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EFFECT OF STEEL FIBER AND COIR FIBER'S DURABILITY PROPERTIES IN COCONUT SHELL AS THE COARSE AGGREGATE OF MODIFIED CONCRETE

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Abstract

The results of the best mix design are discussed, along with the mechanical and durability properties of the coconut shell + fly ash + coir fibre reinforced concrete (CSFCC) and coconut shell + fly ash + steel fibre reinforced concrete (CSFCS) mixes. The best performing mixture out of a total of 17 experimental mixes was chosen for mechanical examination. Two different mixes are made, one with coarse aggregate made of coconut shell (CSFCC) and the other with coarse aggregate made of conventional material (CSFCS). Class F fly ash is used to replace 0, 10, 20, and 30% of the cement, respectively, in weight terms. The durability of CS concrete was evaluated using a variety of tests, including water absorption, the Volume of Permeable Pore Voids (VPV), Sorptivity, the Rapid Chloride Penetrations Test (RCPT), and the CSAC resistance capabilities at high temperatures.

1.INTRODUCTION

Concrete is the material that is most commonly used in the building industry. It has a significant impact on how modern civilization is built. However, concrete as a substance has changed remarkably little since it was first employed in its current form 100 years ago. One of their primary needs is that concrete building materials considerably increase dependability. It is estimated that up to 10% of concrete that is poured in a given year may fail prematurely or perform below average. Given that the global market for concrete construction is worth over $700 billion, even a small reduction in problems would result in significant cost savings and performance benefits. The industry is often cautious, which leads to significant overdesign of many facilities since failure might have devastating effects. Although there is a drive to replace prescriptive specifications with performance-based criteria, it is also widely accepted that there aren't enough test procedures and measurement tools on the market right now. An enhancement in concrete systems' dependability will have a significant, billion-dollar impact on the economy. Another issue is that owing to the enormous amount of concrete produced globally, even though the process of creating it is efficient in terms of emissions and embodied energy, there is still potential for improvement in terms of sustainability and environmental effect. Concrete has a lower embodied energy and emits less emissions than other materials.

Global cement production in 2011 resulted in up to 2.08 million metric tonnes of CO2 emissions, according to the Portland Cement Association (PCA) (based on the assumption that

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for each tonne of cement, 0.9 tonnes of CO_2 are released). Concrete is unique as a building material since it is frequently produced on-site by employees following a quality assurance procedure. Consider a substance that is created from a range of easily accessible raw materials using an extremely energy-efficient process. This substance may be mixed with water to produce a building material that can be moulded into any geometric shape, can be worked on for several hours, and hardens to produce great strength. It is on the field. It is utilised in a rather rudimentary way.

2.LITERATUREREVIEW

Cheng (2005) examined the total collapse behaviour of the bonding characteristics of light-weight concrete and compared everything to conventional concrete. The strength and durability failure pattern of light-weight concrete differs from that of ordinary concrete if the mechanical characteristics are below 45N/mm2. However, the fracture propagation patterns for suitable weight aggregate and light-weight concrete remained similar whenever the compression was more than 45N/mm2. When stirrups are used as transverse reinforcement, bonding strengths have grown by 20% over time with both light-weight and standard weights.

Pul (2011) looked at the ability of light and heavy concrete to adhere. The adhesive qualities of heavyweight and lightweight concrete were tested under simultaneous cyclical and monotonic loads on straight and curved bars. Pull out tests on a number of samples were carried out in order to create the load slip curves. Light-weight concrete has been demonstrated to have a stronger bond than traditional concrete mixtures when utilised with plain bars. However, it was demonstrated that conventional weight concrete had a better bonding than light-weight concrete for re-bars under monotonous and cyclic loads. Simple bars often slide more than re-bars, which must have been identified.

Sancak & Simsek (2012).

Pumice aggregate was used to research the adhesive qualities for lightweight concrete To varied degrees (0, 5, and 10%), silica fume was substituted for cement in three mixes. Silica fume and a super plasticizer with a 2 percent concentration were also added to the remaining three mixes. The results of the study showed that using silica fume and super plasticizer combined significantly increased the binding strength. Additionally, compared to normal weight concrete, concrete with light-weight aggregate containing pumice stone had a decreased adhesive strength for bent bars. The maximum load sliding for distorted bars was around 1-2.4mm, which was not noticeably different.

