International Journal of Engineering & Technology, 7 (2.12) (2018) 437-442

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

A Study on Mechanical Properties of Conventional Concrete and Coconut Shell Concrete by Replacing Cement with Silica Fume

V.R.Prasath Kumar [1*], K. Gunasekaran [2*], Sreerag K.P [3*]

[1] *Assistant Professor*
[2] *Professor*
[3] *Professor*
** Department of Civil Engineering, SRM Institute of Science and Technology, Kattankulathur- 603203, Tamil Nadu, India.*

Abstract

High standing estimation of building materials utilized for development is a component of incredible concern. Coconut shell as a completely substitution in the place of coarse aggregate may totally effective for designers in construction industry. The coconut shell concrete is a light weight solid which may decrease the self-heap of a structure. The under taken project depends on inspecting attributes of coconut shell concrete when contrasted with conventional concrete. Coconut shells going from 10mm strainer and held on 6.3mm were considered to utilize for this study. For the current study M_{100} grade concrete is used to cast the specimens. The principle properties considered testing on coconut shell concrete and conventional concrete is compressive strength, split tensile strength and flexural strength. Examples were taken by supplanting coarse aggregate with coconut shells completely and cement is supplanted by silica fume with various extents of 5%, 10%, 15%, 20%, 25% for compressive strength test and tests were done at 3, 7, 28, 56 and 90 days of curing, it is observed that the ideal compressive strength outcomes were obtained at 10% of silica fume. The flexural strength and split tensile strength of the specimens are calculated with replacement of cement by silica fume with different extents of 0%, 5%, 10% and 15%, tests were done at 3, 7 and 28 days of curing. The optimum replacement percentage of cement by silica fume is 10% for compressive strength, split tensile and flexural strength. The primary principle is to lessen the utilization of natural aggregate by supplanting them with coconut shells and to decrease the density of concrete which makes concrete for simple dealing.

Keywords*: Coconut Shell, silica fume, Conventional concrete, Coconut shell concrete, Compressive Strength, Flexural Strength, Split Tensile strength.*

1. Introduction

Concrete is the primary item in development industry; however there are many negative effects underway of concrete like consistent extraction of aggregates from earth, which prompts natural lopsidedness. In light of this, no accessibility of regular assets to the future era has been acknowledged [1]. Many researches were conveyed to supplant the materials of concrete without change in their properties.

In Asia, the construction ventures are yet to take into account the upside of light weight concrete in raised structures [2]. Wooden chips, plastic waste, material waste, polyethylene, rice husk ash, groundnut shell, coconut shell and so forth: are a portion of the cases for substitution of totals in concrete [3]. The present paper is to spread attention to utilizing coconut shell as substitution with coarse aggregate in concrete. However coconut shell has great strength, high durability, scraped area resistance thus it is reasonable for long standing use [4]. However usage of coconut shell aggregate with replacement of natural stone aggregate will helps to reduce the density of concrete, thereby making it suitable for structural applications. Coconut shell is discarded and is unutilized commercially as a building material especially in concrete. Coconut shell concrete can be used for the construction of pavements, precast structural elements, low cost houses and temporary structures. Utilization of CS will be an important step towards sustainable development. More economical and environmental outcomes can be obtained by utilizing waste materials as light weight aggregates in concrete forms.

The Coconut shell concrete satisfies the minimum requirements of lightweight concrete [5]. The study shows that the compressive strength tends to increase from 0-10% and then decreasing gradually from 15-25%. The materials in the concrete were proportioned by their weights whereas coconut shell aggregate is proportioned by volume to the weight of coarse aggregate. The water cement ratio is obtained by conducting various workability tests, tests were conducted as per specified procedures of Indian standard codes.

The main objective of this project is to replace 100% coarse aggregate with coconut shell aggregate, so as to reduce the usage of natural coarse aggregate and to reduce the density of the concrete for easy handling. The cement content is been partially replaced with silica fumeby 0, 5, 10, 15, 20, 25 % to find the optimum percentage of replacement of silica fume with cement. The mechanical properties of both conventional cement concrete and coconut shell concrete is tested.

