An Experimental Study On the Partial Replacement Of Cement by Silica Fume and Coconut Shell Ash In Concrete

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Abstract - The ascending in the material expense is the matter of worry in the creating development environment. This increment in the material expense is because of the expanded interest for material because of expansion in populace and less accessibility. In this manner there is a need to discover elective material that can be supplanted with elements of cement. Analysts are scrutinizing the material to lessen the expense of development likewise to accomplish the better execution. Coconut shell is horticulture waste and its slag can be utilized as an incomplete trade for bond because of its high silica content. Since the expense of concrete is expanding step by step furthermore the interest is high, there is a need to discover elective restricting material that can be supplanted with bond to minimize the development expense furthermore to accomplish quality. This paper basically manages the powerful usage of horticultural waste material as an incomplete substitution for bond in solid creation. The concrete is supplanted with coconut shell cinder and silica fume in the present work. Cement has been supplanted by coconut shell fiery debris in the measurements of 0%, 5%, 10%, 15% and silica fume by 0%, 5%, 10%, 15%, and 20% weight of cement with w/c proportion 0.48 for M30 concrete. It is found that coconut shell fiery debris and silica fume helped in expanding the execution of concrete when contrasted with the typical cement. Workability tests are led on new concrete and compressive strength for 7, 28, 56, and 90 days and split tensile strength, modulus of elasticity tests are led for 28 days to assess the hardened properties of concrete for various mixes.

***Key Words*: Coconut shell ash, Silica fume, compressive strength, split tensile strength, modulus of elasticity.**

1. INTRODUCTION

Concrete is defined as manmade composite material in which major constituents is binding medium and aggregate particles. It is considered as a very durable material with little or no maintenance. The concrete is mainly designed on the basis of compressive strength at the same time concrete is weak in tensile strength and little resistance to cracking, and more drying shrinkage ,less abrasion and erosion resistance. For special type of constructions like high rise buildings, long span bridges, deep underground structures the concrete should possess high performance in terms of durability and strength. So the inherent properties of normal concrete should be enhanced to the requirement by the addition of admixtures or suitable ingredients. Production of concrete involves the various steps like volume or weigh batching the materials of concrete like cement, coarse aggregate and fine aggregate and water and the mixing it in a proper proportion according to the mix design as per IS codes. The coarse aggregate should not contain any flakiness or elongation and the fine aggregate must be free from debris and any kind of impurities, water used for mixing of concrete must be portable water. Concrete is the most consumed material after water.

Because of the expanding population the requirement for lodging and other development exercises expanding step by step. Furthermore, the expense of fixings utilized as a part of the solid likewise increments with the expanding request. So there is a need to locate the option material that can be utilized as a substitution for elements of cement such that the supplanted material ought to have same properties as that of material that is to be supplanted. Also, the expense of cement is high contrasted with different materials that are utilized as a part of the concrete, and the creation of concrete radiates expansive measure of CO_2 so the usage of modern waste or normally accessible waste has been energized in the development field. Furthermore numerous non-rotting materials will bring about natural risks to conquer all these evil impacts and to upgrade the properties of typical cement by utilizing locally accessible or reused material there by decreasing the shortage of materials of cement furthermore the waste will be minimized. Cement can be supplanted with other actually accessible waste material, for example, coconut shell ash, sugar stick baggasse ash, and such other agribusiness waste materials with the shifting rate to get the wanted quality properties. By utilizing waste materials as a part of concrete production their transfer issue can be minimized. Additionally making the best possible use of rural waste development expense can be minimized likewise making the structure as zero carbon.

1.1 OBJECTIVE

The destinations of the study are as per the following,
- To study the fresh and hardened properties of concrete.
- To locate the sparing answer for high cost of cement.
- To determine the optimum percentage of coconut shell ash and silica fume based on strength criteria.

1.2 NEED FOR THE STUDY

- For requirement of substitute for cement.
- To overcome the material shortage of concrete.
- To lessen the expense by making utilization of locally accessible materials.
- To check different properties of concrete with various percentages of Coconut shell ash and Silica fume.

1.3 SCOPE OF THE PRESENT STUDY

M30 grade of concrete was considered in this present study. Mix design was carried out according to the recommendation of IS 10262-(2009). Cement was partially replaced with coconut shell ash from 5% to 15% and silica fume from 0% to 20% an interval of 5% by weight of cement and strength properties of the concrete will be studied. Properties of cement replaced with silica fume and coconut shell ash concrete in fresh state such as workability and in hardened state such as density, strength tests are carried out.

2. EXPERIMENTAL PROGRAM

Mix design is set up according to the rules in IS code prerequisites for conventional concrete. In the present work M30 mix is utilized. The materials utilized and their properties are talked about before. The materials are proportioned according to mix outline stipulations and measure clustering is finished. The concrete is blended utilizing mechanical blender machine till the homogeneity in the mix is watched. And after that it is filled a metallic plate, to test the workability of the blend the solid is filled into the droop cone in three layers every layer being packed 25 blows and level the top surface of solid, then the droop cone is lifted gradually, then the droop is noted down with the assistance of measuring pole and noted down. And after that the solid is filled into 3D shapes of 100*100*100 mm for testing of compressive quality, 100*100*500 mm rectangular crystal for flexural quality and for split elasticity round and hollow mold of 100mm breadth and 200mm tallness. Modulus of flexibility is tried for tube shaped mold of 150mm width and 300mm tallness utilizing the instrument called extensometer. Like insightful all the mechanical properties of solidified cement are resolved. Compressive quality of the example is tried for 7, 28, 56 and 90 days and Modulus of flexibility, Flexural quality, and Split rigidity are resolved for 28 days.

2.1 MIX DESIGN

Blend outline is set up for M30 concrete according to IS code proposal and taking after are the configuration stipulations.

