EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH POLYPROPYLENE FIBER AND ADMIXTURES INDIVIDUALLY

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Abstract: This project work involves an experimental and laboratory study of the Polypropylene fibers with two types of admixtures those are Quarry dust and Fly ash on the mechanical properties of the concrete used in construction. In this experimental study involves two types of concrete mixes were prepared individually. Polypropylene fiber of 1% to 3% with Quarry dust of 0.1% to 0.3% and Polypropylene fiber of 1% to 4% with Fly ash of 0.1% to 0.4% by weight of cement were added to the mixes. After that a comparative analysis has been carried out for conventional concrete to that of the fiber reinforced in relation to their compressive, split tensile and flexural properties. By the experimental work the compressive, split tensile and flexural strengths are proportionally increased both Polypropylene + Quarry dust and Polypropylene +Fly ash usage. It is observed that the optimum dosages of Polypropylene + Quarry dust is 3% + 0.3% Polypropylene +Fly ash is 4%+ 0.4% by weight of cement. In this project cost analysis is also determined for conventional concrete and fiber reinforced with admixtures individually using experimental test reports.
Keywords: Compressive strength, Fly ash, Fiber reinforced concrete, Flexural strength, Polypropylene fiber, Quarry dust, Split tensile strength.

I. INTRODUCTION

The properties of concrete similar to strength and durability are diverse by make suitable changes in its ingredients like cementious material, aggregate and water and by accumulation various particular ingredients. As a result concrete is extremely well appropriate for a wide range of applications. Though Concrete has a fragile character, weak in stress, partial fatigue life, not capable of cooperative large deformations, low blow strength. Cement concrete is characterized by brittle failure, the almost inclusive loss of loading capacity, once malfunction is initiated. This nature of failure can be defeat by the insertion of a small quantity of short accidentally dispersed fibers (artificial and natural) andcan be accomplished along with others those mixture weaknesses of concrete. By this we can reduce the shrinkage cracking, and increases strength and resistance. The presence of micro cracks at the mortar-aggregate crossing point is liable for the inbuilt limitation of plain concrete. The weakness can be separate by adding of fibers in the concrete mix. There are altered types of fibers are used in usual composite materials to enlarge the concrete mix toughness, or capability to resist crack growth. The main reason of fibers is used to relocate loads at the internal micro cracks. This type of concrete is called fiber-reinforced concrete (FRC). When concrete cracks, the arbitrarily oriented fibers start functioning, capture crack formation and propagation, and thus progress strength and ductility. Thus fiber-reinforced concrete is a merged material basically consisting of conventional concrete or mortar reinforced by fine fibers. Polymer fiber reinforced concrete pavements convince two of the much demanded desires of the pavement material in India financial system and compact pollution. It also has several other recompense like increased load carrying capacity, low maintenance cost, fuel efficiency, longer life, good riding quality, and impermeability to water. The main objective of this thesis is to determine the concrete strength of M20 Grade by unfair replacement of cement from 0% to 2.0% with artificial fiber (polypropylene fiber) and from 0% to 2.5% natural fiber (coconut fiber). The mix design of M20 grade concrete was designed as per the method specified in IS 10262-1982.

1.1 Fiber Reinforced Concrete (FRC)

The term Fiber Reinforced Concrete (FRC) is defined by ACI Committee 544 as a concrete finished of hydraulic cements containing fine and coarse aggregates and irregular discrete fibers. Naturally concrete is brittle under tensile loading. Mechanical properties of concrete can be enhanced by reinforcement with accidentally oriented short discrete fibers, which avert and control initiation, propagation and coalescence of cracks. Reinforcement of concrete with a solo type of fiber may improve the desired properties to a limited level. Fiber Reinforcement is frequently used to provide toughness and ductility to brittle cementious matrices. Fiber Reinforced Concrete is one type of concrete, contains Fibrous materials which increases its structural integrity. It has short discrete fibers that are regularly distributed and randomly oriented. Fibers include polypropylene fiber, glass fibers, steel fibers and natural fibers. In these unlike fibers, that nature of fiber reinforced concrete changes with varying fiber material, densities, concretes, distribution, geometrics, and orientation. In Fiber Reinforced Concrete, fibers can be efficient in impressive cracks at both micro and macro levels.

1.2 Polypropylene Fiber Reinforced Concrete

The Polypropylene fibers are on hand in monofilament form and fit in the thermoplastic polypropylene group. The

Polypropylene fibers are warmth sensitive and above ordinary service temperature their properties may be distorted. Polypropylene fibers are fairly hydrophobic. Polypropylene fibers have been used at little inside to manage plastic shrinkage cracking in concrete.

