Comparatives Study of M20 Grade Conventional Concrete Pavement with M20 Grade Polypropylene Fiber Reinforced Concrete Pavement with Varying Percentages of Admixtures (Quarry Dust and Fly Ash)

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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 the rigid pavement. 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. By analyzing the cost it was found that Polypropylene reinforced concrete with quarry dust pavement is economical than Polypropylene reinforced concrete with Fly ash pavement.

Key words: Compressive strength, Fly ash, Fiber reinforced concrete, Flexural strength, Polypropylene fiber, Quarry dust, Split tensile strength

I. INTRODUCTION

Concrete pavements provide in narrow areas, commonly undergo early compensation due to inappropriate mixing of ingredients and their quality. A pavement is the covered construction on which vehicles travel. The main principle of pavement is to provide a secure and strong surface for vehicles, and to decrease stresses on underlying soils. In India, the usual system of bituminous pavement is commonly used.

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. In recent time's micro fibers, such as those used in established composite materials in concrete mixture to increase its stiffness, or capability to oppose crack growth. FRC is Portland cement concrete reinforced with more or less randomly distributed fibers in the concrete during mixing, and get better concrete properties in all directions. Fibers help to get better the post peak ductility presentation, pre-crack tensile strength, eliminate temperature and shrinkage cracks.

Polymer fiber reinforced concrete pavements assure much demanded necessities of the pavement material because less economy and reduced pollution. It also has several other advantages like longer life, fuel efficiency, low maintenance cost, increased load carrying capacity, good riding quality, and impermeability to water over flexible pavements.

The main objective of this paper is to determine the concrete strength of M20 Grade by partial 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.

Abhijeet.R.Agrawal[1] observes while decreasing the strength of building, to make research on any alternating materials which will reduce the cost and increase the strength of concrete. This convectional construction material also made some difficulty to the environment cannot lead to appropriate disposal and more results on increasing the collision on the environment.

S.A Kanalli[2] investigate relative study of polymer fiber reinforced concrete with conventional concrete. He conducted a groundwork study on compressive strength, tensile strength and flexural using different scope of polypropylene fibers resulted in a varying ratio of fiber dosage of 0.25 percent by volume of M_{20} grade concrete. Experimental values of flexural strength and compressive split tensile of concrete are obtained at 0.75% fiber dosage.

II. EXPERIMENTAL STUDY

A. Materials Used

1) Cement
2) Fine Aggregate
3) Coarse Aggregate
4) Quarry Dust

The quarry dust used for laboratory testing programmer was collected from a crusher unit.

5) Fly Ash

The fly ash used in the experimental programmer is a class - F Fly ash (having CaO =0.89%).

Fig .1: Quarry Dust

Fig. 2: Fly Ash

Properties	**Specific gravity**	**W_L(%)**	**W_P(%)**	**P.I (%)**	**Gravel size particles(%)**	**Sand size particles(%)**	**Fine size particles (%)**	**ISCS**	**γd (kN/m³)**	**W_O (%)**
Quarry Dust	2.64	NP	NP	NP	1	96	2	SP	15.05	8.22
Fly Ash	2.18	NP	NP	NP	0	28	73	SM	14.89	17.39

Table .1: Properties of Admixtures

6) Polypropylene Fiber

Fig 3: Polypropylene Fiber

The Polypropylene fibers are available in monofilament form and belong to the thermoplastic polypropylene group. The Polypropylene fibers are temperature sensitive and above normal service temperature their properties may be altered. Polypropylene fibers are somewhat hydrophobic. Polypropylene fibers have been used at low contents to control plastic shrinkage cracking in concrete. The Polypropylene fiber is produced 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 resistance	Polypropylene by nature is damaged by concentrated alkali action. No proven data of long term alkali resistance.
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: Properties of fibres

B. Mix Design

The mix proportion chosen for this study is M20 grade with water-cement ratio of 0.5. In this test total 90 Cubes of standard size 150x150x150mm and 90 Cylinders of standard diameter 150mm and height 300mm and 90 Prisms of size 500x100x100mm were casted and cured for 7,14 and 28 days and tested as per code IS: 516-1959.

Water	**Cement**	**Fine Aggregate**	**Coarse Aggregate (60% + 40%)**
150 liters	300kg/m3	737.91 kg/m3	1245.8 kg/m3

Table 3: Mix proportion (Kg/m3) and mix ratio

III. TESTS AND RESULTS

Concrete samples were prepared and cured in the laboratory, and are tested, to evaluate the concrete fresh and harden properties like compressive strength, Split tensile strength and flexural strength requirements. The different tests were conducted in the laboratories as shown in below.