Table -1: Mix Proportion

Batch Unit	Cement (Kgs)	Fine Aggregate (Kgs)	Coarse Aggregate (Kgs)	Water (liters)
Meter cube of concrete	400	676	1124	192
Ingredients Proportion	1	1.69	2.81	0.48

2.1 CONCRETE MIX PROPORTIONS

Ordinary Portland cement, Coconut shell fiery remains, Silica fume, Fine aggregate, Coarse aggregate are the materials utilized as a part of the present study. In this study bond is supplanted with coconut shell cinder at a different rates fluctuating from 0%, 5%, 10%, and 15% and silica rage at 0%, 5%, 10%, 15%, and 20%. Furthermore, the impacts were considered. The impacts of fractional substitution are studied for sixteen distinctive blends of M30 cement. All the blends are arranged and cast under room temperature; the blends are as per the following.

Table -2: Mix Proportion for Materials

Mix Design	Cement (Kgs)	Silica Fume (Kgs)	Coconut Shell Ash (Kgs)	Fine Aggregate (Kgs)	Coarse Aggregate (Kgs)	Water (liters)
M	400	-	-	676.50	1124.60	192
M1	380	20	-	676.50	1124.60	192
M2	360	20	20	676.50	1124.60	192
M3	340	20	40	676.50	1124.60	192
M4	320	20	60	676.50	1124.60	192
M5	360	40	-	676.50	1124.60	192
M6	340	40	20	676.50	1124.60	192
M7	320	40	40	676.50	1124.60	192
M8	300	40	60	676.50	1124.60	192
M9	340	60	-	676.50	1124.60	192
M10	320	60	20	676.50	1124.60	192
M11	300	60	40	676.50	1124.60	192
M12	280	60	60	676.50	1124.60	192

M13	320	80	-	676.50	1124.60	192
M14	300	80	20	676.50	1124.60	192
M15	280	80	40	676.50	1124.60	192
M16	260	80	60	676.50	1124.60	192

3. RESULTS AND DISCUSSION

3.1 SLUMP CONE TEST

Table -3: Slump Values for different mixes

Mixes	Slump (mm)
CM	70
SF 5%	65
SF 10%	60
SF 15%	55
SF 20%	50
SF 5% CSA 5%	60
SF 5% CSA 10%	55
SF 5% CSA 15%	40
SF 10% CSA 5%	50
SF 10% CSA 10%	40
SF 10% CSA 15%	35
SF 15% CSA 5%	40
SF 15% CSA 10%	30
SF 15% CSA 15%	20
SF 20% CSA 5%	30
SF 20% CSA 10%	20
SF 20% CSA 15%	10

3.1.1 Effect of SF on Slump

Slump values for concrete containing 5%, 10%, 15% and 20% silica fume are shown in chart 1. From graph it can be seen that workability of the mix decreases that is about 28% with the increasing percentage of silica fume than control mix due to large surface area of silica fume it absorbs more water thereby decreasing the slump value.

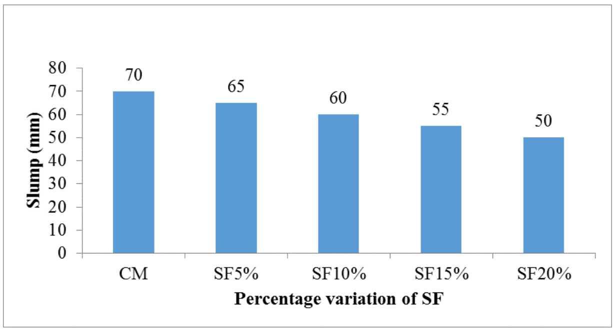

Chart -1: Effect of SF on Slump

3.1.2 Effect of SF and CSA on Slump

Slump values of mix by the addition of coconut shell ash at varying percentages 5%, 10%, 15% and at constant 5%, 10%, 15% and 20% silica fume are shown in chart 2 and 3 are shown in the graph below and it can be seen that slump value goes on decreased compared to control mix with the increasing percentage of coconut shell ash at constant value of silica fume. It is due to the presence of silica fume and coconut shell ash in concrete having more surface area absorbs more water.

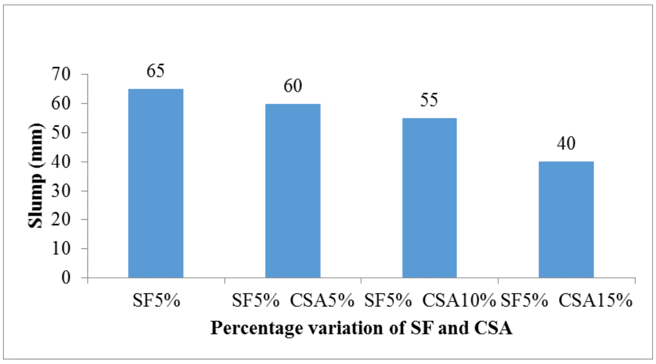

Chart -2: Effect of 5% of SF on various % of CSA on Slump

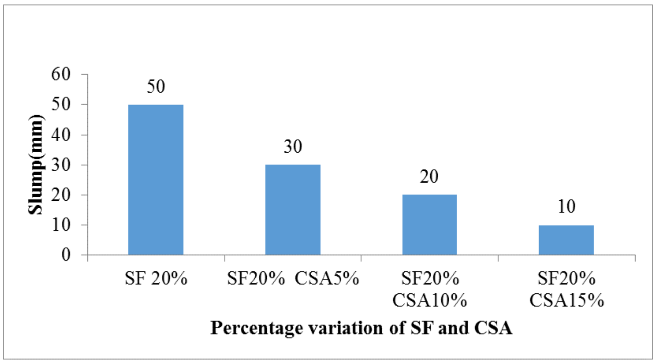

Chart -3: Effect of 20% of SF on various % of CSA on Slump

3.1.3 Effect of CSA and SF on Slump

Slump values of various mixes are shown in the above chart 1, 2 and 3. Here the effect is studied by keeping Coconut shell ash percentage constant and varying the silica fume content. From the below chart it can be seen that the slump goes on decreasing with the increasing percentage of silica fume at a constant percentage of coconut shell ash. It may be due to the large surface area of silica fume it absorbs more water there by making the mix little workable.

