.2mm
Aspect ratio	32-35mm

E. Polyvinyl Chloride Fibre (PVC)

PVC cables are used and these PVC cables are cutted into the pieces of size 30mmto 35 mm.

Figure 5 PVC sample.

Table 1.4Properties of polyvinyl chloride (PVC) fibre

Length of fibre	30-35mm
Diameter of fibre	1-1.5mm
Aspect ratio	32-35

Table 1.5Typical properties of macro-polymer fibre.

Elastic modulus	3000-30,000 MPa
Tensile strength	310-705 M/mm^2
Specific gravity	0.93
Design	Even
Length	30-35mm
Cross section	Circular
Diameter	0.45mm
Surface	Smooth
I/D ratio	80-85

2.2 Mix proportions and casting of specimens

In this paper M25 mix were used and the mix ratios are 1:1:2 as per standards of IS: 456 and IS: 10262. For every mix fibre is added by the mass of cement at 1.5%, 1.75% and 1.85%.The different cube and cylinder specimens were casted as per requirements of the code of practices. These specimens were tested after 7 days and 28 days of curing. Six (6) specimens for 0.0 % and three (3) specimens for other volume fractions were casted and tested, the average values of compressive strengths are reported in histogram(10262:2009., 2009)[5].

Figure 6 Mixing of fibre concrete.

The details of castings, fibre addition and mix ratios are given in table 1.6.

TABLE 1.6

Mix	C:S:A	W/C	% fibre added	Cement (kg/m^3)	Sand (kg/m^3)	Aggregate (kg/m^3)
M25	1:1.40:2.50	0.43	0-3	350	492	890

From each concrete mix, 150 mm cube specimens for assessment of compressive strength and 150 mm diameter and 300 mm height cylindrical specimens for split tensile strength were casted from concrete mixes containing fibre and without fibre. The specimens were demoulded after 24 hours of casting. Thereafter, the demoulded specimens were marked for identification and kept submerged in a curing tank at a temperature ($27^0C \pm 2^0C$) till the age of testing.

2.3 Testing methods

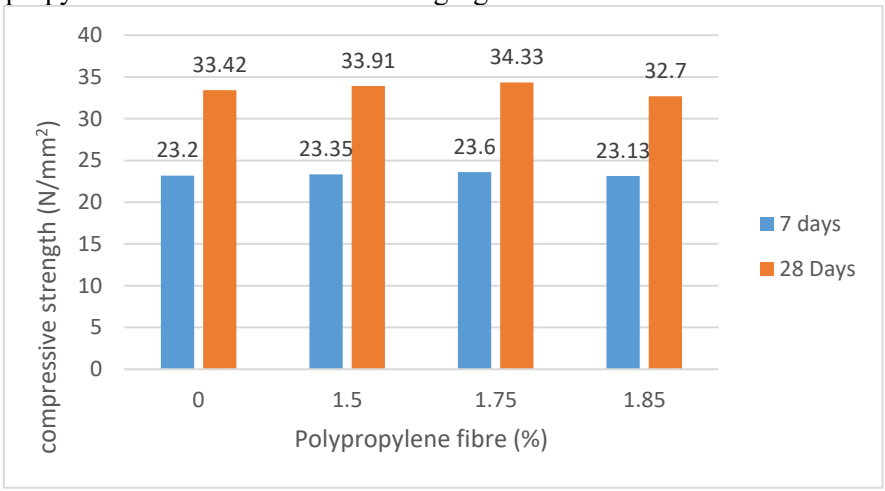
a. Compressive strength

Compressive strength of each concrete mix was determined using compressive testing on cubes and are compared with standard concrete mix at 1.5%, 1.75% and 1.85% fibre and also inter compared with all mixes (1. IS 4031, 1988) [1]. Three specimens of each mix were tested to determine the average compressive strength of concrete mixes at 7 days and 28 days.