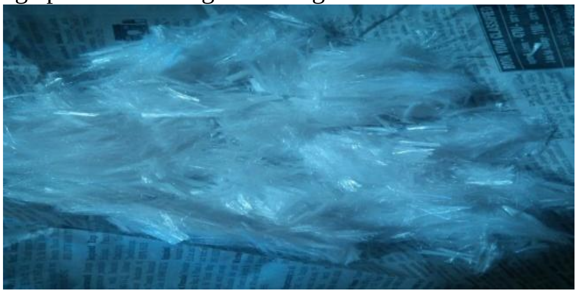

Figure. 1.1 Polypropylene fiber

1.2.1 Advantages of adding Virgin Polypropylene Fibers in Cement Concrete Blocks Fiber reinforcement, like Forta Ferro is added in the casting matrix to inhibit plastic and settlement shrinkage cracking prior to preliminary set to diminish hardened concrete shrinkage cracking
progress impact strength increase

1.3 Quarry Dust:
The quarry dust used for laboratory testing programme was calm from a crusher unit. The geotechnical properties of the quarry dust are Grain size : - a) Gravel size b) Sand size c) Silt size Specific Gravity Compaction characteristics:- a) OMC b) MDD

Figure 1.2: Quarry dust

Industrial waste ignition quarry dust is waste materials which, if reused, will supply to sustainability. One of the possible uses of these materials in bulk quantities is in forced low strength material (CLSM). This evaluates the properties of inhibited low-strength material (CLSM) made using industrial waste incineration quarry dust. A variety of mix proportions of CLSM containing quarry dust were urbanized and the properties evaluated.

1.4 Fly Ash:
The fly ash used in the experimental curriculum is a class -F Fly ash (having CaO =0.89%).The geotechnical properties of the fly ash are Grain size:- a) Clay size b) Silt size c) Sand size Specific Gravity Compaction properties:- a) OMC b) MDD

Figure 1.3: Fly ash

II. MATERIALS AND THEIR PROPERTIES

Raw materials required for the concrete use in the present work are

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Fiber
- admixtures

A. Cement:
Cement may be defined as the adhesive substance capable of uniting fragments or masses of solid matter to a lumped whole Lea et al. (1970). Various types of cements can be used in the concrete production. It should be fresh, free from foreign matters and of uniform consistency.

B. Fine Aggregate:
The most common fine aggregate used in the concrete is river sand. River sand is a vital ingredient in making the two most normally used construction material viz. cement concrete and mortar. The sand should be clean, hard, strong and free from the organic impurities and deleterious substances. It should be capable of producing a sufficiently workable mix with minimum water-cement ratio.

C. Coarse Aggregate:
The aggregates are formed due to natural designation of rocks or by artificial crushing of the rock or gravel. Specific gravity and fineness modulus of aggregate is 2.65 and 6.98 respectively.

D. Water:
Mixing water should be clean, fresh and potable. Water should be free from impurities like clay, loam, soluble salts which leads to deterioration in properties of concrete. Potable water is fit for mixing and curing of concrete.

E. Fiber:
Polypropylene fiber:
The Polypropylene fiber is formed from Reliance industries Ltd., Mumbai. The type of polypropylene fiber is CT 2024. The length of fiber is 8mm and its diameter is 10-200µm.

Description	Polypropylene fiber
Alkali	Polypropylene by nature is damaged by concentrated alkali
Specific Gravity	0.90-0.91 g/cm^3
Tensile strength	310-760Mpa
Elastic modulus	3.5-4.9 Gpa
Ultimate Elongation (%)	6-15

Table 2.1 Properties of the fiber

Cement
- Cement used in this project is of 53 Grade Ordinary Portland Cement.

Specific Gravity
- Specific gravity of cement used is 3.23.
- The specific gravity of cement as per IS requirements is in between 3-3.5.

Fineness of Cement
- Fineness of cement is tested by sieving of cement.
- Fineness of cement is 92.5%.
- The residue of cement should not exceed 10% by mass as per IS 4031: 1968.

Normal Consistency
- The percentage of water necessary to produce a cement paste of standard consistency is 29%.
- As per IS recommendations the standard consistency of cement should be in the range of 26% -33%.

Initial Setting Time
- The initial setting time of the cement used is 47 minutes. > 30 minutes(As per IS 4031-part5-1988 code)

Final Setting Time
- The final setting time of cement is 4hours 40 minutes. < 10 hours (As per IS 4031- part5-1988 code).