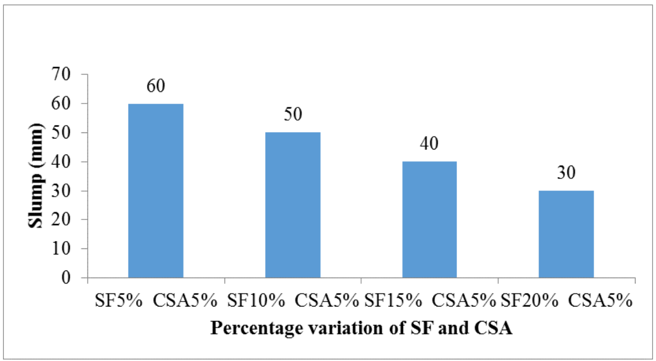

Chart -4: Effect of 5% of CSA on various % of SF on Slump

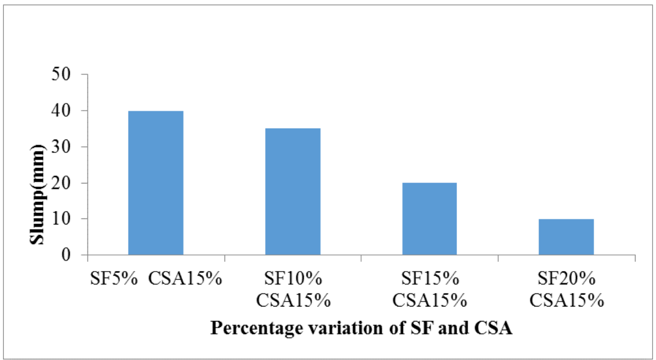

Chart -5: Effect of 20% of CSA on various % of SF

3.2 DENSITY RESULTS

Table -4: Density for different mixes

Mixes	Density (kg/m)
CM	2550
SF 5%	2560
SF 10%	2585
SF 15%	2570
SF 20%	2565
SF 5% CSA 5%	2520
SF 5% CSA 10%	2515
SF 5% CSA 15%	2510
SF 10% CSA 5%	2500
SF 10% CSA 10%	2490
SF 10% CSA 15%	2485
SF 15% CSA 5%	2470
SF 15% CSA 10%	2465
SF 15% CSA 15%	2450
SF 20% CSA 5%	2435
SF 20% CSA 10%	2420
SF 20% CSA 15%	2410

3.2.1 Effect of SF on Density

The density results of concrete mixes containing 5%, 10%, 15% and 20% of silica fume are shown in chart 6. Density values increases as the percentage of silica fume increases, the maximum density obtained for concrete containing 10% silica fume it is due to the reaction between the hydrated cement product and free lime reacts with each other producing more Calcium silicate hydrate and additional CH that fills the pores around the hydrated cement particle.

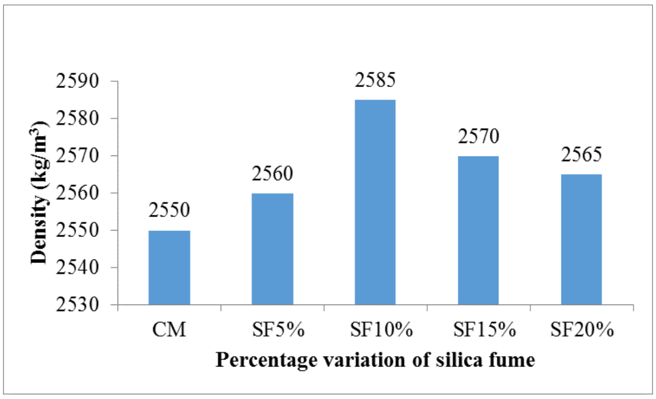

Chart -6: Effect of SF on Density

3.2.2 Effect of SF and CSA on Density

The density results of concrete mixes containing 5%, 10%, 15% coconut shell ash and constant 5% silica fume are there in chart 7. It can be seen that density values decreases as the percentage of coconut shell ash increases for constant value of 5% silica fume. The density results of concrete mixes containing 5%, 10%, 15% coconut shell ash and constant 10% silica fume are there in chart 7. Density values decreases as the percentage of coconut shell ash increases for constant value of 10% silica fume. The density results of concrete mixes containing 5%, 10%, 15% and constant 15% silica fume are there in chart 8 density values decreases as the percentage of coconut shell ash increases for constant value of 15% silica fume. The density results of concrete mixes containing 5%, 10%, 15% and constant 20% silica fume are there in Fig 8 .density values decreases as the percentage of coconut shell ash increases for constant value of 20% silica fume. It may due to the light weight nature of coconut shell ash due to large surface area.

