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AN EXPERIMENTAL STUDY ON PPC BASED HIGH PERFORMANCE CONCRETE USING FOUNDRY SAND AS REPLACEMENT OF RIVER SAND AND ADDING POLYPROPYLENE FIBRES

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Abstract- *As we are knowing, concrete is most vulnerable and widely used material in the world. For making concrete, natural resources like river sand are much used and due to that environmental effects are increasing day by day. For rehabilitating those effects, the replacing materials are used in the concrete like foundry sand and stones. This type of high silica-based materials can improve the strength of concrete. In this study, effect of foundry sand as fine aggregate replacement on the compressive strength, flexural strength and split tensile strength of concrete with a grade of concrete M60 has investigated at different limited curing periods (7,28 and 56 days). The percentage of foundry sand used for replacement were 0%, 10%, 20%, 30%, 40% and 50% by weight of fine aggregate. Test showed impressive results, showing capability of foundry sand for being a component in concrete for imparting strength. Making concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable environment.*

Key words- *Foundry sand, Replacement of sand, High Performance concrete and Polypropylene fibers.*

1. Introduction

The Concrete is a composite construction material made primarily with aggregate, cement, and water, admixture. There are many formulations of concrete, which provide varied properties, and concrete is the most used man-made product in the world. Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. The cost of concrete production primarily depends on the cost of its constituent raw materials namely, cement, aggregates (coarse and fine) and water. Among the constituent raw materials, the Natural River sand which forms around 35% of the concrete volume.

Plays an important role in deciding the cost of concrete. Depleting sources of Natural River sand and strict environmental guidelines on mining has gradually shifted the attention of the concrete industry towards a suitable fine aggregate alternative that can replace the presently used Natural River sand. Foundry sand has surfaced as a viable alternative to Natural River sand and is being now used commonly throughout the world as fine aggregate in concrete. Foundry sand is very high in silica is regularly discarded by the metal industry. High performance concrete (HPC) is developed gradually over the last 15 years with respect to production of concrete with higher and higher strength. To enhance the properties such as durability, strength, workability, economy has increased due to the usage of mineral admixtures in making high performance concrete. Polypropylene Fibers are one of the main types of Fiber used in the market. The emergence of polypropylene Fibers has introduced to the world the possibility of having a high-performance and more cost-effective product in the market place. Polypropylene fibers also possess better durability as plastic does not rust. It also contributes to the ease in handling as it weighs about one-fifth of an equivalent steel fiber.

2. MATERIALS AND THEIR PROPERTIES

(a) CEMENT

Portland Pozzolana Cement, "Product of Future," is prepared by a fully-automated, dry manufacturing process using state of the art technology under strict quality assurance at all stages of manufacturing with the help of the "ROBOTIC (POLAB)" system. PPC is manufactured by inter-grinding well-burnt OPC Clinker with gypsum and pozzolanic materials like power-station fly ash or silicious earths.

(b) COARSE AGGREGATE

Generally, aggregates occupy 75% to 80% of the volume of concrete and have a natural rock (crushed stone, or natural gravels) and sands. In general, a rounded aggregate and smaller aggregate particles aid in the flow ability and deformability of the concrete as well as aiding in the prevention of segregation and deformability of the concrete as well as aiding in the prevention of segregation. Aggregates should also be free of impurities like silt, clay, dirt or organic matter. If these materials coat, the surfaces of the aggregate, they will isolate the aggregate particles from the surrounding concrete, causing reduction in strength. As with conventional concrete construction, the maximum size of the coarse

aggregate for fiber reinforced concrete depends upon the type of construction. Typically, the maximum sizes of coarse aggregate used in fiber reinforced concrete ranges from approximately 10 mm to 20 mm.

Coarse aggregate of size 20 mm

The coarse aggregate of size 20 mm used for the experimental work was satisfying the criteria as shown in Table below.