A. Slump Cone Test

Slump cone test was conducted to determine the slump of the ordinary reinforced concrete mixes.

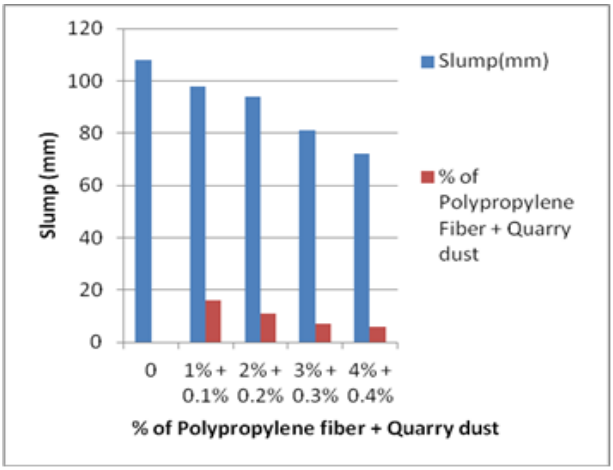

Fig. 4: Variation Of Slump With Different % Of Polypropylene Fiber + Quarry Dust

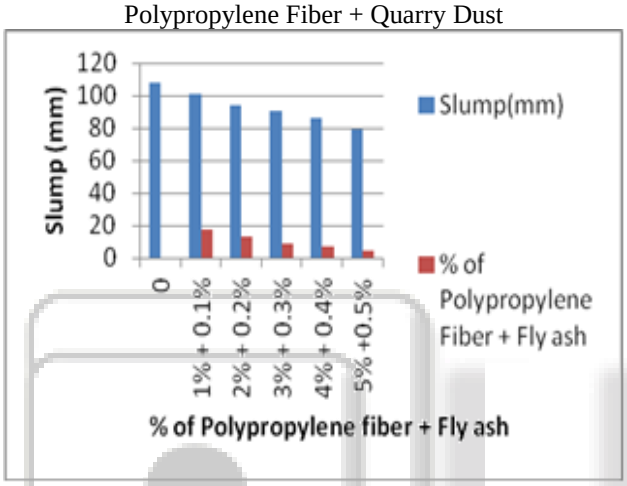

Fig .5: Variation of slump with different % of Polypropylene Fiber + Fly ash

B. Mechanical Characteristics of PFRC and Quarry Dust

1) Compressive Strength of PFRC and Quarry Dust

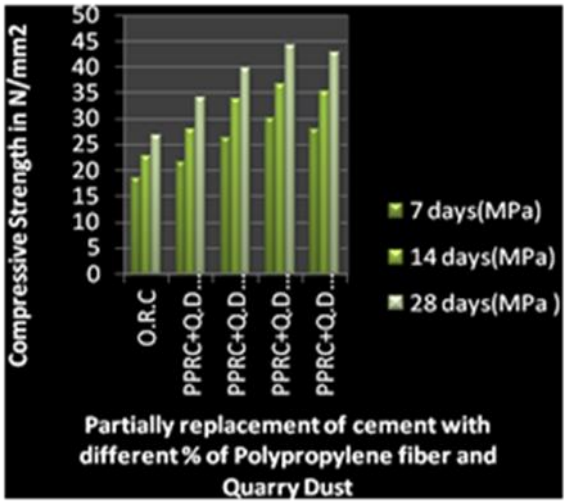

Fig .6: Compressive strength values of O.R.C and PPRC+ Q.D at 7, 14 and 28 Days

2) Split tensile strength of PPRC and Quarry Dust cylinder specimens

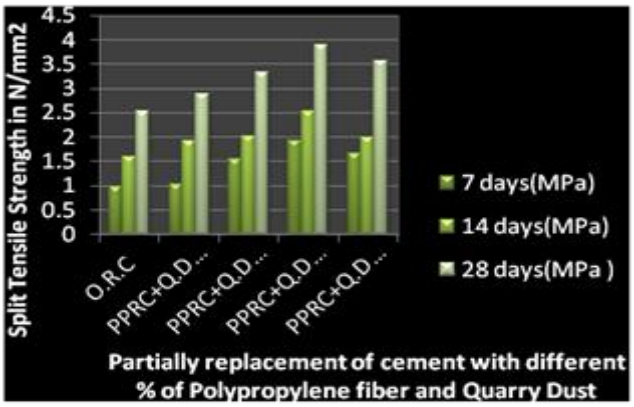

Fig .7: Split tensile strength values of O.R.C and PPRC+ Q.D at 7, 14 and 28 Days