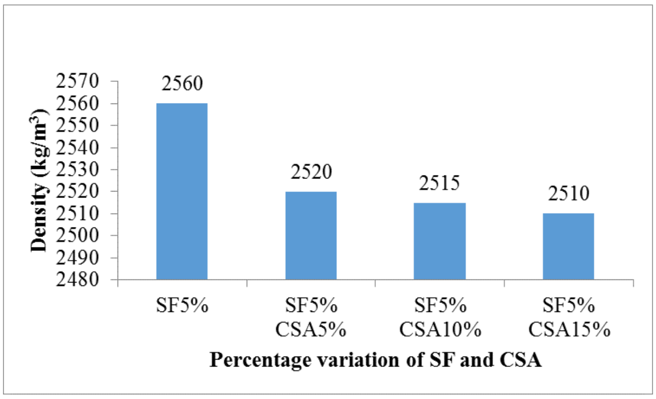

Chart -7: Effect of 5% of SF on various % of CSA on Density

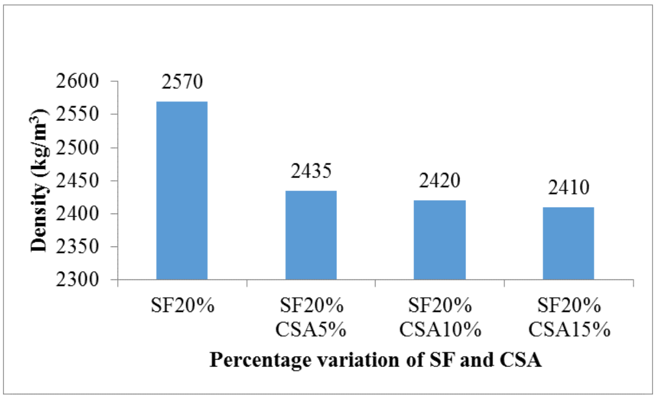

Chart -8: Effect of 20% of SF on various % of CSA on Density

3.2.3 Effect of CSA and SF on Slump

Density values of various mixes are shown in the above chart 9 and 10. Here the effect is studied by keeping Coconut shell ash percentage constant and varying the silica fume content. From the above chart it can be seen that density goes on decreasing with the increasing percentage of silica fume at a constant percentage of coconut shell ash. It may be due to the presence of coconut shell ash which is light weight in nature and also the specific gravity of coconut shell ash is less than that of silica fume and cement.

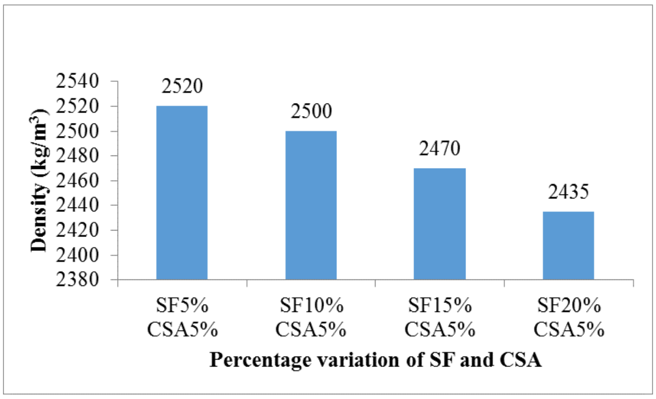

Chart -9: Effect of 5% of CSA on various % of SF on Density

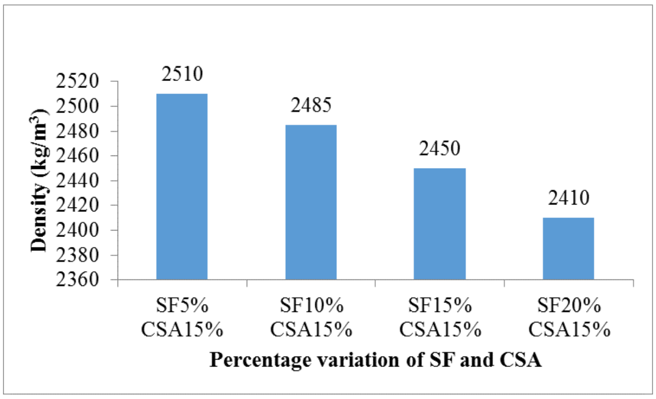

Chart -10: Effect of 20% of CSA on various % of SF on Density

3.3 COMPRESSIVE STRENGTH RESULTS

Table -5: Compressive strength results

	Compressive Strength (N/mm²)		
Mixes	7 Days	28 Days	56 Days
CM	27.34	45.40	46.34
SF 5%	31.44	51.23	52.47
SF 10%	33.45	53.54	54.80
SF 15%	30.83	54.09	51.20
SF 20%	28.63	48.47	49.68
SF 5% CSA 5%	30.12	51.48	52.60
SF 5% CSA 10%	32.50	53.15	54.87
SF 5% CSA 15%	30.50	50.42	51.78
SF 10% CSA 5%	31.79	53.87	54.65
SF 10% CSA 10%	34.89	55.85	57.70
SF 10% CSA 15%	32.42	51.35	52.60
SF 15% CSA 5%	29.30	49.97	50.20
SF 15% CSA 10%	32.65	51.78	52.72
SF 15% CSA 15%	30.78	50.89	51.73
SF 20% CSA 5%	25.86	48.72	49.78
SF 20% CSA 10%	27.60	50.84	51.94
SF 20% CSA 15%	25.60	48.81	49.65

3.1 EFFECT OF SF ON COMPRESSIVE STRENGTH

Chart 11 shows the variation of compressive strength of concrete with the addition of silica fume on concrete. The compressive strength results of concrete mixes containing silica fume 5%, 10%, 15% and 20% along with control mix are there in Fig 3.1. From the figure it is observed that compressive strength of concrete mixes containing 5%, 10%, 15% and 20% silica fume increases by 15.03%, 22.34%, 12.76% and 6.25% at 7 days, 11.76%, 20.45%, 7.09% and 6.34% at 28 days and 4.5%, 10.3%, 3.2% and 6.72% at 56 days respectively than the control mix. From the graph maximum compressive strength obtained for the concrete mix containing replacement of cement by 10% silica fume due to reaction between silica fume and hydrated product more C-S-H will be formed, it is responsible for strength of concrete.