Physical properties				
1	Water Absorption (%)	0.97	Max. - 2.0 %	IS 2386(III)-1963
2	Sp. Gravity of Sand	2.81	2.6 - 2.9	
3	Elongation Index in (%)	12.34	--	IS 2386(I)-1963
4	Flakiness Index in (%)	10.70	--	
5	Aggregate Impact value (%)	14.35	Max. - 45.0 %	IS 2386(IV)-1963
6	Aggregate Crushing Value (%)	17.37	Max. - 45.0 %	
7	Aggregate Abrasion Value (%)	17.40	Max. - 45.0 %	
8	Fineness Modulus	7.8	2.2 – 3.2	IS 383-2016

(c) FINE AGGREGATE

All type of sands is suitable for fibre reinforced concrete. Either crushed or rounded sands can be used. Siliceous or calcareous sands can be used. The fine aggregate was locally available river sand which was passed through 4.75 mm sieve. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation Based on the type of the aggregate they required different amount of water for produce a workable concrete. Depending on the shape, the rough textured or angular shaped aggregates require increased amount of water to produce workable concrete. The smooth and rounded shaped aggregate require lesser amount of water with respect to the rough textured aggregates. Flaky or flat shaped aggregate having very less bonding effect so that it must be avoided or limited to some extent.

The division in to zones is based primarily on the percentage passing the 600 µm sieve. The particles finer than the 600 µm are generally classified as fine aggregate. The locally available fine aggregates used. The fine aggregates used for the experimental work was satisfying the criteria as shown in Table below.

Physical properties				
1	Zone of Sand	II	---	
2	Fineness Modulus of sand	2.8	2.2 – 3.2	IS 383-2016
3	Water Absorption (%)	1.1	Max - 2 %	
4	Sp. Gravity of Sand	2.67	2.6 - 2.7	IS 2386(III)-1963
5	Silt Content in % (finer than 75 µ)	2.2	max.- 3 %	

(d) WATER

Water is an important ingredient require for making concrete. The chemical reaction process which is also known as heat of hydration depends mainly on water and cement. Thus, water is the most important factor for the making concrete. Due to the addition of water to cement, the cement paste occurs which is very helpful to bond the various coarse aggregate and fine aggregate particles with each other. Thus, the water plays an important role and hence, the quality and quantity of water should also be taken in to consideration while making concrete because it directly affects the strength of concrete. Water taken in use should be such that it can be fit for drinking can be considered. For the practical use the tap water was used for making concrete. Potable water is used here for the casting.

(e) FOUNDRY SAND

Foundry sand is a byproduct from the production of both ferrous and nonferrous metal castings. It is high quality silica sand. Foundries use high quality size-specific silica sands for use in their molding and casting operations. In the casting process, molding sands are recycled and reused many times.

Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space and because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns. One such industrial by-product is waste foundry sand (WFS). Waste foundry sand is a by-

product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the

Physical Properties			
1	Fineness Modulus	1.53	2.2 – 3.4
2	Water Absorption (%)	0.81%	Max - 2 %
3	Sp. Gravity	2.6	2.6 - 2.8
4	Silt Content in % (finer than 75 μ)	0.45	max.- 3 %

sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as waste foundry sand. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns.

(f) SUPER PLASTISIZER & FIBERS

To improve strength and workability of concrete, we need to use super plasticizer in concrete. It can reduce water without affecting strength and workability. We are going to use Glenium sky 8233 PCE (polycarboxylic ether) based. Polypropylene fibers are used mainly to control cracking in the initial setting stages. These fibers are produced from homo-polymer polypropylene resin in a variety of shapes and sizes, and with different properties.

4. METHADOLOGY AND RESULTS

By referring all literatures regarding this study, I have concluded that concrete can give higher strength by replacing up to 50% Foundry sand as River Sand for normal strength concrete. So, for further study on High performance concrete, I continue my study of research with using 45%, 50% and 55% replacement of Foundry Sand as River Sand.