C. Flexural Strength of PPRC and Quarry Dust Prism Specimens

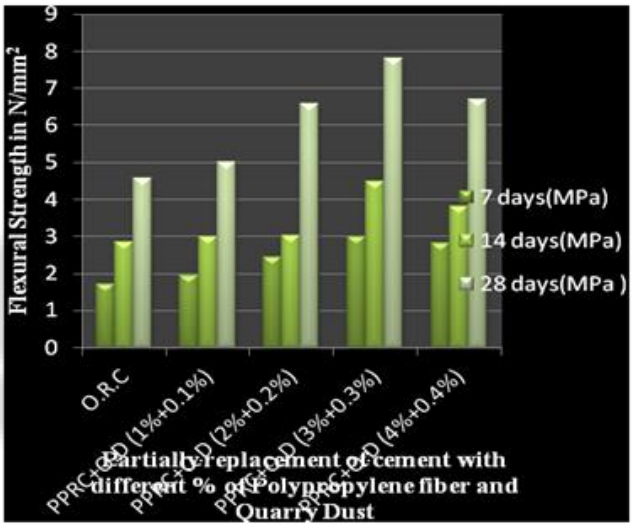

Fig. 8: Flexural strength values of O.R.C and PPRC+ Q.D at 7, 14and 28 Days

D. Mechanical Characteristics of PPRC and Fly ash

1) Compressive Strength of PPRC and Fly ash Cube Specimens

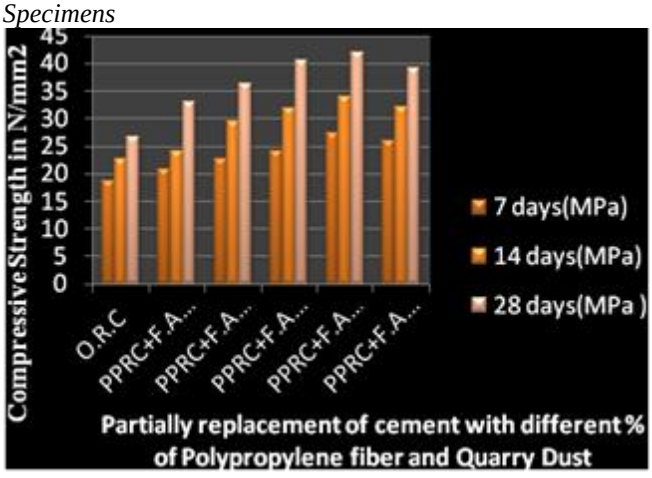

Fig. 9: Compressive strength values of PPRC and Fly ash Cube specimens at 7, 14 and 28 days

2) Split tensile strength of PPRC and Fly ash cylinder specimens

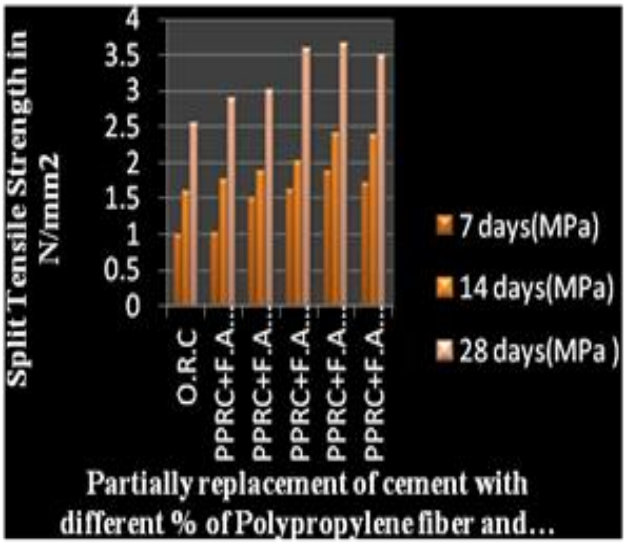

Fig. 10: Split tensile strength values of PPRC and Fly ash cylinder specimens at 7, 14 and 28 Days