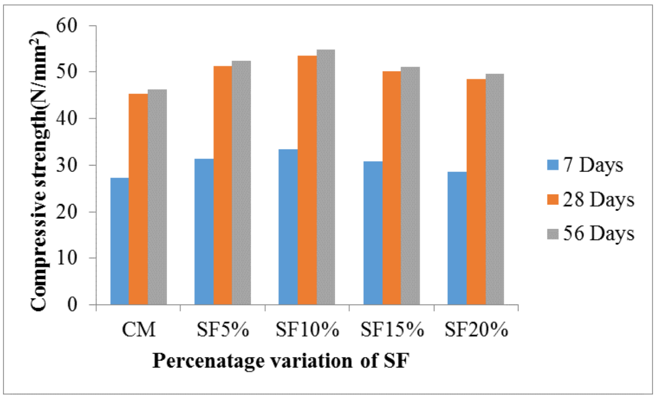

Chart -11: Effect of SF on Compressive Strength

3.2 EFFECT OF SF AND CSA ON COMPRESSIVE STRENGTH

The above chart 12 show the variation of compressive strength of concrete with the various dosage of coconut shell ash at a constant value of silica fume. Chart 12 shows the variation of coconut shell ash at a constant value of silica fume 5% and strength was maximum at 10% replacement of coconut shell ash which is 14.6% more than that of control mixes strength. Variation of coconut shell ash at a constant value of silica fume 10% and strength was maximum at 10% replacement of coconut shell ash which is 18.7% more than that of control mix strength. Variation of coconut shell ash at a constant value of silica fume 15% and strength was maximum at 10% replacement of coconut shell ash which is 12.2% more than that of control mix strength. Chart 13 shows the variation of coconut shell ash at a constant value of silica fume 20% and strength was maximum at 10% replacement of coconut shell ash which is 10.7% more than that of control mix strength. It may be due to the strength enhancement property of the silica fume and coconut shell ash due to high silica content.

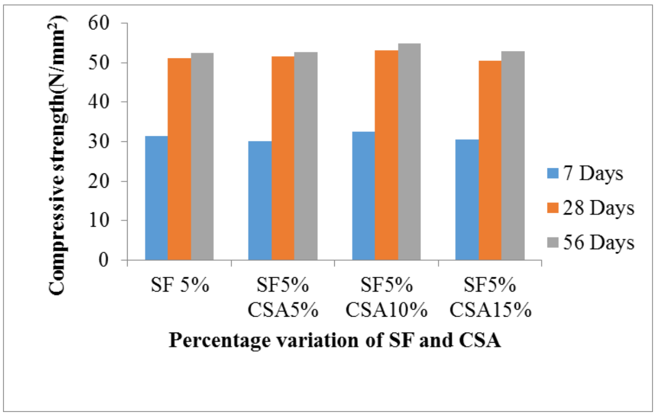

Chart -12: Effect of SF 5% and various % of CSA on Compressive Strength

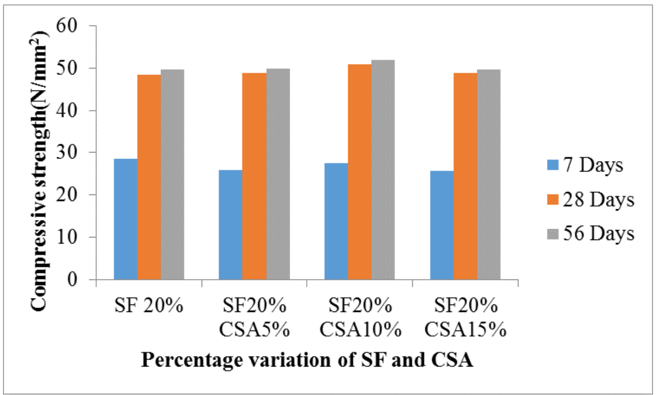

Chart -13: Effect of SF 20% and various % of CSA on Compressive Strength

3.3 EFFECT OF CSA AND SF ON COMPRESSIVE STRENGTH

Compressive strength of various mixes is shown in the above chart 14 and 15. Here the effect is studied by keeping Coconut shell ash percentage constant and varying the silica fume content. From the above chart it can be seen that compressive strength goes on increasing with the increasing percentage of silica fume up to 10% replacement at a constant percentage of coconut shell ash after that strength decreases. It may be due to the reaction between Silica fume and hydrated products of cement produce more C-S-H it is responsible for strength of concrete.