The earlier researches shows that the coconut shell concrete is an effective form of concrete material or substituent regarding its cost effectiveness, lesser impact to the environment by eliminating the natural coarse aggregates, and also imparting the similar strength parameters of conventional cement concrete structures with the

addition of silica fume by replacing the cement at an optimized percentage.
The former experiments and studies also shows that theuse of coconut shells in concrete is an evident form of producing less denser concrete, colloquially named as light weight concrete. The addition of silica fume shows that they reduces bleeding and segregation significantly, which helps the concrete material to attain better bonding, abrasion resistance etc.
Due to high silica content and fineness of silica fume they act as an excellent pozzolanic material. Thus the researches proves that when silica fumes are added with the coconut shell concrete, what obtains as output is an effective and efficient light weight concrete material with much lesser density, strength and durability. Also better workability is attained with the use of silica fumes which makes the concrete cohesive as required.

2. Experimental Programme

2.1. Materials Used

Cement is the most important building material for any construction work, and it is selected based on the age, strength, exposure conditions and durability requirements. Ultra tech OPC 53 Grade is taken for this project, and properties are given in the table 1.Fine aggregates consist of natural river sand with most particles passing through a 4.75 mm sieve and retaining in 75 micron is used for this project and confirming to IS 383:1970.The aggregate is sieved over 4.75mm sieve; the aggregate received is termed coarse aggregate. Gravel, cobble and boulders are few materialize below this division. The top size aggregate used might be susceptible upon a few circumstance. In broad, 40mm size aggregate used for regular strengths and 20mm size is passed down for high strength concrete. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. For this project, the coarse aggregates passing through 12.5mm and retaining in 10 mm sieve is used for conventional concrete preparation, confirming to IS 383:1970. Silica fume, generally known as micro silica, is anamorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine dust collected as a by-product of the silicon and ferrosilicon alloymanufacturing and consists of rounded mites with a mean particle diameter of 150mm.Silica fume is acquired from Aastra chemicals, Chennai. It was used as partial replacement of cement in different extents from 0%, 5%, 10%, 15%, 20% and 25% for this project.
Coconut shells were collected from local dealers, which were cleaned and sundried to analyze its properties. Coconut shells passing from 100mm strainer and retaining on 6.3mm retainer were used for the study. Coconut shells were cleaned with water and sundried due to its high water absorption quality. In current study coconut shell aggregates were replaced with coarse aggregate in a volume basis then weight basis. Ordinary drinking water was used in the preparation of concrete specimens and normal tap water was used for curing. Changing of water is done on alternate days for curing of specimens.

2.2 Coconut Shell Processing Technique

The coconut crushing machine was developed and installed in the Civil Engineering Department, SRM University by Dr.K.Gunasekaran. The collection of coconut shell was done in and around Kancheepuram district, Tamil Nadu. The well dried plain coconut shell was fed in to the crushing machine, which reduces the size of the coconut shell to less than 8mm and so on. as fine aggregates with a mass thickness of 1860kg/m3 conforming to IS: 383-1987[8] and coarse aggregate passing through 12.5mm strainer and held in 10mm strainer are utilized for this review.
ACI method is utilized for planning concrete of grade M100, light weight concrete blend is typically established by trail mixes. A

the crushed aggregate was screened were coconut shell powder and coconut shell aggregate was collected separately. The coconut crushing machine and crushed aggregate is shown in the below figure.1.

Figure 1. Coconut Crushing Machine & Crushed Aggregates

Figure-2. Material Collection **Figure-3.** Specimen preparation

2.3 Specimen Preparation

The compressive strength was determined by Coconut shell concrete and conventional concrete cubes of size 100mmx100mmx100mm were casted with various silica fume proportions of 0%, 5%, 10%, 15%, 20% and 25% in replacement with cement. Split tensile strength of cylinder size 100mm diameter and 200mm height were used and for flexural strength of beam size 500mmx100mmx100mm were used. In present study coarse aggregate is replaced with coconut shell by volume basis, to the volume of coarse aggregate taken. The casting of specimen was carried out confirming IS: 516-1959. Material collection and casting of concrete cube specimens are shown in the below figure 2 & 3.

2.4 Mix Design Details

The cement used is Ordinary Portland Cement of Ultra Tech brand of 53 grade affirming to IS: 12269-1987 [7]. The aggregate passing through 4.75mm strainer and holds in 90 microns are utilized

similar mix proportion is utilized for both conventional and coconut shell concrete, however for CSC a similar volume of coarse aggregate utilized as a part of CC is supplanted by CS. The blend extent utilized is 1:0.62:1.64 and water cement ratio of 0.3 [9].