Fine Aggregate (Sieve analysis)
- Specific gravity of fine Sand is 2.74 and sieve analysis was conduct to the fine sand which shows the sand belong to zone III as per IS: 383-1917.

S.No	IS sieve No	Particle size	Wt.retained	% retained	Cumulative % retained	% finer	zone3
1	4.75	4.75	2	0.4	0.4	99.6	90-100
2	2.36	2.36	4	0.8	1.2	98.8	85-100
3	1.18	1.18	24	4.8	6	94	75-100
4	0.6	0.6	84	16.8	22.8	77.2	60-79
5	0.3	0.3	338	67.6	90.4	9.6	12 – 40
6	0.15	0.15	46	9.2	99.6	0.4	0-10
7	0.075	0.075	2	0.4	100	0	
8	PAN	0	0	0	100	0	

Table 2.2 Grain size analysis of sand

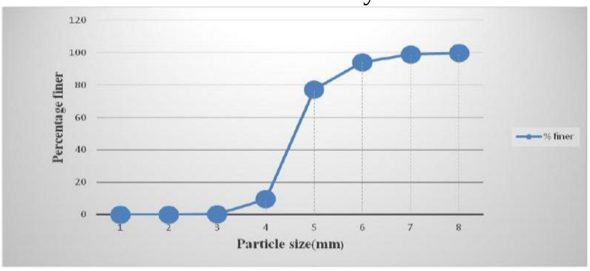

Figure. 2.1: Grain size analysis of sand

Size	Specific gravity
20mm	2.62
10mm	2.58

Table 2.3 Specific Gravity of aggregates

Aggregate Impact value
Average impact value of aggregate sample = 19.85% Aggregate impact value should not be more than 45 percent by weight for aggregates used for concrete former than wearing surfaces and 30 percent by weight for concrete to be used as wearing surfaces, such as run ways, roads.

Aggregate crushing value
Average crushing value of aggregate sample = 25.88%. Aggregate crushing value should not be more than 45 percent by weight for aggregates used for concrete former than wearing surfaces and 30 percent by weight for concrete to be used as wearing surfaces, such as run ways, roads and pavements.

Properties	Quarry dust	Fly ash
Specific gravity	2.64	2.18
W_L (%)	NP	NP
W_P (%)	NP	NP
P.I (%)	NP	NP
Gravel size particles (%)	1	0
Sand size particles (%)	96	28
Fines size particles (%)	2	73
ISCS	SP	SM
γd (kN/m^3)	15.05	14.89
W_O (%)	8.22	17.39

Table 2.4: Properties of Admixtures

III. MIX DESIGN

All the mixes prepared are corresponds to M-25 grade. For the design of mix IS: 10262-2009 recommendations are adopted. Design mix proportions of M-20 grade Concrete are given in the following.

Mix-proportions:
Cement = 300kg/m3
Water = 150 liters
Fine aggregate = 737.91 kg/m3
Coarse aggregate = 1245.8 kg/m3
Chemical admixture = 2.17 kg/m3
Water-cement ratio = 0.5
Workability of concrete :

% of Polypropylene Fiber + Quarry dust	Slump(mm)
0	108
1% + 0.1%	97
2% + 0.2%	94
3% + 0.3%	81
4% + 0.4%	72

Table 3.1 Slump values for different % of Polypropylene Fiber + Quarry dust

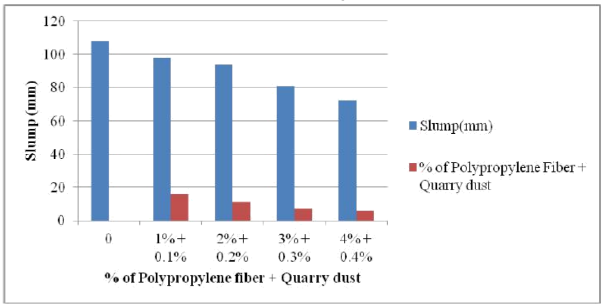

Figure. 3.1 Variation of slump with different % of Polypropylene Fiber + Quarry dust

% of Polypropylene Fiber + Fly ash	Slump(mm)
0	108
1% + 0.1%	101
2% + 0.2%	94
3% + 0.3%	91
4% + 0.4%	86
5% +0.5%	79