3. MATERIALS

The chemical characteristics of CS, crushed granite, river sand, cement, fly ash, and fibres, as well as the CS-cement compatibility, were investigated. Studies were also done into the durability and strength characteristics of CS concrete.

The necessary tests on coconut shell (CS) and traditional granules were carried out according to Bureau of Indian Standards, and the results are shown in Table 3.1 Coconut shell aggregate with a size range of 4.75 mm to 12.5 mm has the best packing density

Table 1: CS, crushed granite, and M sand properties

Mechanical and physical characteristics		**CS**	**Crushed granite**	**M sand**
Maximum size (mm)		12.5	12.5	-
Moisture content (%)		4.0	-	-
Water absorption (24 hrs.) (%)		23	0.20	-
Specific gravity	1.67 -1.16	2.85	2.82	2.64
	1.33 -1.46	2.8	2.8	-
Impact value (%)		8.26	13.42	-
Crushing value (%)		2.23	18.83	-
Abrasion value (%)		1.62	15.81	-
Bulk Density (kg / m^3)	680	1650	1650	1860
	560	1450	1450	-
Voids (%)	38.12	41.51	41.5	-
	47.76	48.63	48.6	-
Fineness modulus		6.33	6.67	3.1
Shell thickness (mm)		3 – 8	-	-

* Saturated Surface Dry

3.2Cement

As a binding material, 53 Grade Ordinary Portland Cement adhering to IS 12269:2014 has been utilized. Ultra tech was the brand name of the cement utilized. Table .2 lists the physical characteristics.

Table 2: Physical properties of cement

Items	**Analysis results**	**Necessities of IS 12269: 2013**
Fineness – Specific surface	305 m^2/g	Not less than 225
Specific gravity	3.15	-

Consistency	33 %	-
Time of initialization	76 minutes	greater than 30
Final time for configuring	430 minutes	not greater than 600
Soundness (Le Chatelier method)	0.4 mm	Not more than 10

3.3 Coarse Aggregate In the CSFCS mixes, machine crushed granite coarse aggregate with sizes ranging from 3 to 12 mm was utilized. Figure 1 depicts the crushed granite coarse aggregates gradation. Particle size distribution, aggregate impact value (AIV), aggregate crushing value (ACV), aggregate abrasion value, and bulk density were all calculated. in table 1.

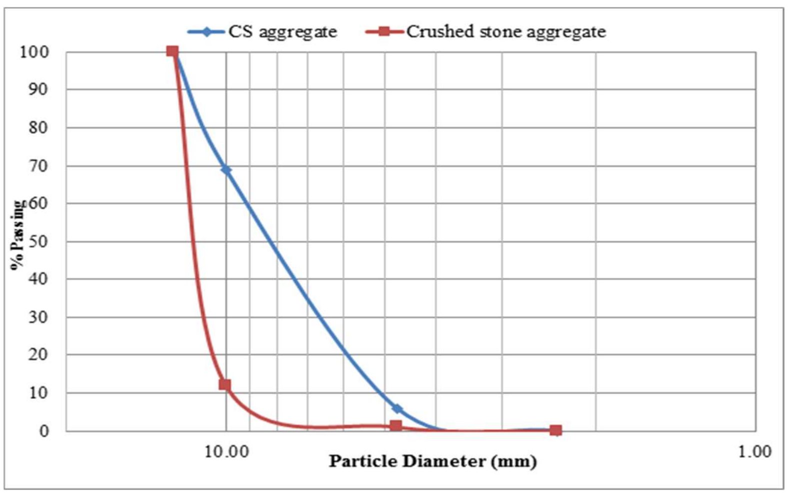


Fig1.sieve analysis of course aggregate

3.4 Fine Aggregate M-sand is a byproduct of such processing of stones to create particulate smaller around 4.75 mm at aggregates crusher plants. Quarry dust meets the criteria for the substitute medium as a substitute for sand at a very cheap cost. Dumping the crushers powder inside one location also adds load, because create pollution.