PRELIMINARY MIX DESIGN FOR OPTIMIZATION

Mix design for concrete grade of M-60 has been carried out to finding out optimum content of Foundry Sand as per IS-10262:2009, which is shown below:

Mix design calculation for M60 conventional concrete

Ingredients	Content (per m^3)	Proportioning
Cement Content (kg)	504 (388+116)	1
Water Content (kg)	141.61	0.29
Fine aggregate (kg)	683.24	1.35
Coarse Aggregate(kg)	1108.13	2.19
Superplasticizer (ml)	4.66	0.009
Polypropylene fibres (kg)	10.08	0.02
Total Weight (kg)	2437.19	

Replacement of River sand was carried out by Foundry sand in different proportions of 45%, 50%, and 55% and then cubes were filled with concrete of M60 grade and the 3 Day and 7 Day Compressive Strength Test was taken having the results shown below.3 cubes were made for each different proportion to obtain an average result.

Compressive Strength Test results after 3 Days

REPLACEMENT (in %)	WEIGHT AFTER 3 DAYS (in Kg)	LOAD (kN)	STRENGTH (N/mm^2)	AVERAGE STRENGTH AFTER 3 DAYS
0%	**8.24, 8.13, 8.45**	**445.5, 483.75, 396**	**19.8, 21.5, 17.6**	**19.63**
45%	**8.27, 8.10, 8.39**	**435.37, 447.75, 466.42**	**19.35, 19.87, 20.73**	**19.98**
50%	**8.16, 8.24, 8.44**	**455.17, 476.32, 468**	**20.23, 21.17, 20.80**	**20.73**
55%	**7.93, 8.23, 8.41**	**447.97, 444.6, 454.27**	**19.91, 19.76, 20.19**	**19.95**

Compressive Strength Test results after 7 Days

REPLACEMENT (in %)	WEIGHT AFTER 7 DAYS (in Kg)	LOAD(kN)	STRENGTH (N/mm^2)	AVERAGE STRENGTH AFTER 7 DAYS
0%	8.20, 8.27, 8.33	801.09, 759.33, 768.48	35.60, 33.74, 34.15	34.5
45%	8.60, 8.35, 8.20	781.11, 751.41, 745.47	34.71, 33.39, 33.13	33.74
50%	**8.33, 8.47, 8.28**	**824.92, 820.89, 809.55**	**36.63, 36.48, 35.98**	**36.37**
55%	8.18, 8.05, 8.35	765.51, 740.52, 752.40	34.02, 32.91, 33.44	33.45

❖ **FINAL TEST STUDY FOR M60 HPC**

By getting the compressive strength values of previous M60 mix, we can get good suitability of Foundry Sand by replacing it at 50% in a concrete mix. By considering that arbitrary condition we have carried out Replacement of River sand by Foundry Sand by 50% and then cubes of size 150mm X 150mm X 150mm, beams of size 100mm X 100mm X 500mm and cylinders of size 150mm diameter and 300mm height were casted with concrete of M60 grade for Compressive Strength Test, Flexural Strength Test and Split Tensile Strength Test respectively and results were taken on the 7, 28 and 56day having the results shown below. Three cubes were made for each different proportion to obtain an average result. The cubes of size 150mm X 150mm X 150mm were also be casted and cured for 28 and 56 days in acid for carried out results of durability properties of concrete.

- **Mechanical Properties of Concrete**

(a) Compressive Strength Test:

Results of the Compressive Strength Test for M60 grade Concrete is as shown below. The cubes of 0% Replacement and 50% Replacement by Foundry Sand as sand were casted and tested at 7 Days, 28 Days and 56 Days.

	REPLACEMENT (in %)	WEIGHT (in Kg)	STRENGTH (N/mm²)	AVERAGE STRENGTH (N/mm²)
7 Days	0%	8.20, 8.27, 8.33	35.60, 33.74, 34.15	34.5
	50%	8.33, 8.47, 8.28	36.63, 36.48, 35.98	36.37
28 Days	0%	8.29, 8.38, 8.57	61.56, 62.47, 62.23	62.08
	50%	8.13,8.31,8.34	61.32, 60.78, 61.10	61.06
56 Days	0%	8.42,8.47,8.59	62.31, 63.18, 62.97	62.82
	50%	8.53,8.41,8.61	61.93, 61.31, 61.76	61.67

(b) Split Tensile Strength Test :

A cylindrical mould of having standard size of 300mm length and 150mm diameter is used for the test. Cylinders with Conventional concrete and concrete with 50% River Sand Replaced by Foundry Sand were Casted and tested after 28 Days and 56 Days.

