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MECHANICAL PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF SILICA FUME, M-SAND AND COCONUT SHELL

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Abstract:

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water and river sand is the main raw material used as fine aggregate in the production of concrete. The natural sources of river sand are getting depleted gradually. The demand for the protection of the natural environment and the ban on mining in some areas is further aggravating the problem of availability of river sand. Silica fume, also known as micro silica, is a by-product of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica fume is also collected as a by-product of other silicon alloys such as ferrochromium, Ferro magnesium, and calcium silicon.Manufacture sand and coconut shells are used to replace fine aggregate and coarse aggregate respectively. This work examines the possibility of using all three replacements for cement, fine aggregate and coarse aggregate for new concrete and tested for its compressive, Tensile and flexural strength up to 28 days of age and were compared with those of conventional concrete. To assess effectiveness of partial replacement of sand by its weight with 10%, 20%, 30 % of M-Sand. Silica fume dosages used are 10%,15% & 20% of the total Cement. Coconut Shells replacements used are 10%,20% & 30% of the total Coarse aggregates.It is found that Silica fume provided peak strength at 15% where M-sand at 30 % and Coconut shell at 10 % later the strength reduced with increase in percentage of coconut shells individually. On combined application we found highest strength for SF 15% + MS 30 % + CS 10% in compression.Whereas split tensile strength was observed highest for the following combination SF 15% + MS 30 % + CS 30%.

Key Words: Cement, Sand, Coarse aggregate, M-Sand, Silica Fume, Compressive strength, Split tensile strength.

1. INTRODUCTION

The concrete innovation has made colossal walks in past decades. Concrete is an extremely solid and flexible mouldable development material or Concrete is a composite material that comprises basically of a coupling medium inside which are inserted particles or sections of total. In pressure driven cement concrete, the fastener is framed from a blend of pressure driven cement and water. It comprises of cement, sand and total (e.g., rock or smashed shake) blended with water and admixture. The cement and water shape a glue or gel which coats the sand and total. At the point when the cement has synthetically responded with the water (hydrated), it solidifies and ties the entire combine. The underlying solidifying response ordinarily happens inside a couple of hours. It takes half a month for concrete to achieve full hardness and quality. Concrete can proceed to solidify and pick up quality over numerous years. The concrete made for particular applications

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and it contains a few unique materials like GGBS, Metakoalin, Pozzolanic materials. The advancement of determining the concrete according to its execution necessities as opposed to the constituents and fixings in concrete has opened incalculable open doors in concrete to configuration concrete according to particular prerequisites.

Table 1 – Physical properties of cement

S.No.	Characteristics	Test results	Requirements as per IS 12269 – 1987
1	Fineness (retained on 90-µm sieve)	6%	<10%
2	Normal Consistency	33%	--
3	Initial setting time of cement	90 min	30 minutes (minimum)
4	Final setting time of cement	340 min	600 minutes (maximum)
5	Expansion in Le-chatelier method	4 mm	10 mm (maximum)
6	Specific gravity	3.15	3.10 – 3.25

2. MATERIAL PROPERTIES AND EXPERIMENTAL INSVESTIGATIONS

CEMENT:

In this investigation, Zuari Cement of 53 grade review Ordinary Portland Cement fitting in with IS: 12269– 1987 was utilized for the whole work. The cement was bought from single source and was utilized for throwing of all examples. The physical properties of cement are outfitted in Table 1

FINE AGGREGATE:

The physical properties of sand are furnished in Table 2. Sieve analysis was performed to determine fineness modulus and grain size distribution of sand and sieve analysis was given in table 3. The gradation curve is shown in Fig 1

TABLE 2– Physical Properties of River Sand

S. No	Test conducted	Results obtained		Permissible Limits as per IS 383 – 1970
1	Specific gravity	2.67		2.5 to 3.0
2	Fineness modulus	3.05		--
3	Bulk density	**Loose State**	1450 kg/m^3	1400 to 1750 kg/m^3
		Compacted State	1520 kg/m^3	
4	Water absorption (%)	1.09		Max 3%
5	Sieve Analysis	Zone – II		--

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Table 3.– Sieve Analysis of Sand

Sieve Size	Weight Retained (gm)	Cumulative % Retained	Cumulative % Passing	Zone - Specifications as per IS:383-1970 for % Passing			
				I	II	III	IV
4.75 mm	0	0	100	90-100	90-100	90-100	95-100
2.36 mm	22	2.2	97.8	60-95	75-100	85-100	95-100
1.18 mm	46	6.8	93.2	30-70	55-90	75-100	90-100
600 µ	215	28.3	71.7	15-34	35-59	60-79	80-100
300 µ	419	70.2	29.8	5-20	8-30	12-40	15-50
150 µ	282	98.4	1.6	0-10	0-10	0-10	0-10
Pan	14	99.8	0.2	---	---	---	---
Total = 305/100 Fineness Modulus = 3.05							

