An Experimental Study on PPC based High Performance Concrete using Crushed Fine Aggregates as Replacement of River Sand & Adding Polypropylene Fibres

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Abstract— As we are knowing, concrete is a most widely used material in the world after water. For making concrete, natural resources like river sand are much used and due to excavation of sand, environmental effects are increasing day by day. For rehabilitating those effects, the replacing materials are used in the concrete like Crushed Fine Aggregates. This type of eco-friendly materials can improve the strength of concrete and minimize the cost of future construction.

Key words: PPC, Concrete, Crushed Fine Aggregates, River Sand & Polypropylene Fibres

I. 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. 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. Such type of concrete is good for Retaining wall, High rise buildings, Underwater construction, Water tank, In road construction, Pre-cast concrete products like railway sleepers, electric power poles, parking tiles etc.

II. ADVANTAGES OF HPC

a) Construction of High-Rise buildings with the accompanying savings in real estate costs in congested areas. Reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures.
b) Superior long-term service performance under static, dynamic and fatigue loading.
c) Low creep and shrinkage.
d) Higher resistance to freezing, thawing and chemical attack.
e) Reduced maintenance and repairs.
f) Smaller depreciation as a fixed cost.

III. MATERIALS INCORPORATED

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.

1) Advantages

a) Higher durability of concrete structure due to less permeability of water.
b) More resistance towards the attack of alkalies, sulphates, chlorides, chemicals.
c) Better work ability.
d) Low heat of hydration.
e) Due to high fineness, PPC has better cohesion with aggregates and makes more dense concreteness.
f) Comparative lower Water-Cement ratio provides an added advantage for the further increase of compressive strength of the concrete.
g) Better surface finish.

Sr. No.	Parameters	Results Obtained	Requirements as per IS:12269 (1987)
1	Fineness by sieve Analysis	8% retention on 90µm sieve	Maximum 10%
2	Standard consistency in (%)	28%	
3	Setting time in Minutes		
	(a) Initial setting time (Minute)	47min	Minimum - 30 Minute
	(b) Final setting time (Minute)	260min	Maximum- 600 Minute
4	Soundness By Le-chat Expansion in (mm)	2.1 mm	Maximum-10.00 mm
5	Compressive Strength (in MPa)		
	3 Days	30.56 MPa	Minimum- 27.00 MPa
	7 Days	39.81 MPa	Minimum- 37.00 MPa
	28 Days	56.14 MPa	Minimum- 53.00 MPa

Table 1: Physical Properties of Cement

B. Fine Aggregates (River Sand & CFS)

1) Sand

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 600µm sieve. The particles finer than the 600µm 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	---
3	Water Absorption (%)	1.1	Max - 2 %
4	Sp. Gravity of Sand	2.67	2.6 - 2.7
5	Silt Content in % (finer than 75 µ)	2.2	max.- 3 %

Table 2: Physical Properties of Sand

2) Crushed Fine aggregates

Crushed stone or angular rock is a form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers. It is distinct from gravel which is produced by natural processes of weathering and erosion, and typically has a more rounded shape. Crushed stone is one of the most accessible natural resources, and is a major basic raw material used by construction, agriculture, and other industries. Despite the low value of its basic products, the crushed stone industry is a major contributor to and an indicator of the economic well-being of a nation. The demand for crushed stone is determined mostly by the level of construction activity, and, therefore, the demand for construction materials. Natural materials such as river sand and crushed fine stone are generally used in concrete as fine aggregates. These rocks have been used as dimension stones and in mortar for thousands of years.

Physical properties			
1	Fineness Modulus	2.88	---
2	Water Absorption (%)	1.4	Max - 2 %
3	Sp. Gravity	2.72	2.6 - 2.7
4	Silt Content in % (finer than 75 µ)	1.6	max.- 3 %

Table 3: Physical Properties of Crushed Fine Aggregates

C. Coarse Aggregates

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 fibre reinforced concrete depends upon the type of construction. Typically, the maximum sizes of coarse aggregate used in fibre reinforced concrete ranges from approximately 10 mm to 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 %
2	Sp. Gravity of Sand	2.81	2.6 - 2.9
3	Elongation Index in (%)	12.34	--
4	Flakiness Index in (%)	10.70	--
5	Aggregate Impact value (%)	14.35	Max. - 45.0 %
6	Aggregate Crushing Value (%)	17.37	Max. - 45.0 %
7	Aggregate Abrasion Value (%)	17.40	Max. - 45.0 %
8	Fineness Modulus	7.8	--

Table 4: Physical Properties of Coarse Aggregates

D. Fibers

Polypropylene Fibres have been used in the concrete for a better flexural Strength. Polypropylene fibers has been the most successful commercial application so far among the synthetic polymeric fibers discussed above. 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. The main advantages of polypropylene fibers are their alkali resistance, relatively high melting point (165˚C) and the low cost of the material. Their disadvantages are poor fire resistance, sensitivity to sunlight and oxygen, a low modulus of elasticity (1-8 GPa) and poor bond with matrix. The length of the Fibres vary from 10 to 15mm and diameter of 30 to 100 micron. The specific Gravity of these Fibre is 0.91 and its melting point is 160 to 170 degrees.

E. Super-Plasticizer

To improve strength and workability of concrete, we need to use super plasticizer in concrete. It can reduce water without affecting strength and workability. Glenium sky 8233 PCE (polycarboxylic ether) based has been incorporated as a Super-plasticizer.