Split Tensile Strength Test

	REPLACEMENT(%)	STRENGTH(N/mm²)	AVERAGE STRENGTH(N/mm²)
28 Days	0%	4.42, 4.36, 4.45	4.41
	50%	4.63, 4.67, 4.71	4.67
56 Days	0%	4.62, 4.59, 4.58	4.60
	50%	4.59, 4.94, 4.96	4.93

(b) Flextural strength test:

The Results of the Flexural Strength are shown below. Beam Specimen of 100X100X500mm size were used for conventional Concrete and Concrete with 50% replacement of River Sand by Foundry Sand were casted and the 28 Days and 56 Days result were taken. Four-point Flexure Test method was used for the determination of Flexural Strength.

Flexural Strength Test

	REPLACEMENT (%)	STRENGTH(N/mm²)	AVERAGE STRENGTH(N/mm²)
28 Days	0%	6.02, 6.26, 6.18	6.15
	50%	6.40, 6.48, 6.39	6.42
56 Days	0%	6.38, 6.32, 6.42	6.37
	50%	6.61, 6.54, 6.60	6.58

(c) Durability Test:

(a) Acid Attack Test:

Acid Attack Test was carried out by adding Sulphuric acid (H_2SO_4) with 5% molality in Normal Water and curing it for 28 Days and 56 Days and then the Compressive strength tests were carried out after 28 and 56 Days of Curing. By the results, it can be concluded that 50% replacement of Foundry Sand by river sand can give good resistance to acid attack than conventional concrete.

Acid Attack Test

	REPLACEMENT (in %)	WEIGHT (in Kg)	STRENGTH (N/mm²)	AVERAGE STRENGTH (N/mm²)
28 Days	0%	8.21, 8.37, 8.43	58.82, 59.37, 59.13	59.10
	50%	8.32, 8.49, 8.26	59.83, 58.89, 60.47	59.73
56 Days	0%	8.61, 8.74, 8.57	56.89, 56.94, 57.28	57.03
	50%	8.42, 8.61, 8.39	57.26, 57.42, 56.97	57.22

(b)NaCl Attack Test

NaCl Attack Test was carried out by adding NaCl whose chemical name is Sodium Chloride(NaCl) in Normal Water and curing it for 28 Days and 56 Days and then the Compressive Strength Test was carried out after 28 and 56 Days of Curing.

NaCl Attack Test

	REPLACEMENT (in %)	WEIGHT (in Kg)	STRENGTH (N/mm²)	AVERAGE STRENGTH (N/mm²)
28 Days	0%	8.46, 8.51, 8.23	58.57, 58.73, 58.84	58.71
	50%	8.37, 8.29, 8.41	58.34, 59.19, 59.32	58.95
56 Days	0%	8.62, 8.49, 8.37	57.18, 56.98, 56.89	57.02
	50%	8.43, 8.38, 8.17	57.22, 57.97, 57.64	57.61

(c)Sorptivity Test

The result of the Sorptivity Test are shown below. The Test for conventional Concrete and Concrete with 50% Replacement of River Sand by Foundry Sand is Carried out after 28 Days.

Elapsed Time in min	28Days Normal Concrete Result in mm/min$^{0.5}$	28Days FS replacement Concrete Result in mm/min$^{0.5}$
15	0	0
30	2.32*10-5	2.32*10-5
45	1.89*10-5	1.89*10-5
75	4.41*10-5	2.94*10-5
90	4.02*10-5	4.02*10-5
180	4.74*10-5	2.84*10-5
255	3.98*10-5	2.39*10-5
360	3.56*10-5	2.01*10-5