COARSE AGGREGATE:

The physical properties of coarse aggregate are furnished in Table 4. and the sieve analysis of 20mm coarse aggregate is given in table 5

Table 4 Physical Properties of Coarse Aggregate

S. No	Test conducted	Results obtained		Permissible Limits as per IS 383 – 1970
1	Specific gravity	2.78		2.5 to 3.0
2	Bulk density	**Loose State**	1480 kg/m^3	1400 to 1750 kg/m^3
		Compacted State	1560 kg/m^3	
3	Elongation Index	20%		Max 25%
4	Flakiness Index	22%		Max 25%
5	Fineness modulus	7.52		--
6	Water absorption (%)	1.20		Max 3%

Table 5 Sieve Analysis of Coarse Aggregate

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IS sieve	Weight retained(kgs)	Cumulative % weight retained	Weight Passing	Cumulative weight % Passed
80 mm	0	0	100	0
40 mm	0	0	100	0
20 mm	5.2	52	48	5.2
10 mm	4.8	100	0	4.8
4.75 mm	0	100	0	0
2.36 mm	0	100	0	0
1.18 mm	0	100	0	0
600 µ	0	100	0	0
300 µ	0	100	0	0
150 µ	0	100	0	0
Total = 752/100 Fineness Modulus = 7.52				

WATER:

Water, the least expensive but the most important component of concrete. Locally available fresh bore well water confirming to the requirements of IS: 456 - 2000 was used for mixing concrete and curing the specimens as well.

SILICA FUME:

Silica fume is a by-product resulting from the reduction of high quantity quartz with coal in electric arc in the manufacture of silicon or ferrosilicon alloy. And it is obtained from ASTRRA chemicals, Chennai. The chemical properties of silica fume is as follows.

Table 6 Chemical properties of Silica Fume

S.No.	Property	Results
1	Silica (SiO_2)	99.886%
2	Alumina (Al_2O2)	0.043%
3	Ferric Oxide (Fe_2O_3)	0.040%
4	Titanium Oxide (TiO_2)	0.001%

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5	Calcium Oxide (CaO)	0.001%
6	Magnesium Oxide (MgO)	0.000%
7	Pottasium Oxide (K_2O)	0.001%
8	Sodium Oxide (Na_2O)	0.003%
9	Loss On Ignition	0.015%

COCONUT SHELL :

The physical properties of coconut shells are as follows.

Table 7 - Physical properties of coconut shells are specified in the table below.

S. No	Physical Property	Test Results
01	Specific Gravity	1.33
02	Water Absorption (%)	24
03	Bulk Density(kg/m3)	800
04	Shell Thickness	(2-7)mm

MANUFACTURED SAND:

The Manufactured Sand (MS) is a by-product of the crushing and screening process in the quarries. Quarry generates considerable volumes of quarry fines while crushing the rock into aggregates.

Table 8 Properties of M-Sand

S.No.	Property	Value
1	Specific Gravity	2.84
2	Water Absorption	5.6%
3	Fineness Modulus	2.84

3. TEST SPECIMENS :

Concrete test specimens consist of 150 mm × 150 mm × 150 mm cubes, cylinders of 150 mm diameter and 300 mm height. Concrete cube specimens were tested at 3, 7, 28 & 56 days of curing to obtain the compressive strength of concrete. Cylindrical specimens were tested at the age of 28 days to obtain the compressive strength and split tensile strength of concrete.

Table 9 – Mix Proportions for M30 Grade Concrete per cubic meter

S. No	Mix Identification	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregate	Water (lit)	Silica Fume (kg)	M-Sand (kg)	Coconut Shells

				(kg)				(Kg)
1	CC	340	730.15	1294.45	153	0	0	0
2	10% SF	306	730.15	1294.45	153	34	0	0
3	15% SF	289	730.15	1294.45	153	51	0	0
4	20% SF	272	730.15	1294.45	153	68	0	0
5	10% MS	340	657.14	1294.45	153	0	76.4	0
6	20% MS	340	584.12	1294.45	153	0	152.8	0
7	30% MS	340	511.10	1294.45	153	0	229.21	0
8	10% CS	340	730.15	1165.01	153	0	0	60.92
9	20% CS	340	730.15	1035.56	153	0	0	121.84
10	30% CS	340	730.15	906.12	153	0	0	182.77
11	15% SF + 30% MS+ 10% CS	289	497.69	1134.44	153	51	229.21	60.92
12	15% SF + 30% MS+ 20% CS	289	497.69	1008.39	153	51	229.21	121.84
13	15% SF + 30% MS+ 30% CS	289	497.69	882.34	153	51	229.21	182.77