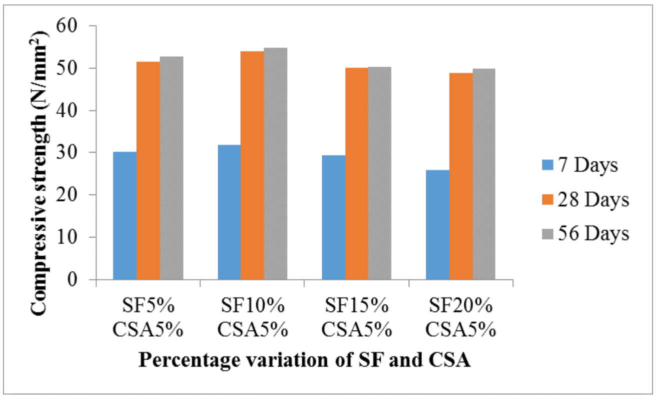

Chart -14: Effect of CSA 5% and various % of SF on Compressive Strength

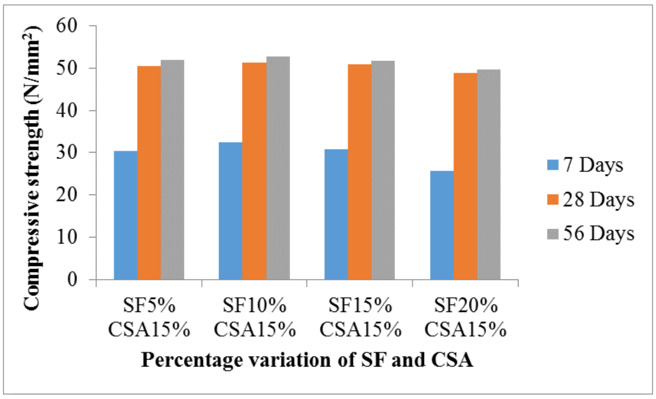

Chart -15: Effect of CSA 20% and various % of SF on Compressive Strength

3.4 SPLIT TENSILE STRENGTH

Table -6: Split tensile strength results

Mixes	Split Tensile Strength (N/mm²)
CM	3.34
SF 5%	3.7
SF 10%	4.2
SF 15%	3.93
SF 20%	3.50
SF 5% CSA 5%	3.9
SF 5% CSA 10%	4.2
SF 5% CSA 15%	3.8
SF 10% CSA 5%	4.5
SF 10% CSA 10%	4.7
SF 10% CSA 15%	4.3
SF 15% CSA 5%	4.1
SF 15% CSA 10%	4.4
SF 15% CSA 15%	4.0
SF 20% CSA 5%	3.7
SF 20% CSA 10%	4.0
SF 20% CSA 15%	3.6

3.4.1 EFFECT OF SF ON SPLIT TENSILE STRENGTH

The split tensile strength of various concrete mixes containing 5%, 10%, 15% and 20% silica fume and control mix are there in chart 16. From the figure the split tensile strength of concrete mix containing silica fume is higher compared than the control mix. The maximum tensile strength is obtained for the mix containing 10% silica fume due to pozzolanic reactivity of silica fume and its ability to fill void. The split tensile strength increases by 10.7% for concrete mix containing 5% silica fume, 25.7% for concrete mix containing 10% silica fume and 17.6% for concrete mix containing 15% silica fume, 5% for concrete mix containing 20% silica fume than the control mix.

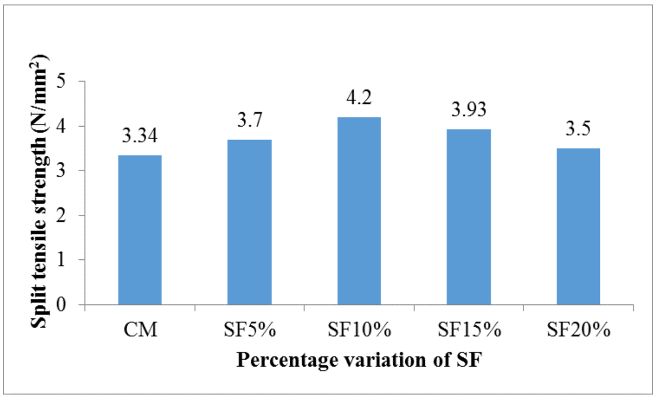

Chart -16: Effect of SF on Split Tensile Strength

3.4.2 EFFECT OF SF AND CSA ON SPLIT TENSILE STRENGTH

Chart 17 and 18 shows variation of split tensile strength of concrete with the addition of constant value of silica fume and varying percentage of coconut shell ash as partial replacement for cement, chart 17 shows the variation of split tensile strength with varying percentage of coconut shell ash at a constant value of silica fume 5% split tensile strength was maximum at 10% replacement of coconut shell ash that is 25.7% more than control mix. Chart 18 shows the variation of split tensile strength with varying percentage of coconut shell ash at a constant value of silica fume 20% split tensile strength was maximum at 10% replacement of coconut shell ash that is 19.76% more than control mix. This is due to high silica content of both coconut shell ash and silica fume which is responsible for strength.

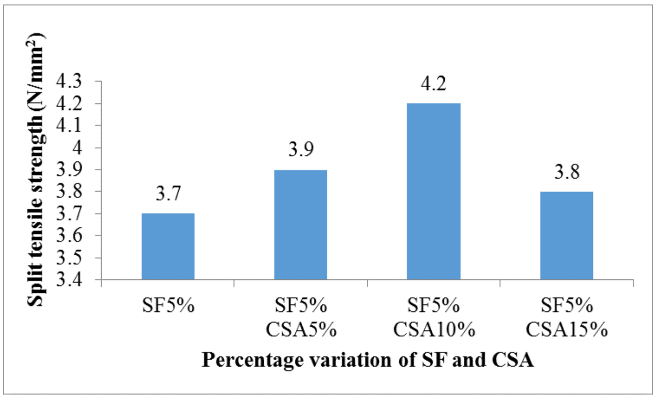

Chart -17: Effect of SF 5% and various % of CSA on Split Tensile Strength

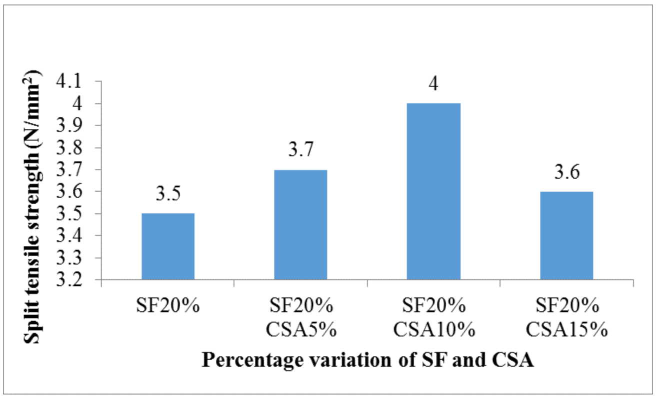

Chart -18: Effect of SF 20% and various % of CSA on Split Tensile Strength

3.4.3 EFFECT OF CSA AND SF ON SPLIT TENSILE STRENGTH

Split tensile strength of various mixes is shown in the above chart 19 and 20. Here the effect is studied by keeping Coconut shell ash percentage constant and varying the silica fume content. From the above chart it can be seen that split tensile strength goes on increasing with the increasing percentage of silica fume up to 10% replacement at a constant percentage of coconut shell ash. It may be due to the reaction between Silica fume and hydrated products of cement produce more C-S-H it is responsible for strength of concrete after that strength decreases.

