Performance Evaluation of Polypropylene Fiber Reinforced Concrete With Quarry Dust

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Abstract- *In Indian scenario, fine aggregate is obtained from the river bed. But due to huge time gap between formation of natural sand and its rate of consumption, the ecological balance of the rivers has been disturbed and huge crises and scarcity of natural sand is observed. Now a day's District Administrator is facing the serious problem from 'sand mafia' due to large storage of illegal sand. In the present study, emphasis is made to investigate the utilization of quarry dust in Polypropylene Fiber reinforce concrete.The outcomes of this research work will promote the optimum application of quarry dust& Polypropylene Fiber and to conserve the natural resources for sustainable development of concrete industry.*

Keywords- fine aggregate, polypropylene fibre, quarry dust, natural sand.

I. INTRODUCTION

Concrete is a miraculous and most widely utilized man made material for civil engineering construction. Concrete is a backbone of infrastructural development in the whole world due to strength, structural stability, high mold ability and low cost. India has taken major initiative in developing infrastructures such as Airports, Power Projects, Express Highways, Bridges, Dams, Commercial and Residential housing projects, Sky Scrapers, and industrial structures etc. to meet the requirement of globalization.

As compared to other construction material such as structural steel, aluminium and glass, the production of concrete involves least amount of energy consumption. Also concrete saves energy during the entire service life of a building due to its excellent thermal capacity, which enables it to absorb, store and radiate heat, stabilizing the internal temperature in a building. Concrete is a recyclable material and aggregates extracted after recycling can be reused. The admirable environmental and the profile of concrete is enhanced further due to its ability to use waste product from other industries such as fly ash, granulated blast furnace slag, silica fume, ferrosilicon and stone crusher dust from stone crusher etc.

This paper is parted as optimum percentage replacement of quarry dust with natural sand and addition of polypropylene fiber as replacement of cement in concrete for optimum replacement of sand. The conclusion has summarized key resultsin the end of the paper.

II. REASERCH

➢ Testing of Materials

1) Cement

Sr.no	Properties	Results obtained	Standard values
1	Normal Consistency	33%	-
2	Initial Setting Time (minutes)	22	Not be less than 30 minutes
3	Final Setting Time (minutes)	329	Not be greater than 600 minutes
4	Soundness (mm)	2.4	<10
5	Fineness	8.6	<10
6	Specific gravity	3.15	-

Physical Properties of Cement.

2) Fine Aggregate

Sr. No.	Properties	Results obtained
1	Type	Natural
2	Specific Gravity	2.45
3	Bulking	5.26 %
4	Dry Loose Bulk Density	1460 kg/m³
5	Fineness Modulus	3.18
6	Water Absorption	1.5 %
7	Surface Texture	Smooth
8	Particle Shape	Rounded
9	Grading Zone (Based on percentage passing 0.60 mm)	Zone I

.Physical Properties of Fine Aggregates.

IS Sieve Designation	Percentage passing by weight for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90 100	90 100	90 100	95 100
2.36-mm	60-95	75-100	85-100	95-100
1.18 mm	30 70	55 90	75 100	90 100
600 micron	15 34	35 59	60 79	80 100
300 micron	5 20	8 30	12 40	15 50
150 micron	0 10	0 10	0 10	0 15

Grading Limit for Fine Aggregate IS: 383-1970

IS Sieve Designation	Percentage by weight passing for all-aggregate	
	40 mm Normal size	20 mm Normal size
80 mm	100	-
40 mm	95-100	100
20 mm	45-75	95-100
4.75 mm	25-45	30-50
600 micron	8-30	10-35
150 micron	0-6	0-6

Grading limit of all –in- aggregate IS: 383-1970

The aggregates were sieved through a set of sieves to obtain sieve analysis and the same is presented in Table.