4. RESULTS AND DISCUSSIONS:

COMPRESSIVE STRENGTH:

It is observed that the compressive strength of concrete prepared by replacing 15% Silica Fume as Partial replacement of Cement exhibits improved Compressive Strength upto 15.40% compared to Control Concrete and also observed that with further increase in content of Silica Fume – The Compressive Strength decreases. The Maximum improvement is observed at 30% of Manufactured Sand replaced in Fine Aggregate resulted in 21% higher compared to Control Concrete. Coconut Shells are partially replaced as replacement for Coarse Aggregate to an extent 10%, 20% & 30%. But 10% replacement of Coconut Shell replacement exhibited 5.67% improvement in Compressive Strength compared to Control Concrete and further replacements i.e. 20% & 30% of Coconut Shells resulted in deterioration of strength properties. Combined application of 15% Silica Fume, 30% Manufactured Sand and 10% Coconut Shells proved to be optimum combination of all by resulting in 29.84% increase in Compressive Strength compared to Control Concrete. The above results are graphically represented below.

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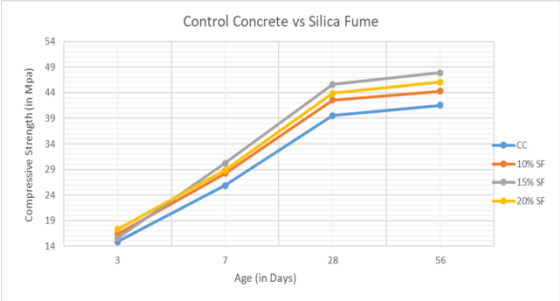
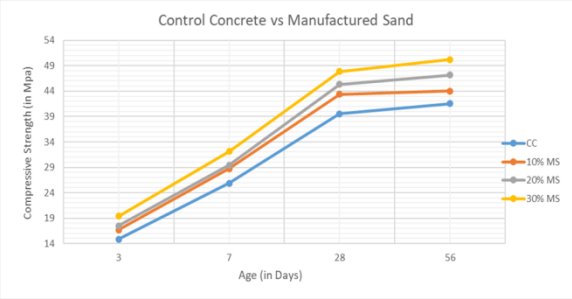
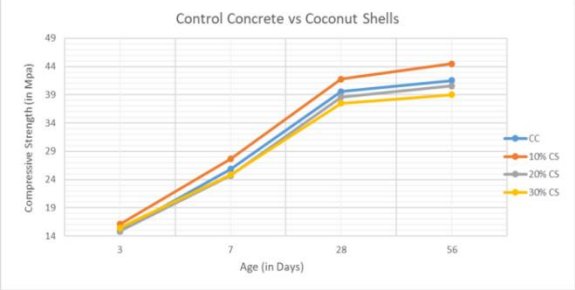


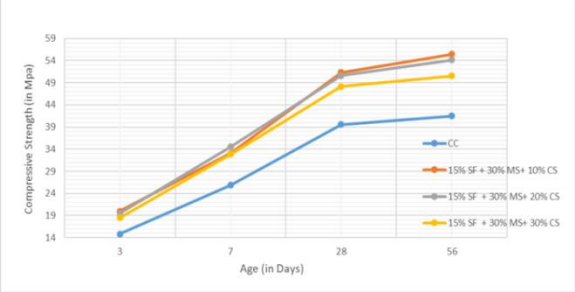
(i)Silica Fume



(ii) Manufactured Sand



(iii) Coconut Shells



(iv) 15% Silica Fume + 30% M Sand and Coconut Shells

Fig. 1. Variation of Cube Compressive Strength of M30 Grade Concrete with age for different percentages of Silica Fume, M Sand and Coconut Shells

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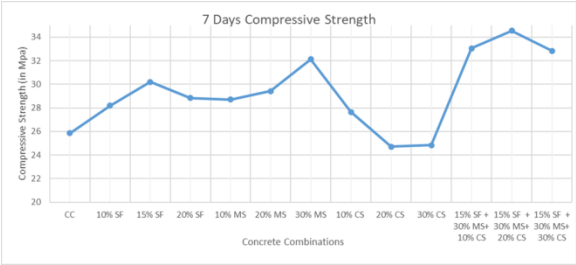
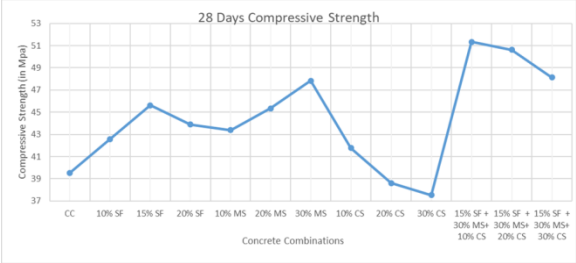
The variation of 7 – Days and 28 Days Compressive Strength of Concrete with various proportions of Silica Fume (10%, 15% & 20%), Manufactured Sand (10%, 20% & 30%), Coconut Shells (10%, 20% & 30%) & Combined Applications is shown in Fig 2.