2.5 Method of Testing

Compressive test is done at the respective ages of 3, 7, 28, 56 and 90 days of cubes, Three cubes were taken out of curing for testing at the this perspective ages. The cubes are placed under the compressive testing machine in such way that the heap is connected to the inverse side of cast. The compressive strength was assessed for different rates of cement replaced with silica fume which are 0%, 5%, 10%, 15%, 20% and 25%, the tests were done at 3, 7, 28, 56 and 90 days of curing according to IS 516-1959 [10]. The flexural strength and split tensile strength were assessed for different rates of cement replaced with silica fume which are 0%, 5%, 10% and 15%. The Split tensile strength of concrete is dictated by splitting the cylinder over the vertical width. The test was done by setting a cylinder sample horizontally in between the loading frames of the compression testing machine. The heap was connected till the specimen fails. Tests were done at 3rd, 7th and 28th days curing of concrete according to IS: 5816-1999 [11]. Flexural strength test were done according to IS: 516-1959 [12].

Figure-4. Covering of Specimens With Polythene Sheet

Figure-5. Testing of Specimen

For the preparation of coconut shell concrete, the design mix ratio followed is 1: 0.62: 1.64,and the water content is 0.3. In above mix proportion various percentage replacement of silica fume is added, say, 0, 5, 10, 15, 20, 25 percentages. The quantity of materials (in kg) and water content (in liters) required for 15 number of cubes of size 100mmx100mmx100mm is tabulated and shown in table 1 below.

Table-1. Mix Proportion of Concrete for 1:0.62:1.64:0.3

Cement replaced with silica fume in %	Percentage of Cement + S.F	Material Proportion of Coconut shell Concrete for 15 Cubes					Material Proportion of Coconut shell Concrete for 15 Cubes				
		Wt. of Cement in kg	Wt. of S.F in kg	Wt.of FA in kg	Wt.of CA in kg	Water in liters	Wt.of Cement in kg	Wt.of Silica Fume in kg	Wt.of FA in kg	Wt.of Coconut Shell in kg	Water in liters
0	**100+0**	12.15	0	7.53	19.92	3.64	12.15	0	7.53	8.75	3.64
5	**95+5**	11.54	0.61	7.53	19.92	3.64	11.54	0.61	7.53	8.75	3.64
10	**90+ 10**	10.94	1.21	7.53	19.92	3.64	10.94	1.21	7.53	8.75	3.64
15	**85+ 15**	10.33	1.82	7.53	19.92	3.64	10.33	1.82	7.53	8.75	3.64
20	**80 + 20**	9.72	2.43	7.53	19.92	3.64	9.72	2.43	7.53	8.75	3.64
25	**75 + 25**	9.12	3.03	7.53	19.92	3.64	9.12	3.03	7.53	8.75	3.64

3. Results and Discussion

3.1 Physical Properties Of Coarse Aggregate And Coconut Shell

Coconut shell is one of the horticultural wastes so as to supplant coconut shell with regular aggregate (coarse aggregate), first we have to know whether the physical properties of coconut shell matches to coarse aggregate. Table 2 demonstrates that the physical properties of coconut shell.

The low density of coconut shell aggregate is advantages for coconut shell concrete which will be lighter compared to conventional concrete.

3.2 Chemical Composition of Cementitious Material

Silica fume is composed in electrical arc furnaces as a by-product of the manufacturing of elementary silicon or alloys containing silicon; often known as solidified silica fume or micro silica. Ordinary Portland cement (Ultra tech) was purchased from a local buyers. The chemical composition of both Silica fume and OPC is given in table 3.

3.3 Workability results of Coconut shell concrete

The property of concrete that determines the amount of favourable internal work essential to produce maximum compaction i.e. workability is the amount of energy to triumph over friction while compacting. Also defined as the relative speed with which concrete can be blended, conveyed, molded and compacted. From the slump and compaction factor values obtained, the comparison of workability between conventional cement and the coconut shell concrete stays similar. The workability of coconut shell concrete attains similar to the conventional cement concrete. The workability parameters are shown in the table 4.

Table-2. Physical Properties of Coconut Shell.