Total weight taken = 1000gm

Sieve	Retained on Each Sieve		Cumulative % Retained	Passing Through %
	Wt(gms)	%		
40.00mm	0	0	0	100
20.00mm	0	0	0	100
10.00mm	0	0	0	100
4.75mm	35	3.5	4.5	95.5
2.36mm	40	4.0	8.5	91.5
1.18mm	200	20.0	31.5	68.5
600 micron	430	43.0	74.5	25.5
300 micron	280	24.0	98.5	1.5
150 micron	10	1.0	99.5	0.5
Pan	05	0.5	1.0	99
Total	1000	100	318	

Fineness Modulus of Fine Aggregates

Fineness Modulus of sand = (Cumulative % Wt. Retained)/100

= 318/100

=3.18

3) Coarse Aggregate

Sr. No	Properties	Results obtained
1	Type	Natural
2	Specific Gravity	2.67
3	Dry Loose Bulk Density	1530 Kg/m³
4	Fineness Modulus	6.86
5	Water Absorption	0.6 %
6	Surface Texture	Rough
7	Particle Shape	Angular

Physical Properties of Coarse Aggregates (20 mm)

Total weight taken = 5000gm

Sieve	Retained on Each Sieve		Cumulative % Retained	Passing Through %
	Wt(kg)	%		
80	0	0	0	100
50	0	0	0	100
40	0	0	0	100
20	1.379	27.58	27.58	72.42
12.5	2.529	50.58	78.16	21.84
10	0.204	4.08	82.24	17.76
4.75	0.734	15.68	97.92	2.08
2.36	0.104	2.08	100	0
600 u	0	0	100	0
300 u	0	0	100	0
150 u	0	0	100	0
Total	5000	100	686	

Fineness Modulus of Coarse Aggregates

F.M. = (Cumulative % Wt. Retained)/100
= 686/100
=6.86

4) Quarry dust

Sr.no	Properties	Results obtained
1	Specific Gravity	2.50
2	Bulking	5.33%
3	Dry Loose Bulk Density	1800 Kg/m³
4	Fineness Modulus	2.90
5	Water Absorption	0.5 %
6	Surface Texture	Rough

Physical Properties of Quarry Dust

5) Fibers

Sr. No	Property	Value/Form
1	Material	Polypropylene (Fabricated stabilized)
2	Water absorption	NIL
3	Specific gravity	0.921
4	Denier	1050
5	Dispersion	Excellent
6	Cut Length	20 mm, 30mm
7	Tensile strength	0.67 KN/Sq.mm
8	Melting point	>165 °C
9	Acid and salt resistance	High
10	Alkali resistance	Excellent
11	Color	Natural white

Properties of Polypropylene Fiber (Bajaj Reinforcement LLP, Nagpur)

6) Details of Specimen

Table 4.10: Details of Test Specimen

Test property	Specimen	Size in mm
C		
Compressive strength	Cube	150 x 150 x 150
Split tensile strength	Cylinder	150 (dia) x 300
Flexural strength	Prism	100 100 x 500

➢ **Performance Analysis**

Sr. No	Artificial Sand (%)	Natural Sand (%)	Concrete Grade	Water Cement Ratio	Slump in mm 1	2	3	Average slump in mm
1	00	100	M30	0.45	101.72	97.88	86.30	95.3
2	40	60	M 30	0.45	100.41	82.9	93.86	92.39
3	60	40	M 30	0.45	94.4	93.49	81.8	89.89
4	100	00	M 30	0.45	64.86	65.52	58.57	62.95

Slump Test

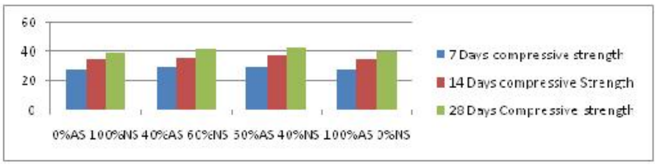
SN	Artificial Sand (%)	Natural Sand (%)	Concrete Grade	Water Cement Ratio	Compaction Factor 1	2	3	Average Compaction Factor
1	00	100	M30	0.45	0.91	0.8	0.93	0.88
2	40	60	M30	0.45	0.92	0.81	0.89	0.87
3	60	40	M30	0.45	0.87	0.8	0.92	0.86
5	100	00	M30	0.45	0.85	0.82	0.83	0.83

Compaction factor

Compressive Strength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Compressive Strength N/mm2 Cube 1	Cube 2	Cube 3	Avg.
1	7 Days	0	100	M30	28.15	25.17	28.74	27.36
2		40	60	M30	30.16	29.84	27.81	29.27
3		60	40	M30	30.14	31.05	27.49	29.56
4		100	0	M30	27.53	29.20	25.13	27.29
5	14 Days	0	100	M30	34.10	33.79	35.18	35.02
6		40	60	M30	35.60	34.60	36.13	35.47
7		60	40	M30	38.14	37.50	37.19	37.61
8		100	0	M30	34.13	34.25	35.60	34.67
9	28 Days	0	100	M30	39.45	41.83	35.97	39.09
10		40	60	M30	43.20	44.33	38.05	41.86
11		60	40	M30	44.03	44.91	38.14	42.36
12		100	0	M30	41.34	35.45	40.16	39.99