Table 1.7 Cube compressive strength of M25 grade of concrete

Designation	Polypropylene (%)	Compressive Strength of M25 grade Of concrete (N/mm^2)			
		7 days		28days	
		P_{exp}	P_{exp}/P_{ref}	P_{exp}	P_{exp}/P_{ref}
M25P0	0	23.20	1.0	33.42	1.0
M25P1.5	1.5	23.35	1.03	33.91	1.02
M25P1.75	1.75	23.6	1.032	34.33	1.025
M25P1.85	1.85	23.13	0.97	32.70	0.96

The compressive strength at 7 days and 28 days of maturity of M25 grade concrete is initially perceived to be increasing up to the addition of 1.75% of polypropylene fibre and then start decreasing with the further upsurge in polypropylene fibre at 1.85%. Graph between compressive strength vs polypropylene fibre is shown in following figure



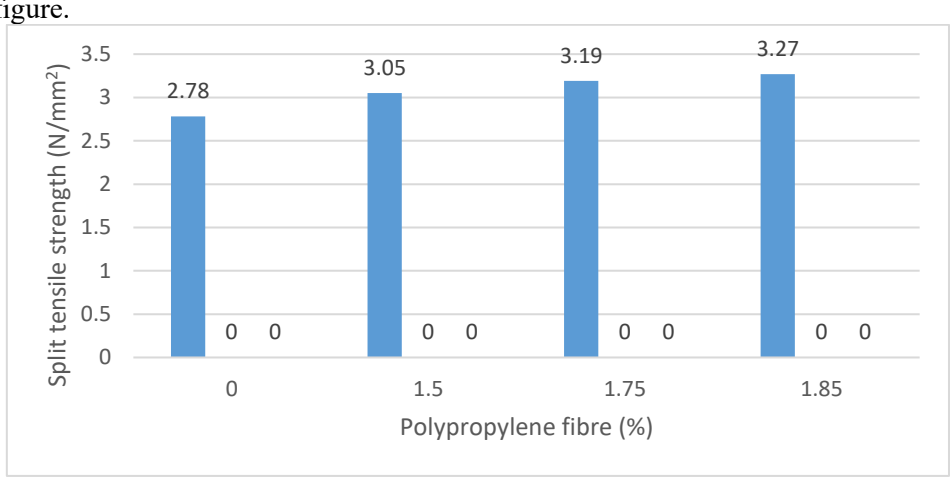
B.Split tensile strength

After finalization of mix proportion of M25 grade concrete, different percentage of polypropylene fibre such as 0%, 1.5%, 1.75% and 1.85% are added and tested for split tensile strength. Concrete cylinder specimens of size 150 mm x 300 mm were casted, cured and tested at 28 days of maturity. The results of split tensile strength at 28 days maturity for M25 grade concrete is tabulated below. Here P_{ref}value is 2.78 N/mm^2.

Table 1.8 Split tensile strength of M25 grade of concrete

Designation	Polypropylene (%)	Split tensile strength of M25 grade of con--crete (N/mm^2)	
		P_{exp}	P_{exp}/p_{ref}
M25P0	0	2.78	1.0
M25P1.5	1.5	3.05	1.11
M25P1.75	1.75	3.19	1.16
M25P1.85	1.85	3.27	1.19

The detected value of splitting tensile strength at 28 days maturity of M25 grade of concrete is observed to be 2.78 N/mm^2 and increased upto 3.27 N/mm^2 with the addition of 1.85% of polypropylene fibre .Graph between split tensile strength vs polypropylene fibre is shown in following figure.