Sl.No	Physical Properties	Coarse Aggregate	Coconut Shell
1	Specific gravity	2.76	1.18
2	Impact value	12.5%	2.5%
3	Crushing value	6.4%	1.29%
4	Fineness modulus	6.94	2.3
5	Abrasion value	1.85%	5.6%
6	Thickness	10–12mm	4-6mm
7	Bulk Density	1650Kg/m^3	600Kg/m^3

Table-3. Chemical Composition of Silica Fume

Sl.No	Chemical Composition	Silica Fume (%)	OPC
1	Sio_2	90	21.6
2	Al_2o_3	0.4	1.33
3	Fe_20_3	0.4	3.7
4	Cao	1.6	63.0
5	So_3	0.4	0.88
6	Na_20	0.5	0.4
7	K_20	2.2	0.51

Table-4. Workability of Conventional Cement Concrete and Coconut Shell Conrete

Replacement of Cement with Silica Fume(%)	Conventional Cement Concrete		Coconut Shell Con-crete	
	Slump Value (cm)	Compaction Factor	Slump Value (cm)	Compaction Factor
0%	28.8	0.935	28.6	0.923
5%	29.1	0.940	28.9	0.930
10%	29.4	0.951	29	0.942
15%	29.5	0.959	29.1	0.943
20%	29.7	0.972	29.5	0.958
25%	29.9	0.978	29.8	0.975

3.4 Compressive Strength of Concrete

The test were conducted as per IS 516-1959 to get compressive strength of concrete for the age period of 7, 14, 28, 56 and 90 days. Cubes were tested with compressive testing machine (CTM) of 2000 kN capacity. The results are given in the figure 6 & 7 below.

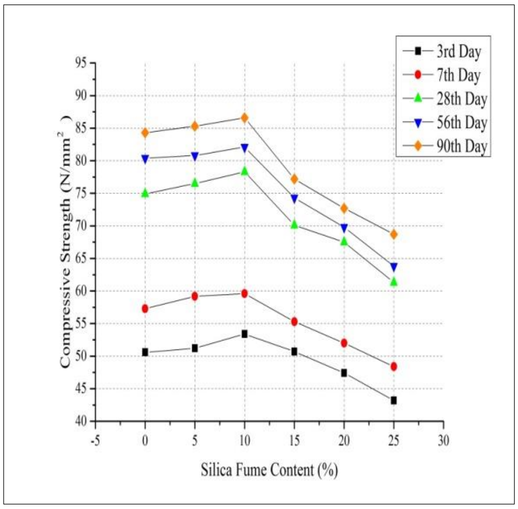

Figure-6. Compressive Strength of Conventional Concrete

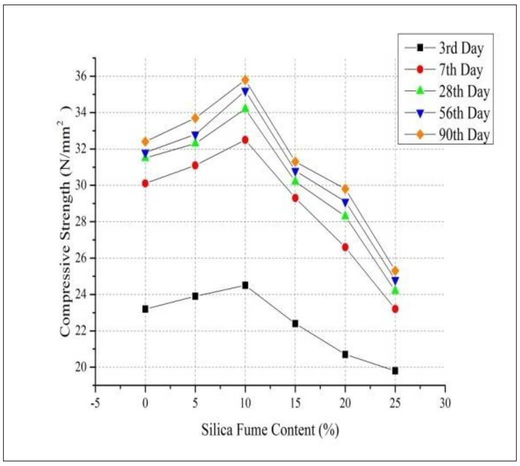

Figure-7. Compressive Strength of Coconut Shell Concrete

The developments of the long run compressive strengths of the traditional cement concrete and the coconut shell concrete are shown in the figure 6 and 7. It has been observed that the concrete has attained major strength gain in the early phases and further the compressive strength increase with age. The figures shows the compressive strength of conventional cement concrete and coconut shell concrete by supplanting of cement with silica fume in various percentage. The compressive strength of concrete supplanting cement with silica fumes increases from 0% to 10% and afterward diminishes. Thus ideal silica fume content is 10% for both conventional and coconut shell concrete. It is observed that for conventional concrete the highest compressive strength is 86.6N/mm2 at 10% replacement of cement with silica fume which is 2.7% more than controlled concrete and for coconut shell concrete the highest compressive strength is 35.8N/mm2 at 10% replacement of cement with silica fume which is 10.5% more than controlled coconut shell. The addition of silica fume in coconut shell concrete significantly enhanced the compressive strength, and same is shown in the figures 6&7. With the addition of 5% and 10% of silica fume, the compressive strength of coconut shell concrete over 28 days increased, whereas high early strength of around 90% were obtained for 7th day and 28thday. The strength have been increased for the mixes containing silica fume and this might be attributed by the fineness for silica fume and reaction between the silicon dioxide and calcium hydroxide. However, when the content for SF builds past 10%, the compressive strength begins to decline, the diminishment in strength might be expected with absence of water in the blend since self-desiccation of the sample make voids.