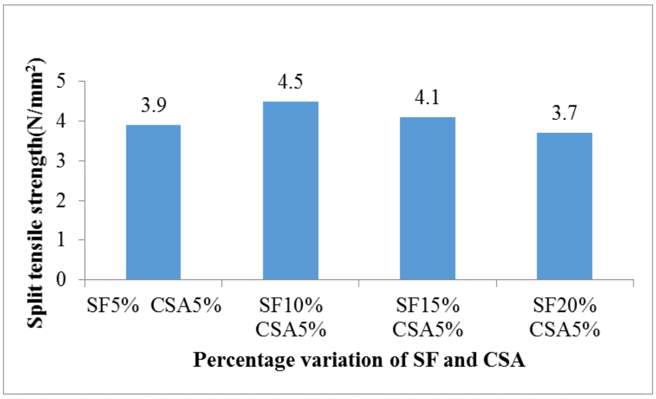

Chart -19: Effect of CSA 5% and various % of SF on Split Tensile Strength

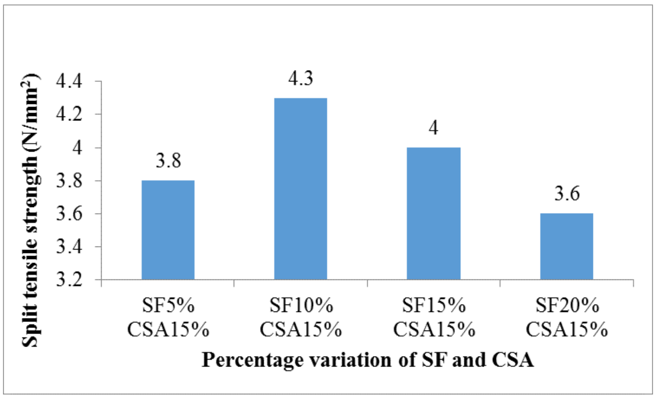

Chart -20: Effect of CSA 20% and various % of SF on Split Tensile Strength

3.5 FLEXURAL STRENGTH RESULTS

Table -7: Flexural Strength results

Mixes	28 Days Flexural Strength (N/mm²)
CM	3.07
SF 5%	3.3
SF 10%	4.56
SF 15%	4.23
SF 20%	4.1
SF 5% CSA 5%	3.42
SF 5% CSA 10%	4.23
SF 5% CSA 15%	3.62
SF 10% CSA 5%	4.6
SF 10% CSA 10%	4.81
SF 10% CSA 15%	4.53
SF 15% CSA 5%	4.3
SF 15% CSA 10%	4.52

SF 15% CSA 15%	4.30
SF 20% CSA 5%	4.20
SF 20% CSA 10%	4.34
SF 20% CSA 15%	4.15

3.5.1 EFFECT OF SF ON FLEXURAL STRENGTH

Flexural strength of various concrete mixes containing 5%, 10%, 15% and 20% silica fume and control mix are there in chart 21. From the figure the flexural strength of concrete mix containing silica fume is higher compared than the control mix. The maximum flexural strength is obtained for the mix containing 10% silica fume due to pozzolanic reactivity of silica fume and its ability to fill void. The flexural strength increases by 23.7% for concrete mix containing 5% silica fume, 48.5% for concrete mix containing 10% silica fume and 37.7% for concrete mix containing 15% silica fume, 30.3% for concrete mix containing 20% silica fume than the control mix.

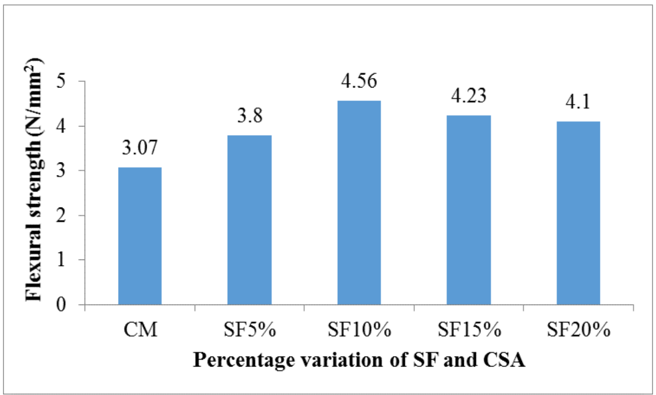

Chart -21: Effect of SF on Flexural Strength

3.5.2 EFFECT OF SF AND CSA ON SPLIT TENSILE STRENGTH

The above chart 22 and 23 shows variation of flexural strength of concrete with the addition of constant value of silica fume and varying percentage of coconut shell ash as partial replacement for cement, chart 22 shows the variation of flexural strength with varying percentage of coconut shell ash at a constant value of silica fume 5% flexural strength was maximum at 10% replacement of coconut shell ash that is 37.7% more than control mix. Chart 23 shows the variation of flexural strength with varying percentage of coconut shell ash at a constant value of silica fume 20% flexural strength was maximum at 10% replacement of coconut shell ash that is 41.3% more than control mix. This is due to high silica content of both coconut shell ash and silica fume which is responsible for strength