C. Flexural strength of concrete

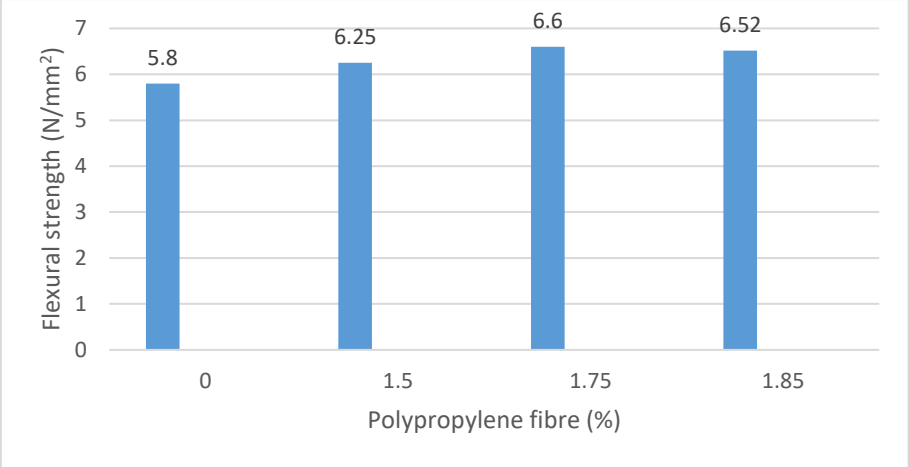
After accomplishment of mix proportion of M25, different proportion of polypropylene (PP) fibre such as 0 %, 1.5 %, 1.75% and 1.85 are added and tested for flexural strength. Concrete prism specimens of size 100 mm x 300 mm were casted, cured and tested at 28 days of maturity. And the loading rate is 0.65 N/mm^2/minute.

The results of flexural strength of M25 grade of concrete after 28 days of maturity is tabulated below.

Table 1.9 flexural strength of M25 grade of concrete

Designation	Polypropylene (%)	Flexural strength of M25 grade of concrete (N/mm^2)	
		P_{exp}	P_{exp}/p_{ref}
M25P0	0	5.8	1.0
M25P1.5	1.5	6.25	1.052
M25P1.75	1.75	6.60	1.95
M25P1.85	1.85	6.52	1.83

The flexural strength at 28 days of maturity of M25 concrete recognized to be 5.9 N/mm^{2}and increased upto 6.60 N/mm^2 with the addition of 1.75% of polypropylene (PP) fibre and then start decreasing with the further upsurge of 1.85% polypropylene fibre upto a value of 6.52 N/mm^2.Graph between flexural strength vs polypropylene fibre is shown in following figure.



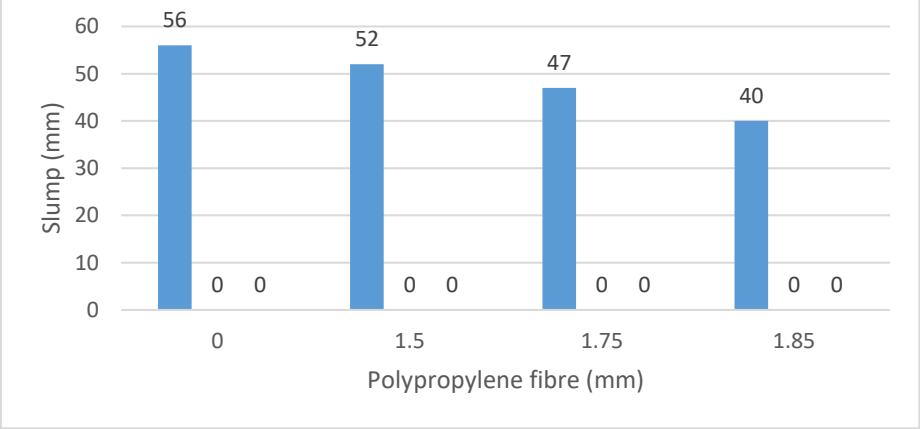
D. Workability of concrete

After finalizing the mix proportion of M25 grade of concrete, different proportion of polypropylene fibre such as 0%, 1.5%, 1.75% and 1.85% were added and tested for workability of concrete by slump test.

Table 1.10 Workability of M25 concrete

Designation	Polypropylene (%)	Workability (mm)
M25P0	0	56
M25P1.5	1.5	52
M25P1.75	1.75	47
M25P1.85	1.85	40

Workability of M25 concrete is recognized to be plunging with the addition of polypropylene (PP) fibre. The slump value was initially recognized as 56 mm for 0% polypropylene (PP) fibre and then start decreasing with the surge in polypropylene (PP) fibre upto 40 mm for M25 grade of concrete for 1.85% of polypropylene (PP) fibre. Graph between slump vs polypropylene (PP) fibre is shown in following figure.