3.5 Split Tensile Strength

The tests were conducted as per IS 516-1959 to get split tensile strength of concrete for the age period of 7, 14, 28, 56 and 90 days. Cylinders were tested with CTM of 2000kN capacity. Split tensile strength test is determined to find the tensile strength of concrete by using concrete cylinder specimens. Concrete is not expected to resist direct tension due to its brittle nature, therefore concrete generate cracks which when subjected to tensile forces. Thus, it's a necessity to determine the tensile strength of concrete to determine the load at which concrete component breaks. The results are shown in the figures 8 & 9 below.

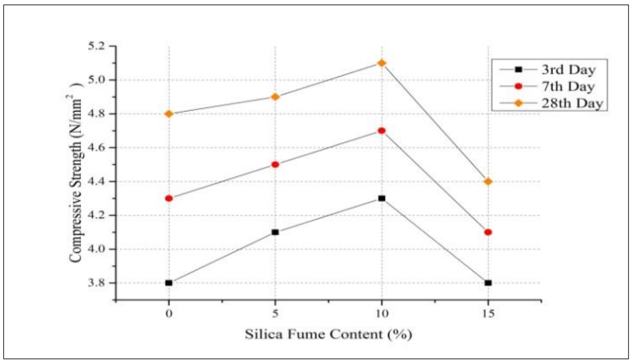

Figure-8.Split Tensile Strength of Conventional Concrete

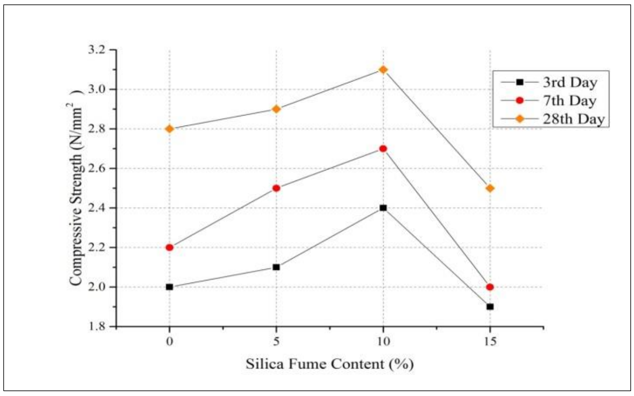

Figure-9. Split Tensile Strength of Coconut Shell Concrete

The split tensile test on cylinders are done at 3rd, 7th and 28th day by placing the cylinders horizontally on an compression testing-machine of 2000kN capacity. It can be noted downthat the split tensile strength get to increase with expanding compressive strength. It is observed that for conventional concrete the highest split tensile strength is 5.1N/mm^2 at 10% replacement of cement with silica fume which is 6.25% more than controlled concrete and for coconut shell concrete the maximum compressive strength is 3.1N/mm^2 at 10% replacement of cement with silica fume which is 10.7% more than controlled coconut shell concrete which is shown in the figures 8 & 9.The split tensile strength of concrete mix having silica fume will be higher compared over the coconut shell concrete. Maximum tensile strength is obtained for the mix-having 10% silica fume because of pozzolanic reactivity also its capacity to fill voids. Because of this it was observed that the effect of SF in the LWC mixtures increase the tensile strength of CSC. Cement for mineral admixture of 10% SF appeared to give an ideal tensile strengththan that with other mixes, and it is roughly 49% higher over those least obliged strength of 2 N/mm^2 for-light weight concrete concerning as per ASTM.

3.6 Flexural Strength of Concrete

The tests were done as per IS 516-1959 to get split tensile strength of concrete for the age period of 7, 14, and 28 days. Beams were tested with flexural testing machine of 100kN capacity. The results are shown in the figure 10 and 11 below.

