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Combined Effect of Mineral Admixtures in High-Performance Concrete

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Abstract — High Performance Concrete (HPC) is a propelled sort of concrete that can increase the strength and versatility of concrete structures. For many years, High performance concrete (HPC) is the innovative type of concrete. It has been developed and used for many purpose in construction results in increased characteristics compared to conventional concrete. Fly ash, Silica fume, Quarry Dust has been popularly used in as mineral admixtures and along with that water also used as natural admixture in HPC to improve the mechanical properties. The utilization of nearby materials is a principal venture to spare materials and vitality and lessen the cost of concrete. The cement has been partially replaced with silica fume, combination of coconut shell and eggshell ash (with equal proportions). In order to found out the mechanical properties of High-Performance concrete, concrete specimens were casted and tested for 7, 28 days up to failure. In this investigation the mechanical properties of HPC are compared to Controlled Specimens.

Key Words — Mechanical Properties, Silica Fume, Combination of Coconut shell and Egg shell ash, Compressive strength, Tensile strength, Flexural Strength, Mineral Admixture.

I. INTRODUCTION

Concrete is commonly made with a mixture of cement, fine aggregate, coarse aggregate with required measure of admixtures. Concrete is the significant structural material utilized in the construction field. In this investigation cement has been partially replaced with combination of coconut shell ash and eggshell ash up to 15% at equal proportions and in addition to that silica fume is partially replaced for cement up to 15%. Totally these admixtures are treated as mineral admixture in the replacement of cement. The main objective of this investigation is to find out the mechanical properties of high-performance concrete with these mineral admixtures. Finally, the HPC results are compared to controlled concrete.

Balaji and Vetturayasudharsanan already investigates an experimental study on 20% removal of concrete at tension zone, the removal of concrete at tension zone in beams. It doesn't affect the bending behavior of the concrete [1] and also feasibility study on perfoband rib shear connectors [2]. From these two articles the up to 30% replacement in cement it doesn't affect the behavior of concrete. The mechanical properties of HPC is always slightly higher than the controlled concrete mix. So, this main reason behind that HPC is more durable, versatile and more durable [3-7]. Indian standard codes are referred for standard testing of materials used in this investigation [8-12]. The ordinary cement structured on the premise of compressive quality doesn't meet any functional requirements, for example, impermeability, protection from frost, thermal breaking enough. The ultra-High-Performance concrete gives better results to that [13-16]. Hence, it is proposed to compare the mechanical properties of HPC with mineral admixtures with controlled concrete mix.

A. High-Performance Concrete

High-Performance Concrete is characterized as the concrete that has been intended to be progressively more durable and if important, stronger than conventional concrete. High-Performance Concrete materials are basically made out of indistinguishable materials from customary concrete blends. Be that as it may, the extents are planned or designed to give the quality and solidness required for the basic and natural prerequisites of the undertaking.

B. Combination of Coconut Shell and Egg Shell Ash

The product of combination of coconut shell ash and eggshell ash were produced by the collecting of eggshells in locally available hotels, mini restaurants and coconut mart. The fibers of coconut shell are removed. The eggshells are cleaned using water and the eggshell is dried over the sunlight. The coconut shell and eggshell are weighted simultaneously [17-18]. And the materials

are burn up to it get coal form under the constant temperature of 70^0C for 3hours. It was grinded with 550 Vats mixer grinder for 10 minutes. Fig. 1. Shows the Combination of Coconut Shell and Egg Shell Ash.

Fig. 1. Combination of Coconut Shell and Egg Shell Ash

II. MATERIALS USED

A. Cement

Cement used for this entire investigation is locally available Ordinary Portland Cement (OPC) of grade 53 [19]. The cement was tested for its different properties to satisfy these Indian standards, IS: 4031–1988 and IS: 12269–1987. The various properties test result was shown in Table. 1.

Table 1. Properties of Cement

Properties	Value
Specific gravity	3.25
Fineness	2%
Standard consistency	34%
Initial setting time	35 min
Final setting time	6 hours

B.Fine Aggregate and Coarse Aggregate

Fine aggregate used for this entire investigation is the locally available river sand. After the testing of this river sand, it comes under Zone II having fineness modulus of 2.89 conforming to IS: 383 – 1970. The maximum grain size of coarse aggregate is 20mm conforming to IS 2386. the properties of river sand are shown in below Table 2. The properties of silica fume, superplasticizer and combination of coconut shell ash and eggshell ash as shown in Table. 3,4 & 5.

Table 2. Properties of Fine Aggregate & Coarse Aggregate

Properties	Fine Aggregate	Coarse Aggregate
Specific gravity	2.344	2.833
Fineness	2.997	6.617
Water Absorption	1%	2%

C. Silica Fume, Super plasticizer and Cementitious Material

The properties of these materials are shown in Table 3,4 & 5.