2.4 .Conflict of Interest Statement:

The authors have no competing interests to declare that are relevant to the content of this article.

2.5 Credit Authorship Contribution Statement Shilpa Chauaun: research, conceptualization, validation, formal analysis, visualization, writing — review and editing; Mohd Auqib Makroo, Shilpa Chauhan: review and editing. Mohd Auqib Makroo conceptualization, supervision, visualization, writing — original draft. association with businesses or organizations that could profit or lose financially from the publishing of this study. Every funding source used for this research is openly revealed

2.6 CONCLUSION:-

- On an average to payoff maximum compressive strength with mono-filament macro fibre the superlative dosage be finite 1.5% to 1.75%, after further hike these strength properties decreases.

- The fibres interim as platform between the concrete matrix to disseminate the stresses uniformly thus making the whole matrix resist the deformation.
- Flexural strength shows around 9.5% increment for M25 grade of concrete with the addition of 1.75% of polypropylene (PP) fibre and decreases after further addition.
- The optimal percentage of Polypropylene (PP) fibre we can add is upto 1.75% of cement content both in compressive and split tensile strength. And after 1.75% of polypropylene (PP) fibre compressive and split tensile strength gradually decreases.
- After the addition of 1.75% of polypropylene fibre in M25 concrete it results the reduction of cracks and shrinkage

References

1. IS 4031, "Indian Standard Specification for Physical Test for Hydraulic Cement Determination of Compressive Strength, Bureau of Indian Standards", New Delhi, 1988.
2. Nagarkar P, Tambe S, Pazare D, Study of fibre reinforced concrete; 1987.
3. Hannant, D.J. Durability of polypropylene fibres in Portland cement-based composites: eighteen years of data. Cement and Concrete Research, 1998.
4. Method of test for strength of concrete- IS 516:1959.
5. Guidelines for concrete mix proportioning- IS 10262:2009.
6. M. Alhozaimy, P. Soroushiad n,& F. Mirza, "Mechanical Properties of Polypropylene Fibre Reinforced Concrete and the effects of Pozzolanic Materials", Cement & Concrete Composites.
7. Banthia and R. Gupta, Influence of Polypropylene fibre geometry on plastic shrinkage cracking in concrete.Cement and conceter Research.
8. Priti A. Patel., Dr. Atul K. Desai., and Dr. Jatin A. Desai., "Evaluation Of Engineering Properties for Polypropylene Fibre Reinforced Concrete", International Journal of Advanced Engineering Technology, Vol. 3, Issue 1, January-March 2012, pages 42-45.
9. Dr. T.Ch. Madhavi, L. Swamy Raju, Deepak Mathur, 'Polypropylene Fibre Reinforced Concrete-A Review', International Journal of Emerging Technology and Advanced Engineering', Vol 4, Special Issue 4, June 2014, pages 114-118.
10. IS 10262, "Recommended Guidelines for Concrete Mix Design", Bureau of Indian Standards, New Delhi, 1982.
11. **https://www.powermag.com/advantages-of-fibre-reinforced-concrete/**
12. N Ghosni, B Samali, and K Vessalas, "Evaluation of structural behaviour of polypropylene fiber reinforced concrete beam under cyclic loading", in ST Smith (ed.), 23rd Australasian Conference on the Mechanics of Structures and Materials (ACMSM23), Vol. I, Byron Bay, NSW, Southern Cross University, Lismore, NSW, pp. 319-326, 2014.
13. M. Alhozaimy, P. Soroushiad n,& F. Mirza, "Mechanical Properties of Polypropylene Fiber Reinforced Concrete and the effects of Pozzolanic Materials", Cement & Concrete Composites, Vol. 18, pp. 85-92, 1996.
14. Amsa M and Ariyannan "Experimental Study on Polypropylene Fiber Reinforced Concrete", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 04, 2018.R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
15. Khalid, F.S., Irwan, J.M., Ibrahim, M.W., Othman, N. and Shahidan, S., 2018. Performance of plastic wastes in fiber-reinforced concrete beams. Construction and Building Materials, 183, pp.451-464.
16. Kshitija Nadgouda, "Coconut fibre reinforced concrete", International Journal ofMechanicalAndProductionEngineering,vol.4,2015.
17. Kumar, R.A. and Malik, S.V., 2016. "Experimental study on effective utilization ofe-wasteinconcrete",internationaljournalof innovation technology andresearchIJITR,vol.4,pp.5262-5,2016.
18. Mohod, M.V., "Performance of polypropylene fibre reinforced concrete", IOSRJournalofMechanicalandCivilEngineering,vol.12,pp.28-36,2015
19. Hsie, M., Tu, C. and Song, P.S., 2008. Mechanical properties of polypropylene hybrid fiber-reinforced concrete. Materials Science and Engineering: A, 494(1- 2), pp.153-157.