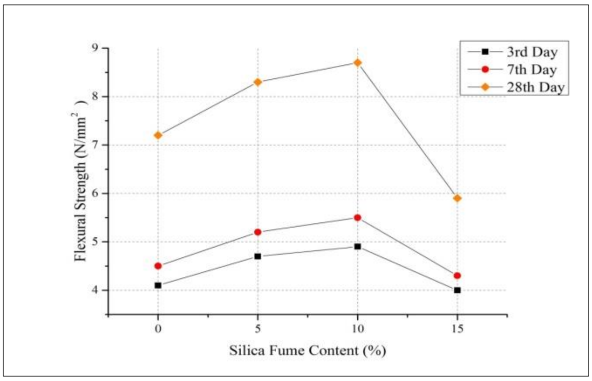

Figure-10.Flexural Strength of Conventional Concrete

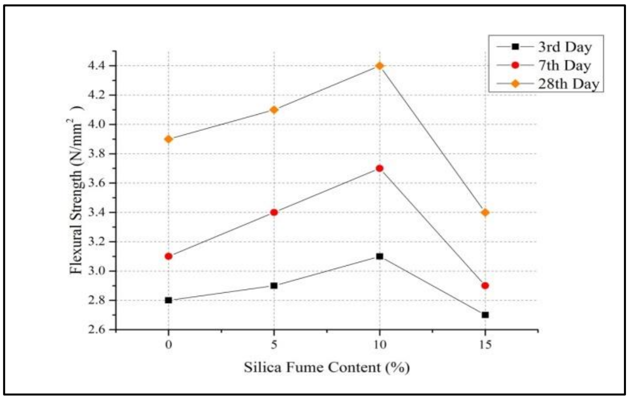

Figure-11.Flexural Strength of Coconut Shell Concrete

The flexural strength of conventional cement concrete and coconut shell concrete increases with increase in silica fume percentage up to 10%, and later decreases rapidly. It is observed that for conventional concrete the maximum flexural strength is 8.7N/mm^2 at 10% replacing of cement with silica fume which is 20.8% higher than the controlled concrete and for coconut shell concrete conventional concrete the maximum compressive strength is 4.4N/mm^2 at 10% replacement of cement with silica fume which is 12.8% more than controlled coconut shell concrete. The flexural strength test is habitually employed with a specimen of circular or rectangular cross-segment which will be twisted until crack and yielded by utilizing thethree points flexural strength technique. The flexural strength is noted for the maximum stress encountered for the materials atits moment of rupture. The highest flexural strength isacquired to those mixes containing 10% silica fume because of the pozzolanic reactivity of the silica fume and furthermore its capability to fill voids. From the past study by Gunasekaran et al. [1] demonstrated that coconut shell concretehas a flexural strength of 4.68 N/mm^{2}that might have been 17.5% from claiming their compressive strength quality 26.7 N/mm^2. The increase in the flexural strengthof CSC at 0% supplanting was less than with its higher replacements of silica fume. Extra addition of SF gave a negative impact on the flexural strength quality.

4. Conclusion

From the results obtained it is evident that the silica fume is a superior substitution for cement. The rate of strength pick up in silica fume concrete is obtained high. After performing all tests and analyzing their results, the accompanying conclusions were listed below:

1. 100% replacement of coarse aggregate with coconut shell aggregate tends to reduce the density of concrete and usage of natural aggregate.
2. The 90th day average compressive strength of coconut shell concrete with 10% replacement of silica fume were found to be 35.8N/mm2, which is 10.5% higher in strength compared to controlled concrete.

3. The 90th day average compressive strength of conventional concrete with 10% replacement of silica fume were found to be 86.6N/mm2, which is 2.7% higher in strength compared to controlled concrete.
4. The average 28th day split tensile strength of coconut shell concrete and conventional concrete were found effective at 10% replacement of silica fume, for coconut shel1 concrete it shows 10.7% higher than controlled concrete and for conventional concrete it shows 6.25% higher than controlled concrete.
5. The average 28th day flexural strength of coconut shell concrete and conventional concrete were found effective at 10% replacement of silica fume, for coconut shel1 concrete it shows 12.8% higher than controlled concrete and for conventional concrete it shows 20.8% higher than controlled concrete.
6. It is observed that replacement of cement with silica fume tends to increase from 0% to 10% further increase in silica fume tends to decrease in compressive strength, split tensile strength and flexural strength.

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