Table 3.2 Slump values for different % of Polypropylene Fiber + Fly ash

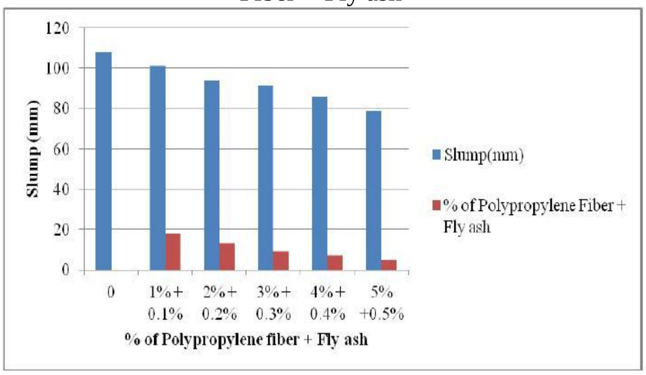

Figure. 3.2 Variation of slump with different % of Polypropylene Fiber + Fly ash

Preparation of Specimens :

Mix designation	Description of Mix
Ordinary Reinforced Concrete	O.R.C
PPRC 1+QD	1% PPRC+0.1% QD
PPRC 2+QD	2% PPRC+0.2% QD
PPRC 3+QD	3% PPRC+0.3% QD
PPRC 4+QD	4% PPRC+0.4% QD
PPRC 1+FA	1% PPRC+0.1% FA
PPRC 2+FA	2% PPRC+0.2% FA
PPRC 3+FA	3% PPRC+0.3% FA
PPRC 4+FA	4% PPRC+0.4% FA
PPRC 5+FA	5% PPRC+0.5% FA

Table 3.3 Description of Concrete mix

Description of mix	Mix proportion(Kg)					
	Cement	F.A.	C.A.	Super plasticizer	Fibers	QD
ORC	1	2.46	4.16	0.007	-	-
ORC+1% PPRC+0.1% QD	1	2.46	4.16	0.007	0.010	0.001
ORC+2% PPRC+0.2% QD	1	2.46	4.16	0.007	0.020	0.002
ORC+3% PPRC+0.3% QD	1	2.46	4.16	0.007	0.030	0.003
ORC+4% PPRC+0.4% QD	1	2.46	4.16	0.007	0.040	0.004

Table 3.4 Proportion of the concrete with and without Polypropylene fiber with Quarry Dust

Description of mix	Mix proportion(Kg)					
	Cement	F.A.	C.A.	Super plasticizer	Fibers	FA
ORC	1	2.46	4.16	0.007	-	-
ORC+1% PPRC+0.1% FA	1	2.46	4.16	0.007	0.010	0.001
ORC+2% PPRC+0.2% FA	1	2.46	4.16	0.007	0.020	0.002
ORC+3% PPRC+0.3% FA	1	2.46	4.16	0.007	0.030	0.003
ORC+4% PPRC+0.4% FA	1	2.46	4.16	0.007	0.040	0.004
ORC+5% PPRC+0.5% FA	1	2.46	4.16	0.007	0.050	0.005

Table 3.5 Proportion of the concrete with and without Polypropylene fiber with Fly ash

IV. TEST RESULTS

Compressive strength:

The compressive strength of a material is that value of uni-axial compressive stress reached when the material fails completely. The compressive strengths of concrete has been evaluated by testing cubes of size 15cm*15cm*15cm.

The compressive strength is determined by the ratio of failure load to the cross sectional area of the specimen.

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	18.55	22.62	26.72
PPRC+Q.D (1%+0.1%)	21.51	28.02	34.02
PPRC+Q.D (2%+0.2%)	26.33	33.87	39.56
PPRC+Q.D (3%+0.3%)	29.99	36.54	44.26
PPRC+Q.D (4%+0.4%)	28.02	35.09	42.78

Table 4.1 Compressive strengths of PPRC and Quarry Dust cube specimens

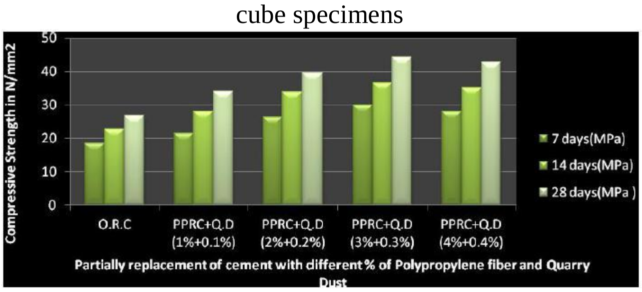

Figure. 4.1 Compressive strength values of O.R.C and PPRC+ Q.D at 7, 14 and 28 Days