Table 6.3: - Results of Compressive Strength with Different Replacement Percentage of sand

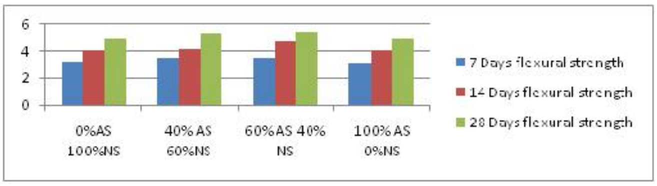


Results of Compressive Strength with Different Replacement Percentage of sand

Flexural Strength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Flexural Strength N/mm2 Prism 1	Prism 2	Prism 3	Avg.
1	7 Days	0	100	M30	3.33	3.30	2.97	3.20
2		40	60	M30	3.61	3.24	3.71	3.52
3		60	40	M30	3.70	3.22	3.61	3.51
4		100	0	M30	3.20	3.21	2.83	3.08
5	14 Days	0	100	M30	3.95	4.12	4.20	4.09
6		40	60	M30	4.18	4.23	4.05	4.15
7		60	40	M30	4.65	4.88	4.70	4.74
8		100	0	M30	3.93	4.06	4.21	4.09
9	28 Days	0	100	M30	5.10	5.06	4.51	4.89
10		40	60	M30	5.06	5.40	5.60	5.35
11		60	40	M30	5.65	5.10	5.60	5.45
12		100	0	M30	4.93	4.60	5.10	4.88

Results of Flexural Strength With Different Replacement Percentage Of Sand

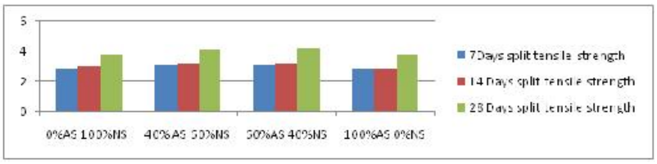


Flexural Strength With Different Replacement Percentage Of Sand

Split Tensile strength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Split Strength N/mm2 Cylinder 1	Cylinder 2	Cylinder 3	Avg.
1	7 Days	0	100	M30	2.93	2.87	2.74	2.85
2		40	60	M30	3.14	3.22	2.80	3.05
3		60	40	M30	3.20	3.16	2.95	3.11
4		100	0	M30	2.93	2.87	2.57	2.79
5	14 Days	0	100	M30	2.97	3.10	2.89	2.98
6		40	60	M30	3.12	3.11	3.23	3.16
7		60	40	M30	3.13	3.20	3.24	3.19
8		100	0	M30	2.69	2.81	2.89	2.80
9	28 Days	0	100	M30	3.90	3.84	3.64	3.79
10		40	60	M30	4.15	4.18	3.95	4.10
11		60	40	M30	4.23	4.47	3.84	4.18
12		100	0	M30	3.87	3.83	3.63	3.79

Results of Split Tensile Strength With Different Replacement Percentage of sand



Results of Split Tensile Strength With Different Replacement Percentage of sand

- **Polypropylene Fibre Reinforce Concrete (PFRC)**

1. Slum cone test

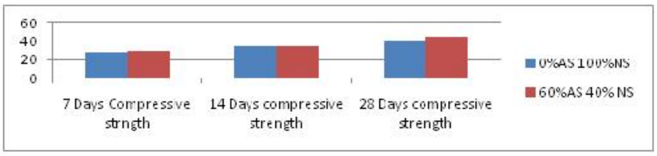
Slump of fresh concrete with PP Fiber for M30

Sr. No	Artificial Sand (%)	Natural Sand (%)	Concrete Grade	Water Cement Ratio	Slump in mm 0.25%	0.5%
1	00	100	M30	0.45	92	88
2	60	40	M 30	0.45	86	76

2. Compressive Strength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Compressive Strength N/mm2 Cube 1	Cube 2	Cube 3	Avg.
1	7 Days	0	100	M30	29.54	26.56	27.88	27.99
2		60	40	M30	30.11	29.86	29.98	29.90
3	14 Days	0	100	M30	34.09	33.42	34.18	34.20
4		60	40	M30	34.85	35.46	34.54	35.06
5	28 Days	0	100	M30	44.30	38.26	43.14	41.90
6		60	40	M30	48.64	41.76	47.27	45.89