20. Yuhazri, M.Y., Zulfikar, A.J. and Ginting, A., 2020, December. Fiber Reinforced Polymer Composite as a Strengthening of Concrete Structures: A Review. In IOP 15 Conference Series: Materials Science and Engineering (Vol. 1003, No. 1, p. 012135). IOP Publishing.Conference Series: Materials Science and Engineering (Vol. 1003, No. 1, p. 012135). IOP Publishing.
21. **https://ijfans.org/issue-content/a-review-on-utilizing-recycled-concrete-as-coarse-aggregate-in-high-strength-concrete-11066.**
22. **https://www.powermag.com/advantages-of-fibre-reinforced-concrete/**
23. SenthilKumar,K.andBaskar,K.,"Developmentofecofriendlyconcreteincorporatingrecycledhigh-impactpolystyrenefromhazardous electronicwaste",JournalofHazardous,Toxic,andRadioactiveWaste,vol.19,pp.401-406,2015.
24. Sofi,A.andPhanikumar,B.R.,"Anexperimentalinvestigationonflexuralbehaviouroffibre-reinforcedpondash-modifiedconcrete"AinShamsEngineeringJournal,vol.6,pp.1133-1142,2015.
25. Kale, S.P. and Pathan, H.I., "Recycling of Demolished Concrete and E-waste",InternationalJournalofScienceandResearch,2013
26. Vats, M.C.andSingh,S.K.,"E-Wastecharacteristicanditsdisposal",International Journal of ecological science and environmental engineering, vol.1,pp.49-61,2014.
27. Prof.,Dr.H.M.Jassima,Dr.AbdulkaderG.A.,"ExperimentalStudyofPolypropyleneFibre-ReinforcedConcrete",InternationaljournalofR&Dinengineering,scienceandmanagement,vol.3,p.p.149-161,2016.
28. Pal,S.,Mishra, M.K.andPandey,V., "Effects ofSurfaceTreatment of PolyesterFibre on Properties of Concrete", International Journal of Innovative Research inScience,EngineeringandTechnology,vol.5,2016.
29. Kumar,K.S.,Premalatha,P.V.andBaskar,K.,"Evaluationoftransportpropertiesofconcretemadewithe-wasteplastic",ASTMInternational,2016.
30. Premur, V., Anić Vučinić, A., Vujević, D. and Bedeković, G., "The possibility forEnvironmental friendly recycling of printed circuit boards" Journal of SustainableDevelopmentofEnergy,WaterandEnvironmentSystems,vol.4,pp.14-22,2016.
31. Kumar, R.A. and Malik, S.V., 2016. "Experimental study on effective utilization ofe-wasteinconcrete",internationaljournalof innovation technology andresearchIJITR,vol.4,pp.5262-5,2016
32. Manjunath,B.A.,"PartialreplacementofE-plasticwasteascoarse-aggregateinconcrete",ProcediaEnvironmentalSciences,vol.35,pp.731-739,2016.
33. SenthilKumar,K.andBaskar,K.,"Developmentofecofriendlyconcreteincorporatingrecycledhigh-impactpolystyrenefromhazardous electronicwaste",JournalofHazardous,Toxic,andRadioactiveWaste,vol.19,pp.401-406,2015.