Table 3. Properties of Silica fume

Properties	Value
Colour	White
Form of nature	Powder
Specific gravity	2.3
Fineness modulus	97%

Table 4. Properties of Super plasticizer (Conplast SP 430)

Properties	Value
Colour	Brown
Form of nature	Liquid
Specific gravity	1.145
Chloride content	Nil
Air entrainment	Approximately 1%

Table 5. Properties of Combination of Coconut shell and Egg shell ash

Properties	Value
Colour	Black
Specific gravity	1.38
Fineness modulus	1%

D. Mix Proportion

The mix proportioning for M40 grade concrete used in the present work. It is designed as per IS 10262-1982 standards. The mix proportioning adopted was cement: cementitious materials sand: coarse aggregate: water/cement ratio respectively. The mix proportion for M40 grade of concrete and various different mixes were shown in Table. 6 and 7.

Table 6. Mix Proportion

Volume of Concrete	Cement	Water	C.M	Fine Aggregate	Coarse Aggregate	Super Plasticizer
By Weight (kg/m^3)	277.05	143.927	118.74	708.53	1163.34	3.5
By Volume	0.7	0.4	0.3	1.79	2.94	1% of cement
Note: C.M – Cementitious Material						

Table 7. Various Mix Proportions

Sl. No	Notation	Mix		
		Cement	S. F	C.M
1	Controlled Concrete	100%	0%	0%
2	Mix 1	80%	15%	5%
3	Mix 2	75%	15%	10%
4	Mix 3	70%	15%	15%
Note: C.M – Cementitious Material				

III. Experimental Investigation

A. General

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. One of the purposes of testing hardened concrete is to confirm that the concrete used at the site has developed the required strength.

B. Workability

The workability is characterized as the property of solid which decides the measure of helpful inner work important to deliver full compaction. The term workability gave to portray the simplicity or trouble with which the solid is taken care of, shipped and put between the structures with least loss of homogeneity. Tested values are shown in table 8,9 & 10.

Table 8. Slump Value

Sl.No	Mix	Slump Value
1	Controlled Concrete	65 mm
2	Mix 1	70 mm
3	Mix 2	70 mm
4	Mix 3	69 mm

Table 9. Compaction Factor

Sl.No	Mix	Compaction Factor
1	Controlled Concrete	0.90
2	Mix 1	0.92
3	Mix 2	0.91
4	Mix 3	0.89

Table 10. Vee Bee Consistometer

Sl.No	Mix	Slump Value	Time Taken
1	Controlled Concrete	13.8 cm	14 sec
2	Mix 1	13.8 cm	10 sec
3	Mix 2	12 cm	11 sec
4	Mix 3	11 cm	12 sec

C. Experimental Work

In these work mineral admixtures such as Silica fume and Combination of coconut shell and eggshell ash were partially replaced for cement. Silica fume is added in constant percentage of 15% for very mix design ratio [20]. Based on various literatures reviewed, combination of coconut shell and eggshell ash was added at a various proportion of 5%, 10%, 15%. The mix proportions are Controlled concrete, Mix 1, Mix 2, and Mix 3. The cube of 150mm × 150mm × 150mm, the cylinder of 150mm dia and 300mm deep and 500mm × 100mm × 100mm. The concrete specimens will be tested following strengths are compressive strength, split tensile strength and flexural strength for 7 days and 28 days.

IV. Results and Discussion

A. Compressive Strength

The results of compressive strength were presented in Table 11.

Table 11 Compressive Strength (M_{40})

Sl. No	Notation	Compressive Strength (N/mm^2)	
		7 days	28 days
1	CC	24.02	39.57
2	Mix 1	27.24	41.12
3	Mix 2	22.93	37.60
4	Mix 3	18.31	30.56

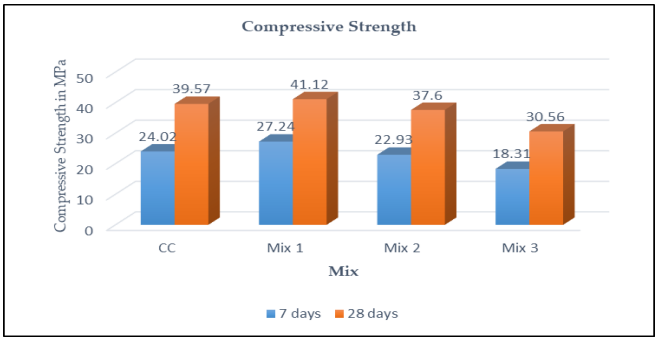

Fig. 2 Compressive Strength

From Fig.2 we observed that the optimum results are achieved in the Mix 1. i.e., 80% of cement, 15 % of silica fume and 5 % of Cementitious material. The results were compressive strength of 41.12 MPa achieved in 28 days and 27.24 MPa achieved in 7 days.