IV. TESTING PROCEDURE

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

Ingredients	Content (kg/m^3)	Proportioning
Cement Content (kg)	504.21	1
Water Content (kg)	141.61	0.29
Fine aggregate (kg)	683.24	1.35
Coarse Aggregate(kg)	1108.13	2.19
Total Weight (kg)	2437.19	

Table 5: Mix Design for M60

Replacement of River sand was carried out by Crushed Fine Aggregates in different proportions of 45%, 50%, and 55% and then cubes were filled with concrete of M60 grade and the 7 Day and 28 Day Compressive Strength Test were performed having the results shown below.3 cubes were made for each different proportion to obtain an average result.

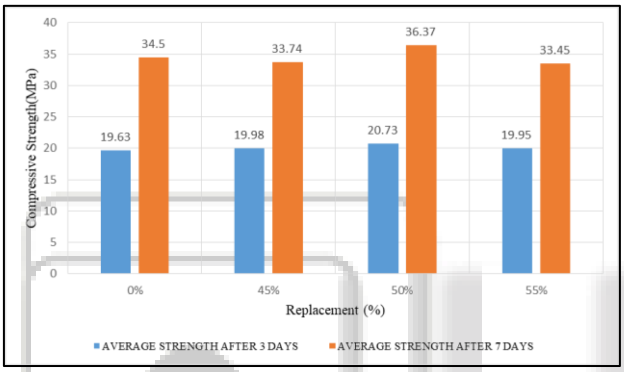

Fig. 1: Compressive Strength after 3 & 7 Day

Compressive Strength Test, Split Tensile Strength and Flexural Strength Test were carried out having the results shown below.

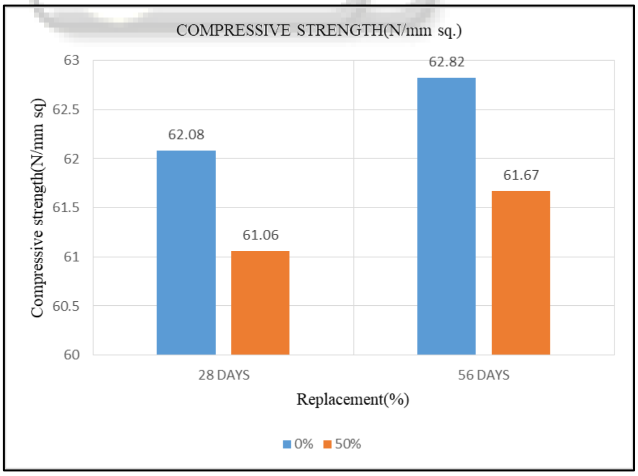

Fig. 2: Compressive Strength Test after 28 & 56 Days

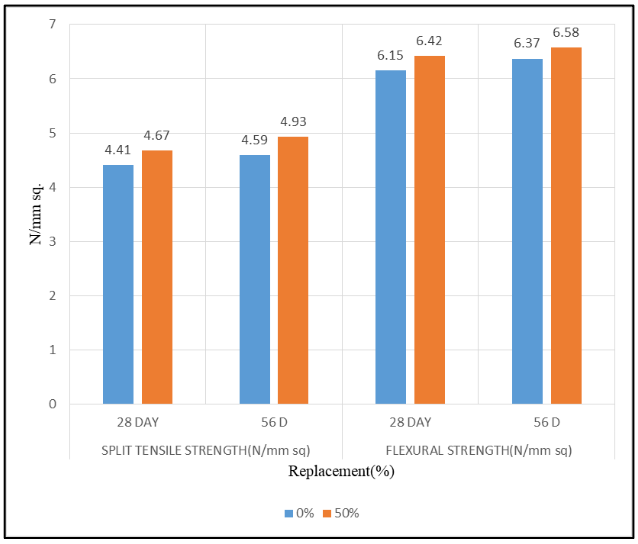

Fig. 3: Split Tensile Strength & Flexural Strength Test after 28 & 56 Days

Further, Acid Attack Test and Salt Attack Test were conducted having results shown below.

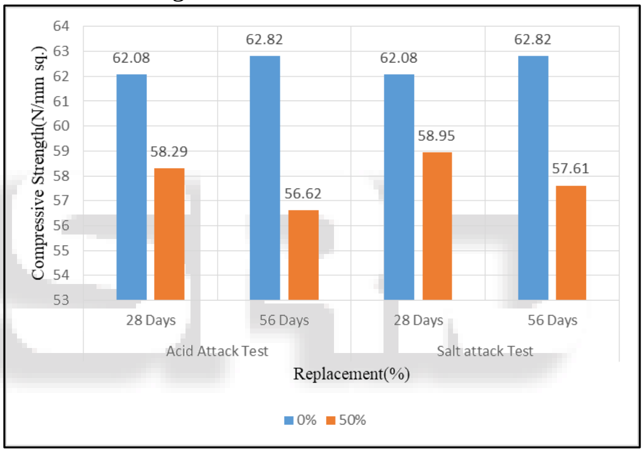

Fig. 4: Acid Attack Test & Salt Attack Test after 28 & 56 Days

V. CONCLUSIONS

Crushed Fine Aggregates can be replaced by River Sand in Concrete up to 50%. The Compressive Strength de creases at 45% replacement of River Sand by Crushed Fine aggregates and Strength gradually increases up to 50% Replacement. Compressive Strength further decreases when Crushed Fine aggregates is replaced up to 55% by River sand. Adding Polypropylene Fibers in Concrete increases the Split Tensile Strength of Concrete.

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