(a) *7 days Cube Compressive Strength*



(b) 28 days Cube Compressive Strength

Fig. 2 Variation of 7 days and 28 days Cube Compressive Strength of M30 Grade Concrete with age for different percentages of

Silica Fume, M Sand and Coconut Shells

SPLIT TENSILE STRENGTH:

The variation of split tensile strength of M30 grade of concrete is shown in Fig. 3. The Split tensile strength of Control concrete is 4.17 MPa. It is observed that all the replacements Silica Fume (10%, 15% & 20%), Manufactured Sand (10%, 20% & 30%), Coconut Shells (10%, 20% & 30%) exhibits increase in Split Tensile Strength Characteristics compared to Control Concrete, But the Optimum mix of Concrete with Silica Fume (15%), Manufactured Sand (30%) & Coconut Shells (30%) resulted in significant improvement with 18.95% more than Control Concrete

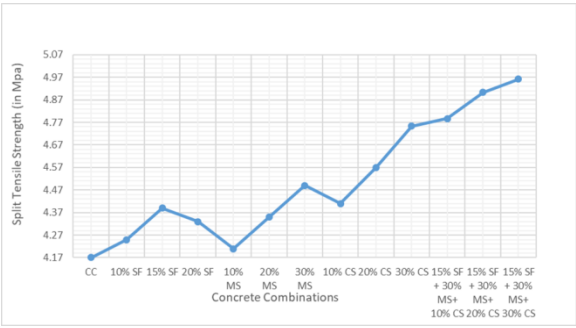


Fig.3 .Variation of Split Tensile Strength of M30 Grade Concrete for different percentages of Silica Fume, M Sand and Coconut Shells.

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FLEXURAL STRENGTH:

The variation of flexural strength of M30 grade of concrete containing various proportions of Silica Fume, M Sand and Coconut Shells is shown in Fig.4. The Flexural strength of Control concrete is 7.95 MPa. It is observed that all the replacements Silica Fume (10%, 15% & 20%), Manufactured Sand (10%, 20% & 30%), Coconut Shells (10%, 20% & 30%) exhibits increase in Flexural Strength Characteristics compared to Control Concrete, But the Optimum mix of Concrete with Silica Fume (15%), Manufactured Sand (30%) & Coconut Shells (30%) resulted in significant improvement with 26.54 % more than Control Concrete.

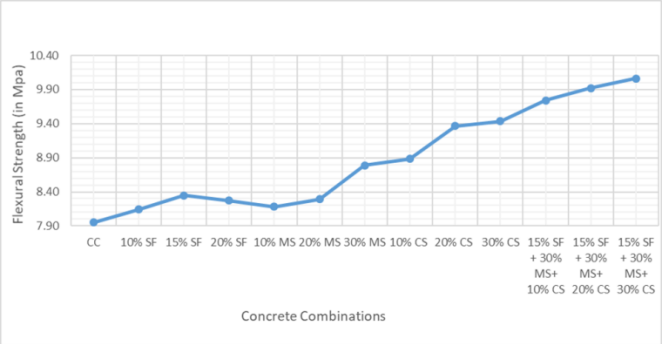

Fig.1 . Variation of Flexural Strength of M_{30} Grade Concrete for different percentages of Silica Fume, M Sand and Coconut Shells.

5. CONCLUSIONS:

Silica fume concrete shows highest compressive strength at 15%. Whereas with the increase in Manufactured Sand (10%, 20% & 30%) as replacement of Fine Aggregate – The Compressive Strength increased upto 30% replacement level and resulted in 21% higher than Control Concrete. In case of Coconut Shell (10%, 20% & 30%) – With the increase in Content of Coconut Shells – The Compressive Strength decreased significantly. Coarse Aggregate replaced with 10% Coconut Shells exhibited 5.67% more than Conventional Concrete. However Combined application of 15% Silica Fume, 30% Manufactured Sand and 10% Coconut Shells proved to be optimum combination of all by resulting in 29.84% increase in Compressive Strength compared to Control Concrete. With combined Application of Silica Fume (15%), Manufactured Sand (30%) & Coconut Shell (30%) – It is observed that the Split Tensile Strength increased about 18.95% compared to Conventional Concrete. With combined Application of Silica Fume (15%), Manufactured Sand (30%) & Coconut Shell (30%)

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