5. CONCLUSIONS

- From this study, we can conclude that by addition of Foundry Sand in concrete can give higher strength than normal concrete in 7 days of High strength concrete.
- As we know by adding Foundry Sand in concrete can reduce the flexural and split tensile strength of concrete. But by adding 2% of polypropylene fibers in concrete can improve 5.89% flexural strength and 4.39% split tensile strength in 28 days.
- Due to addition of Foundry Sand in concrete, we can give good resistant to acid attack and reduce permeability.
- The Mechanical properties like Compressive strength, Flexural strength and Split Tensile strength of M60 grade of concrete can also be achieved by using Foundry Sand as replacement of river sand.
- As per cost comparison of ingredients in concrete, we can conclude that cost of 1 m3 concrete can be saved up to 2.16% by replacing 50% Foundry Sand as fine aggregate.
- By replacing Foundry sand as fine aggregate in concrete can reduce rate of penetration of water in concrete up to 44% compared to normal concrete.

6. REFERENCES

Papers:

1. Yogesh Agrawal, Rafat Siddique, "Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates, ELSEVIER Perspectives in Science (2014) 210-223
2. ViatceslavKonkov, "PRINCIPAL APPROACHES TO HIGH PERFORMANCE CONCRETE APPLICATION IN

CONSTRUCTION" ELSEVIER, Procedia Engineering 57 (2013) 589 – 596
3. MR. Mehul J. Patel, MRS. S. M. Kulkarni, "EFFECT OF POLYPROPYLENE FIBRE ON THE HIGH STRENTH CONCRETE" Journal of information, knowledge and research in civil engineering. ISSN: 0975 – 6744 |NOV 12 TO OCT 13|Volume 2, Issue 2|
4. Salahaldein Alsadey1, Muhsen Salem, "INFLUENCE OF POLYPROPYLENE FIBER ON STRENGTH OF CONCRETE" American Journal of Engineering Research (AJER)e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-5, Issue-7(2016)
5. G. Ganesh Prabhu, Jung Hwan Hyun, Yun Yong Kim "Effects of foundry sand as a fine aggregate in concrete production" Conference Series: Construction and Building materials 70 (2014) 541-521
6. Gurpreet Singh, Rafat Siddique, "Effect of waste foundry sand (WFS) as partial replacement of sand on the strength, ultrasonic pulse velocity and permeability of concrete" ELSIVIER, Construction and Buildings materials 26(2012)416-422
7. Anzar Hamid Mir, "Replacement of Natural Sand with Efficient Alternatives: Recent Advances in Concrete Technology" Anzar Hamid Mir Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 3, (Part -3) March 2015, pp.51-58

Books

8. A. M. Neville, Properties of Concrete – Fourth Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
9. M.S. Shetty, Concrete Technology Theory and Practice, S. Chand & Company Ltd.

IS Codes

10. IS: 2386 (I to IV)– 1963, "Methods of Test for Aggregate for Concrete", Bureau of Indian Standards, New Delhi.
11. IS: 456 – 2000, "Plain and Reinforced Concrete - code of Practice", Bureau of Indian Standards, New Delhi
12. IS: 516-1959 Indian Standard Methods of Tests for Strength of Concrete.
13. IS: 10262-2009 Indian Standard Concrete Mix Proportioning – Guidelines (First Revision).
14. IS: 12269-2013 Indian Standard Ordinary Portland Cement, 53 Grade- Specification.
15. IS: 383-2016 Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.

Websites

16. https://www.researchgate.net/publication/291589581_Foundry sand_as_fine_aggregate_for_concrete
17. http://www.sciencedirect.com/science/article/pii/S0950061809000701
18. https://www.google.com/search?source=hp&ei=kLTjX4WhNLuR4-EPoeigmAg&q=foundry+sand&oq=foundry+sand&gs
19. https://www.google.co.in/search?ei=KjMaWv7zJIjEvQTb14noCQ&q=properties+of+ppc+cement&oq=properties+of+ppc+cement&gs_l=psy-ab.3..0j0i22i30k1l4.5630.18020.0.18815.21.20.1.0.0.0.397.2271.0j12j0j1.13.0....0...1c.1.64.psy-ab..7.4.604...0i13k1j33i21k1.0.PUrD7Jj8BD0