3) Flexural Strength of PPRC and Fly ash Prism Specimens

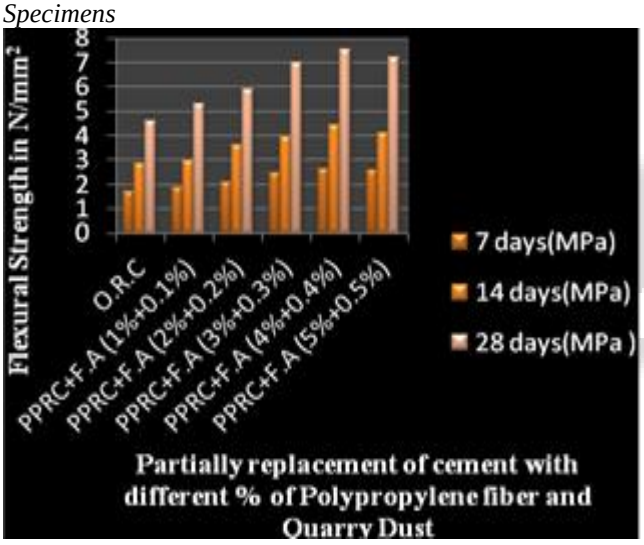

Fig. 11: Flexural strength values of PPRC and Fly ash at 7, 14 and 28 Days

IV. COST COMPARISON

A. Cost Comparison of O.R.C Pavement with P.P.R.C Pavement

A cement concrete pavement is to be laid with following dimensions. Quantity and cost of each material for that stretch is calculated and compared for conventional concrete and polypropylene fiber reinforced concrete in this section.

1) Cost For Conventional Concrete

Length of the pavement = 1m.
Width of the pavement = 3.75m.
Thickness of the pavement = 31cm.
Total volume of concrete required to fill the surface course = L×b×h.

= 1m×3.75m×0.31m.
=1.162m^3

S.no.	Material	Quantity (kg)	Rate per kg in Rs.	Cost in Rs.
1	Cement	348.6	6.4	2231.04
2	Fine aggregate	856.6	0.5	428.3
3	Coarse aggregate (20mm)	870.1	1.24	1070.924
4	Coarse aggregate (10mm)	580.07	0.80	464.056
5	Super plasticizer	2.52	60	151.2

Table 4: Estimation of materials for ordinary reinforced concrete

Therefore, The total cost in Rupees for 1.162m^3 of concrete for a stretch of 1m×3.75m×0.31m

= 4345.52 /-

B. Cost for Polypropylene Reinforced Concrete With Quarry Dust

Length of the pavement = 1m.
Width of the pavement = 3.75m.
Thickness of the pavement = 26cm.
Total volume of concrete required to fill the surface course = L×b×h.

= 1m×3.75m×0.26m.
=0.975m^3

S.no.	**Material**	**Quantity (kg)**	**Rate per kg in Rs.**	**Cost in Rs.**
1	Cement	276.88	6.4	1772.032
2	Fine aggregate	690.78	0.5	345.39
3	Coarse aggregate (20mm)	701.62	1.24	870.00
4	Coarse aggregate (10mm)	467.75	0.80	374.2
5	Super plasticizer	2.033	60	121.98
6	Fibers(Polypropylene)	8.42	600	5052.00
7	Quarry Dust	0.972	1.80	1.7496

Table 5: Estimation of materials for PPRC with QD

Therefore, The total cost in Rupees for 0.975 m^3 of concrete for a stretch of 1m×3.75m×0.25m = 8537.34 /-

S.no	Material	Quantity (kg)	Rate per kg	Cost in Rs.

			in Rs.	
1	Cement	319.725	6.4	2046.24
2	Fine aggregate	801.73	0.5	400.86
3	Coarse aggregate (20mm)	814.3	1.24	1009.73
4	Coarse aggregate (10mm)	542.87	0.80	434.29
5	Super plasticizer	2.35	60	141
6	Fibers(Polypropylene)	10.54	600	6324
7	Fly ash	1.296	1.00	1.296

Table. 6: Estimation of materials for PPRC with FA

Therefore, The total cost in Rupees for 1.05m^3 of concrete for a stretch of 1m×3.75m×0.28m = 10357.41 /-

V. CONCLUSIONS

1) It is observed 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.
2) It is observed that the optimum dosage of polypropylene fiber + Quarry dust is 3%+0.3% & polypropylene fiber + Fly ash is 4%+0.4%.
3) It is observed 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.
4) It is observed 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.
5) It is observed 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.
6) It is observed 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.
7) It is observed 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.
8) It is observed 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.
9) Addition of polypropylene fiber with quarry dust of 3% with 0.3% in concrete, the pavement thickness is decreased by 19.36%.
10) Addition of polypropylene fiber with Fly ash of 4% with 0.4 %in concrete, the pavement thickness is decreased by 9.67%.
11) Construction cost of the pavement is increased by 49.09% by using polypropylene fiber with quarry dust.
12) Construction cost of the pavement is reduced by 58.04% by using polypropylene fiber with Fly ash.

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