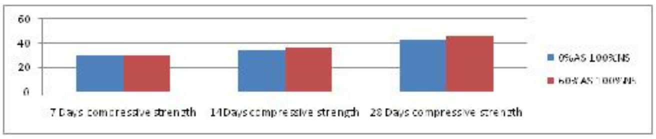
Compressive Strength with PP Fiber 0.25%



Compressive Strength with PP Fiber 0.25%

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Compressive Strength N/mm2			
					Cube 1	Cube 2	Cube 3	Avg.
1	7 Days	0	100	M30	29.86	30.12	29.14	29.70
2		60	40	M30	31.24	29.88	30.14	30.42
3	14 Days	0	100	M30	34.80	33.86	35.40	34.69
4		60	40	M30	35.89	36.65	35.43	36.00
5	28 Days	0	100	M30	43.96	40.55	44.29	43.00
6		60	40	M30	43.05	50.07	47.26	46.79

Compressive Strength with PP Fiber 0.5%

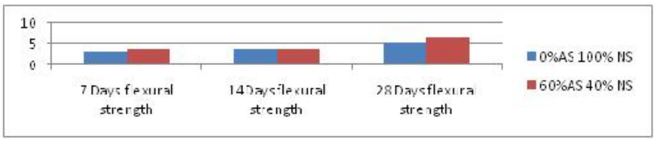


Compressive Strength with PP Fiber 0.5%

3. Flexural Strength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Flexural Strength N/mm2			
					Prism 1	Prism 2	Prism 3	Avg.
1	7 Days	0	100	M30	3.29	3.34	2.68	3.17
2		60	40	M30	3.88	3.67	3.98	3.81
3	14 Days	0	100	M30	4.13	3.95	3.88	3.99
4		60	40	M30	4.18	3.97	4.22	4.13
5	28 Days	0	100	M30	5.43	5.60	5.65	5.56
6		60	40	M30	7.10	6.10	6.89	6.60

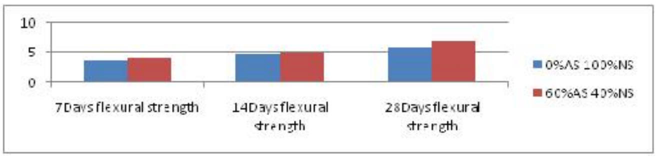
Flexural Strength with PP Fiber 0.25%



Flexural Strength with PP Fiber 0.25%

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Flexural Strength N/mm2			
					Prism 1	Prism 2	Prism 3	Avg.
1	7 Days	0	100	M30	3.67	3.98	3.34	3.66
2		60	40	M30	3.98	4.20	4.13	4.10
3	14 Days	0	100	M30	4.59	5.01	4.67	4.86
4		60	40	M30	4.68	5.13	5.22	5.01
5	28 Days	0	100	M30	6.25	5.6	5.96	5.94
6		60	40	M30	6.05	6.29	7.46	6.91

Flexural Strength with PP Fiber 0.5%

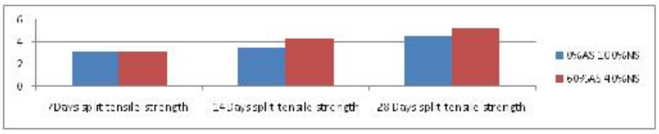


Flexural Strength with PP Fiber 0.5%

4. Split Tensile STrength

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Split Strength N/mm2			
					Cylinder 1	Cylinder 2	Cylinder 3	Avg.
1	7 Days	0	100	M30	3.27	3.13	2.86	3.09
2		60	40	M30	3.18	3.24	3.10	3.17
3	14 Days	0	100	M30	3.09	3.22	3.98	3.43
4		60	40	M30	4.29	3.98	4.61	4.29
5	28 Days	0	100	M30	4.59	4.09	4.86	4.51
6		60	40	M30	5.22	4.78	5.54	5.18s

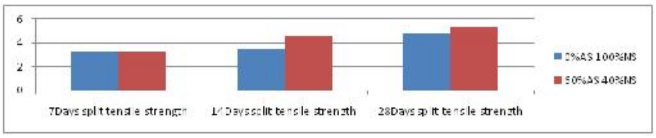
Split Tensile Strength with PP Fiber 0.25%