B.Split Tensile Strength

Table 12. Split Tensile Strength (M40)

Sl. No	Notation	Split Tensile Strength (N/mm^2)	
		7 days	28 days
1	CC	2.2	3.3
2	Mix 1	2.6	3.4
3	Mix 2	2.3	3.2
4	Mix 3	2.1	2.8

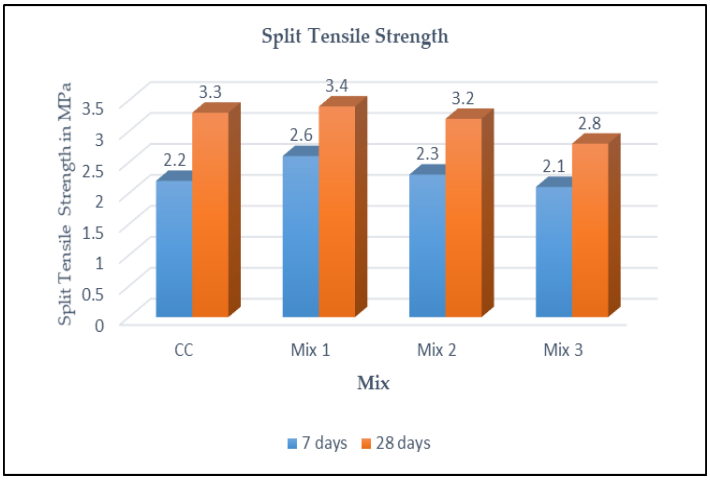

Fig. 3 Split Tensile Strength

From Fig.3 we observed that the optimum results are achieved in the Mix 1. i.e., 80% of cement, 15 % of silica fume and 5 % of Cementitious material. The results were Split Tensile strength of 3.4 MPa achieved in 28 days and 2.6 MPa achieved in 7 days.

C.Flexural Strength

The results of flexural strength were presented in Table 13.

Table 13. Flexural Strength (M40)

Sl. No	Notation	Flexural Strength (N/mm^2)	
		7 days	28 days
1	CC	4.4	5.2
2	Mix 1	4.6	5.8
3	Mix 2	4.3	5.1
4	Mix 3	4.2	4.8

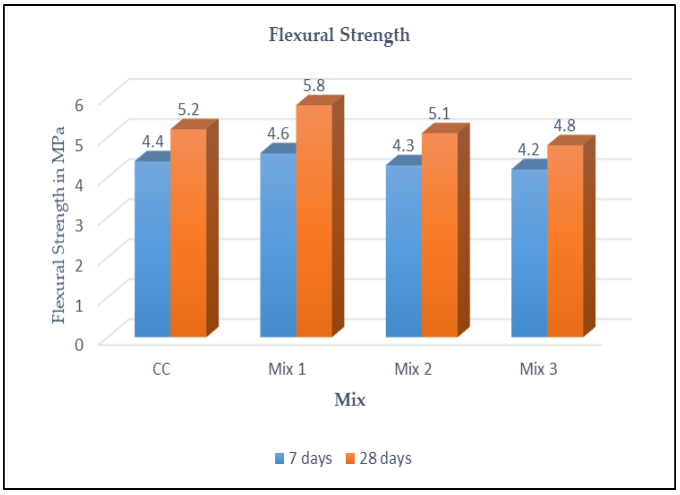

Fig. 4 Flexural Strength

From Fig.4 we observed that the optimum results are achieved in the Mix 1. i.e., 80% of cement, 15 % of silica fume and 5 % of Cementitious material. The results were flexural strength of 5.8 MPa achieved in 28 days and 4.6 MPa achieved in 7 days.

V. CONCLUSION

From the test results we concluded the below points,

- The average compressive strength of HPC is increased in Mix 1 (80% of cement, 15% of silica fume and 5% of combination of coconut shell and eggshell ash) has 3.92% slightly higher than the conventional concrete.
- The split tensile strength of HPC is increased in Mix 1 (80% of cement, 15% of silica fume and 5% of combination of coconut shell and eggshell ash) has 3.92% higher than the conventional concrete.
- The average flexural strength of HPC is increased in Mix 1 (80% of cement, 15% of silica fume and 5% of combination of coconut shell and eggshell ash) has 11% higher than the conventional concrete.
- From this experimental investigation we conclude that Mix 1 (80% of cement, 15% of silica fume and 5% of

combination of coconut shell and eggshell ash) has more than the conventional concrete and other mix proportions of Mix 2 and Mix 3.

- The average compressive strength of HPC is decreased in Mix 2 (75% of cement, 15% of silica fume and 10% of combination of coconut shell and eggshell ash) has 5.24% less than the conventional concrete. But economical in construction.
- The average split tensile strength of HPC is decreased in Mix 2 (75% of cement, 15% of silica fume and 10% of combination of coconut shell and eggshell ash) has 3% less than the conventional concrete. But economical in construction.
- The average flexural strength of HPC is decreased in Mix 2 (75% of cement, 15% of silica fume and 10% of combination of coconut shell and eggshell ash) has 1.92% less than the conventional concrete. But economical in construction.
- From this experimental investigation we conclude that Mix 1 (80% of cement, 15% of silica fume and 5% of combination of coconut shell and eggshell ash) has more than the conventional concrete and other mix proportions of Mix 2 and Mix 3.
- For major building construction we can use Mix 1 (80% of cement, 15% of silica fume and 5% of combination of coconut shell and eggshell ash) and for other building construction conventional concrete is to suitable.
- For minor building construction we can use Conventional Concrete Mix and Mix 2 (75% of cement, 15% of silica fume and 10% of combination of coconut shell and eggshell ash) and for other building construction conventional concrete is to suitable.

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