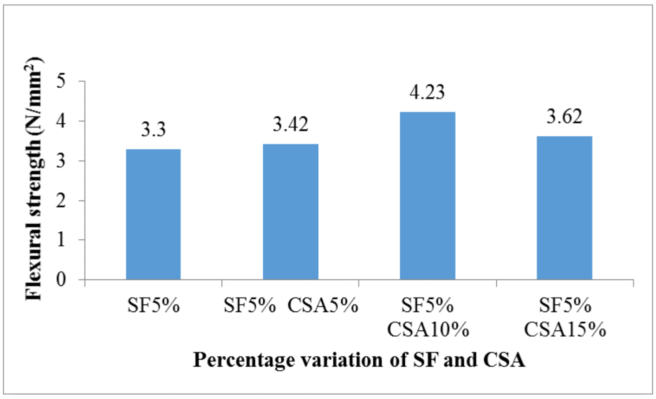

Chart -22: Effect of SF 5% and various % of CSA on Flexural Strength

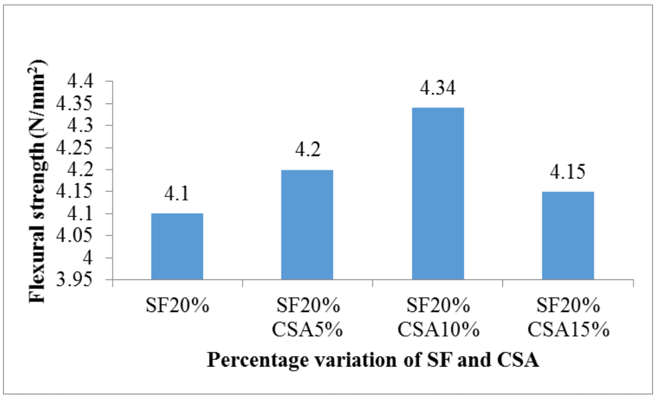

Chart -23: Effect of SF 20% and various % of CSA on Flexural Strength

3.5.3 EFFECT OF CSA AND SF ON SPLIT TENSILE STRENGTH

Flexural strength of various mixes is shown in the above chart 24 and 25. Here the effect is studied by keeping Coconut shell ash percentage constant and varying the silica fume content. From the above chart it can be seen that split tensile strength goes on increasing with the increasing percentage of silica fume up to 10% replacement at a constant percentage of coconut shell ash. It may be due to the reaction between Silica fume and hydrated products of cement produce more C-S-H it is responsible for strength of concrete after that strength decreases.

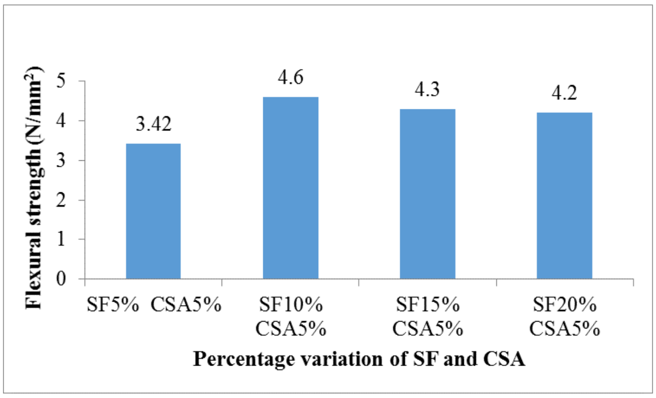

Chart -24: Effect of CSA 5% and various % of SF on Flexural strength

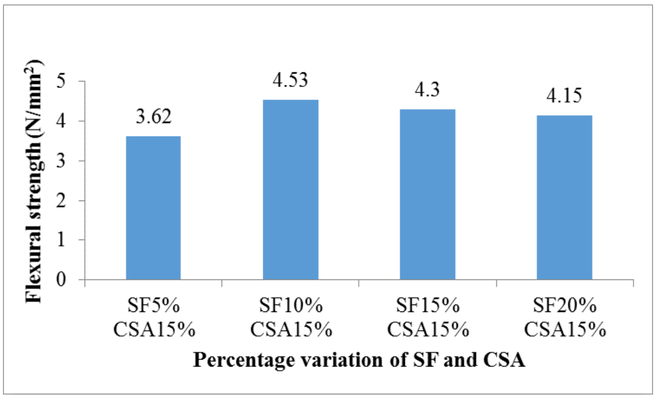

Chart -25: Effect of CSA 20% and various % of SF on Flexural strength

4. CONCLUSIONS

An attempt was made to build up the reasonableness of utilization of coconut shell ash and silica fume as a replacement for cement. Considering certainties and results got the accompanying conclusions were drawn.

- With increase in the quantity of coconut shell ash in concrete density of concrete decreases and with the increasing dosage of silica fume density of concrete increases.
- With the increase in the quantity of coconut shell and silica fume slump decreases.
- When both coconut shell ash and silica fume are utilized as a partial substitution for cement gave higher strength than target strength.
- The compressive strength of 55.85N/mm^2 for 28 days that is 23% more than that of control mix and 57.7 N/mm^2 for 56 days that is 24.5%more than control mix with replacement of 10% of silica fume and 10% coconut shell ash.
- Split tensile and Flexural strength was found to be maximum at 10% of silica fume and 10% coconut shell ash as 4.7 N/mm^2 and 4.81 N/mm^2 respectively.
- Modulus of elasticity of concrete by the addition of various percentage of coconut shell ash and silica fume is maximum at 10% of both silica fume and coconut shell ash 32000 N/mm^{2}compared to control mix (21221N/mm^2).

5. FUTURE WORK

- The durability tests, like corrosive resistance, sulphate attack tests can be taken up.
- Mortar properties of all the mix can be studied.
- Study can be made to determine strength parameters of cement with coconut shell ash and mineral admixture like fly ash and GGBS.

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