Split Tensile Strength with PP Fiber 0.25%

SN	Days	Artificial Sand (%)	Natural Sand (%)	Conct. Grade	Split Strength N/mm2			
					Cylinder 1	Cylinder 2	Cylinder 3	Avg.
1	7 Days	0	100	M30	3.14	3.18	3.27	3.19
2		60	40	M30	3.34	3.26	3.17	3.26
3	14 Days	0	100	M30	3.31	3.54	3.62	3.49
4		60	40	M30	4.23	4.59	4.96	4.59
5	28 Days	0	100	M30	4.93	4.88	4.38	4.73
6		60	40	M30	5.69	4.89	5.35	5.33

Split Tensile Strength with PP Fiber 0.5%



Split Tensile Strength with PP Fiber 0.5%

III. CONCLUSION

Optimum Replacement of sand & Strength Effect

- Non availability of sand at reasonable cost as finer aggregate in cement concrete for various Reasons, search for alternative material stone crusher dust qualifies itself as a suitable sub- stitute for sand at very low cost
- The measured slump values of quarry dust concrete with constant water cement ratio 0.45 are found to be 95.3, 92.39, 89.89 and 62.98mm for different mixes such as 0% quarry dust, 40% quarry dust, 60% quarry dust, 100% quarry dust respectively. It was observed that the slump value decreases with increase in percentage replacement of sand with quarry dust. The above slump value correspond to low degree of workability, suitable for construction of tiles and bricks as per IS 456-2000.
- The measured compaction factor value for quarry dust concrete with constant w/c ratio 0.45 are found to be 0.88,0.87,0.86 and 0.83 for different mixes such as 0% quarry dust, 40% quarry dust, 60% quarry dust , 100% quarry dust respectively. The above

values shows concrete give adequate workability with the increase of quarry dust as fine aggregate.

- It is observed that optimum replacement of natural sand by artificial sand is 60 %.
- There is consistent increase in strength of concrete by replacing natural sand with artificial sand up to 60% and then after the strength reduces.
- For optimum replacement, Using 60% artificial & 40% natural sand, there is maximum % increase is 8.37% in compressive strength, 11.45% in Flexural strength and 10.29% in Split tensile strength for M30 grade of concrete. .

Strength Behaviour With Polypropylene Fiber

- The measured slump values of quarry dust concrete with constant water cement ratio 0.45 are found to be 92 and 86 mm for different mixes such as 0% quarry dust ,60% quarry dust and 100% quarry dust respectively. For 0.25% replacement of cement with PP fiber similarly 88,76 and 56 mm for different mixes such as 0% quarry dust , 60% quarry dust and 100% quarry dust respectively For 0.5% replacement of cement with PP fiber It was observed that the slump value decreases with increase in percentage replacement of sand and PP fiber with quarry dust and cement respectively.
- The Compressive Strength is increased up to 20% for 100% Natural sand and 18.19 % for combination of 60% Artificial & 40% Natural sand with PP Fiber.
- The % increase in compressive strength is maximum for 0.5% Volume Fraction and 20mm Fiber length of PP Fiber..
- The Flexural Strength is increased up to 24.80% for 100% Natural & 0% Artificial sand and 29.94% for combination of 60% Artificial & 40% Natural sand with PP Fiber.
- The Split Tensile Strength is increased up to 30% for 100% Natural & 0% Artificial sand and 29.58% for combination of 60% Artificial & 40% Natural sand with PP Fiber.

IV. APPLICATIONS

a) Concrete Slabs, beams and columns
b) Concrete Roads / Pavements
c) Structural Repairs & Restoration
d) Precast Products – Pipes
e) Water Storage Tanks,, Swimming Pools
f) Pre-stressed concrete electricity poles
g) Canal Lining Works
h) Internal & External Plaster
i) Tunnel Lining Works
j) Industrial / Residential / Commercial Flooring
k) Brickbat Coba, Rooftops
l) Mine Lining Works
m) Roofing Sheets
n) Bridges – Wearing Coat

V. SCOPE FOR FUTURE STUDY

1) High strength concrete may be studied with same Fiber.
2) Combined application of this Fiber and other Fiber (Hybrid fiber) may be considered.
3) Various types of Fiber may be used with different length of fiber.
4) Behavior under creep and shrinkage may be studied.
5) Detailed durability, Bond strength and impact resistance studies of Polypropylene Fiber reinforced concrete.
6) Different grades of concrete may be studied with the same fiber.

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