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	18.55	22.62	26.72
PPRC+F.A (1%+0.1%)	20.84	24.09	33.03
PPRC+F.A (2%+0.2%)	22.66	29.54	36.22
PPRC+F.A (3%+0.3%)	24.02	31.88	40.54
PPRC+F.A (4%+0.4%)	27.44	34.07	41.98
PPRC+F.A (5%+0.5%)	25.89	31.97	39.23

Table 4.2 Compressive strengths values of PPRC and Fly ash Cube specimens

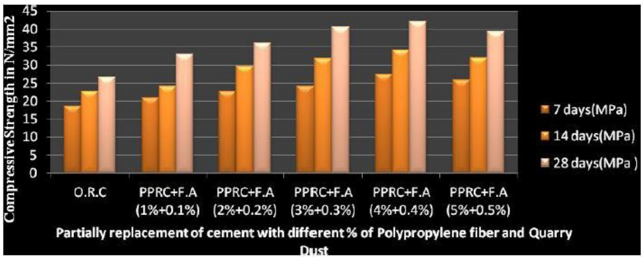

Figure. 4.2Compressive strength values of PPRC and Fly ash Cube specimens at 7, 14 and 28 days

Split tensile strength :

The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing. Tested by keeping the cylindrical specimen in the compressive testing machine and is continued until failure of the specimen occurs.

Splitting Tensile Strength shall be calculated by using the formula. $F_{ct} = 2p/pld$

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	0.99	1.6	2.54
PPRC+Q.D (1%+0.1%)	1.02	1.91	2.89
PPRC+Q.D (2%+0.2%)	1.55	2.02	3.32
PPRC+Q.D (3%+0.3%)	1.92	2.54	3.89
PPRC+Q.D (4%+0.4%)	1.67	2.00	3.57

Table 4.3 Split tensile strengths of PPRC and Quarry Dust cylinder specimens

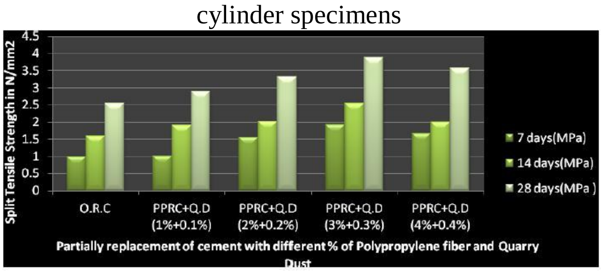

Figure 4.3 Split tensile strength values of O.R.C and PPRC+ Q.D at 7, 14 and 28 Days

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	0.99	1.6	2.54
PPRC+F.A (1%+0.1%)	1.01	1.75	2.88
PPRC+F.A (2%+0.2%)	1.49	1.88	3.01
PPRC+F.A (3%+0.3%)	1.62	2.02	3.58
PPRC+F.A (4%+0.4%)	1.86	2.41	3.65
PPRC+F.A (5%+0.5%)	1.71	2.38	3.50

Table 4.4 Tensile strengths values of PPRC and Fly ash at 7, 14 and 28days

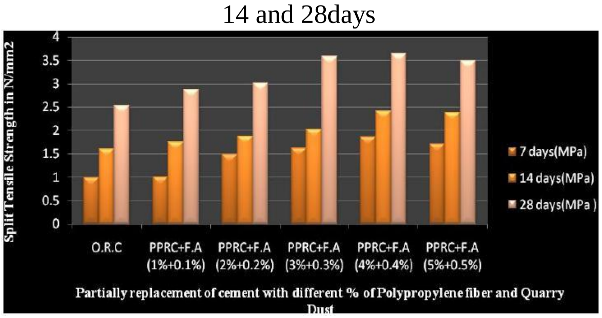

Figure. 4.4 Split tensile strength values of PPRC and Fly ash cylinder specimens at 7, 14 and 28 Days

Flexural strength :

The flexural strength may be expressed as the modulus of rupture f_b,

$f_b = pl/bd^2$

When "a" is greater than 20.0 cm for 15 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen

$f_b = 3p*a/bd^2$

When a is less than 20.0 cm but greater than 17.0cm for a 15.0 cm specimen, or less than 13.3 cm but greater than 11.0cm for a 10.0cm specimen .

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	1.72	2.86	4.57
PPRC+Q.D (1%+0.1%)	1.94	2.99	5.01
PPRC+Q.D (2%+0.2%)	2.45	3.03	6.57
PPRC+Q.D (3%+0.3%)	2.99	4.47	7.82
PPRC+Q.D (4%+0.4%)	2.81	3.82	6.71

Table 4.5 Flexural strength values of PPRC and Quarry Dust prism specimens

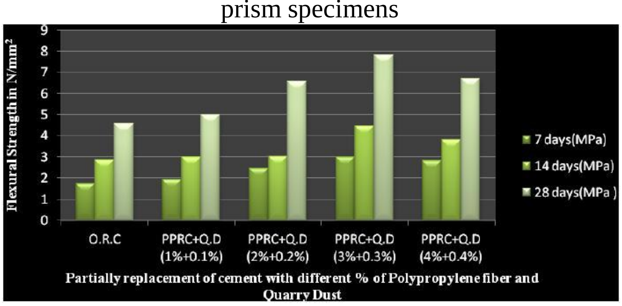

Figure. 4.5 Flexural strength values of O.R.C and PPRC+ Q.D at 7, 14and 28 Days

Mix	7 days(MPa)	14 days(MPa)	28 days(MPa)
O.R.C	1.72	2.86	4.57
PPRC+F.A (1%+0.1%)	1.86	2.92	5.26
PPRC+F.A (2%+0.2%)	2.09	3.58	5.88
PPRC+F.A (3%+0.3%)	2.48	3.91	6.97
PPRC+F.A (4%+0.4%)	2.62	4.39	7.54
PPRC+F.A (5%+0.5%)	2.54	4.08	7.19

Table 4.6 Flexural strength values of PPRC and Fly ash prism specimens

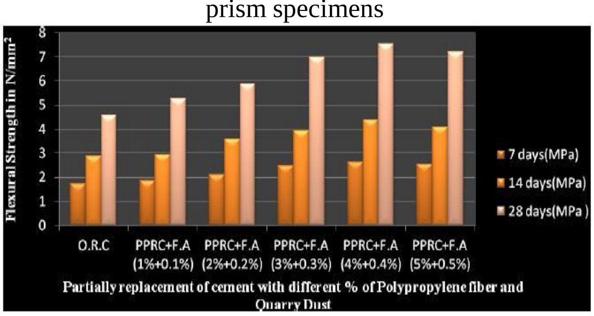

Figure. 4.6 Flexural strength values of PPRC and Fly ash at 7, 14 and 28 Days

V. CONCLUSION

- It is perceived that the concrete slump values are decreasing with the increasing fiber percentage. The reduction in slump with the increase in the fiber will be attributed to presence of fibers which causes obstruction to the free flow of concrete.

- It is perceived that the optimum dosage of polypropylene fiber + Quarry dust is 3%+0.3% & polypropylene fiber + Fly ash is 4%+0.4%.
- It is perceived that the compressive strength of the concrete increases to 21.45%, 32.45% and 39.62% from 1%, 2% and 3% of PPRC and 0.1%, 0.2% and 0.3% of QD when it is compared with ordinary reinforced concrete at 28 days.
- It is perceived that split tensile strength of the concrete increases to 12.11%, 23.49% and 34.70% when % of fiber increases from 1%, 2% and 3% of PPRC and 0.1%, 0.2% and 0.3% of QD when it is compared with ordinary reinforced concrete at 28 days.
- It is perceived that flexural strength of the concrete increases to 8.78%, 30.44% and 41.56% when % of fiber increases from 1%, 2% and 3% of PPRC and 0.1%, 0.2% and 0.3% of QD when it is compared with ordinary reinforced concrete at 28 days.
- It is perceived that compressive strength of the concrete increases to 19.10%, 26.22%, 34.08%, 36.35% when % of fiber increases from 1%, 2%, 3% and 4% of PPRC and 0.1%, 0.2%, 0.3% and 0.4% of FA when it is compared with ordinary reinforced concrete at 28 days.
- It is perceived that split tensile strength of the concrete increases to 11.80%, 15.61%, 29.05%, 30.41% when % of fiber increases from 1%, 2%, 3% and 4% of PPRC and 0.1%, 0.2%, 0.3% and 0.4% of FA when it is compared with ordinary reinforced concrete at 28 days.
- It is perceived that flexural strength of the concrete increases to 13.11%, 22.27%, 34.43%, 39.38% when % of fiber increases from 1%, 2%, 3% and 4% of PPRC and 0.1%, 0.2%, 0.3% and 0.4% of FA when it is compared with ordinary reinforced concrete at 28 days.

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