Table 3: M-Sand Characteristics

M-Sand Characteristics		
1	M-Sand Specific gravity	2.58
2	Fineness modulus	2.52
3	Density	1.68 gm/cc

3.5 Fly Ash

Fly ash is an essential pozzolanic substance that is widely used throughout the world. Fly ash is a waste by-product from power stations that generate energy using coal.

Table 4 : Fly ash and OPC chemical composition

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	LOI
Fly Ash	54.28	24.07	11.03	2.88	2.26	0.14	0.49	2.2	2.88
Cement	20.80	4.80	3.3	64.4	1.3	0.4	0.35	2.8	0.88

Table.4 displays the findings of an examination of the samples of CS fines with cement and cement, taking into account factors including normal consistency, initial and final setting times, compressive strength, and hydration.

Table 5: Cement test results with and without CS fines

Parameters	Cement	Cement with CS fines	Normal range
Normal consistency (%)	32	36	24 - 38
Setting Time (i) Initial setting time (min) (ii) Final setting time	67 7 h 5 min	78 8 h 10 min	greater than 30 not greater than 10 h
Compressive strength (N/mm^2) (i) 3 days (ii) 7 days	27.12 37.26	23.89 29.78	27.00 37.00
Hydration test (i) Maximum hydration temperature (°C) (ii) Maximum slope (ºC/ h)	74 12.35	65 8.55	Greater than 60 -----
Inhibitory index (I) %	2.69	I < 10 Low I = 10-50 Moderate I = 50-100 High I >100 Extreme	Inhibitory index (I) %

3.5 Water

since contaminants can impair setting time, strength, shrinkage, or encourage reinforcing corrosion, the water quality utilised in the concrete manufacturing process is crucial. Water used in the production of concrete and curing should be pure and devoid of impurities including oil, acid, alkali, salt, sugar, silt, and organic matter that can corrode steel or concrete. Concrete may be made using water that can be used for mixing and curing if it is safe to drink. Since the standard campus bore well water is safe to drink, it is utilised in the lab.

Table 6 : Properties of water

Parameters	**Value**	**Permissible value as per IS 456 – 2000**
pH value	7.8	Not less than 6.0
Chloride content (mg/l)	128.5	500 mg/l
Total hardness (mg/l)	110	200 mg/l
Total Dissolved Solids (mg/l)	160	-

3.6 Super plasticizer

In this investigation, a super plasticizer was employed to improve the workability of coconut shell concrete. A highly plasticizing admixture called Conplast SP430, made of suffocated naphthalene polymers, was used. It comes in the form of a viscous solution that dissolves quickly in water. It improves the concrete mixture's capacity to perform with less water by dispersing the tiny particles. It is possible to reduce water by a large amount, which will result in a significant increase in concrete strength. If more super plasticizer is applied, the hardening of concrete may be delayed. Based on the findings of experiments, the ideal super plasticizer dose was determined to be 1.2 percent of binder content. Table 6 displays the super plasticizer's physical characteristics.

Table 7: Properties of super plasticizer

PROPERTIES	**VALUES**
Appearance	Brown liquid
Specific gravity	1.18 @ 22°C ± 2°C
Chloride content	Nil
Air entrainment (%)	Less than 2

Alkali content (g/l)	Less than 55

3.7 Steel Fiber

To determine the ideal amount including both controls mortar. Concrete with coconut shell aggregates by relative density, steel fibbers are added at varying proportions ranging from 0.5% to 1%. The characteristics of the steel fiber utilized are presented in table 8

Table 8: characteristics of the steel fiber

1) **S.No**	2) **Description**	3) **Value**
4) 1	5) Length, mm	6) 40
7) 2	8) Dia, mm	9) 1
10) 3	11) Aspect ratio (l/d)	12) 40
13) 4	14) Strength in Tensile, N/mm2	15) 1250
16) 5	17) Modulus of Elasticity, N/mm2	18) 205000

19) 3.8 Coir Fiber

To determine the ideal amount including both controls mortar. Concrete with coconut shell aggregates by relative density, coir fibbers are added at varying proportions ranging from 0.5% to 1%. The characteristics of the coir fiber utilized are presented in table 9

Table 9: characteristics of the steel fiber

3.9 Coconut Shell

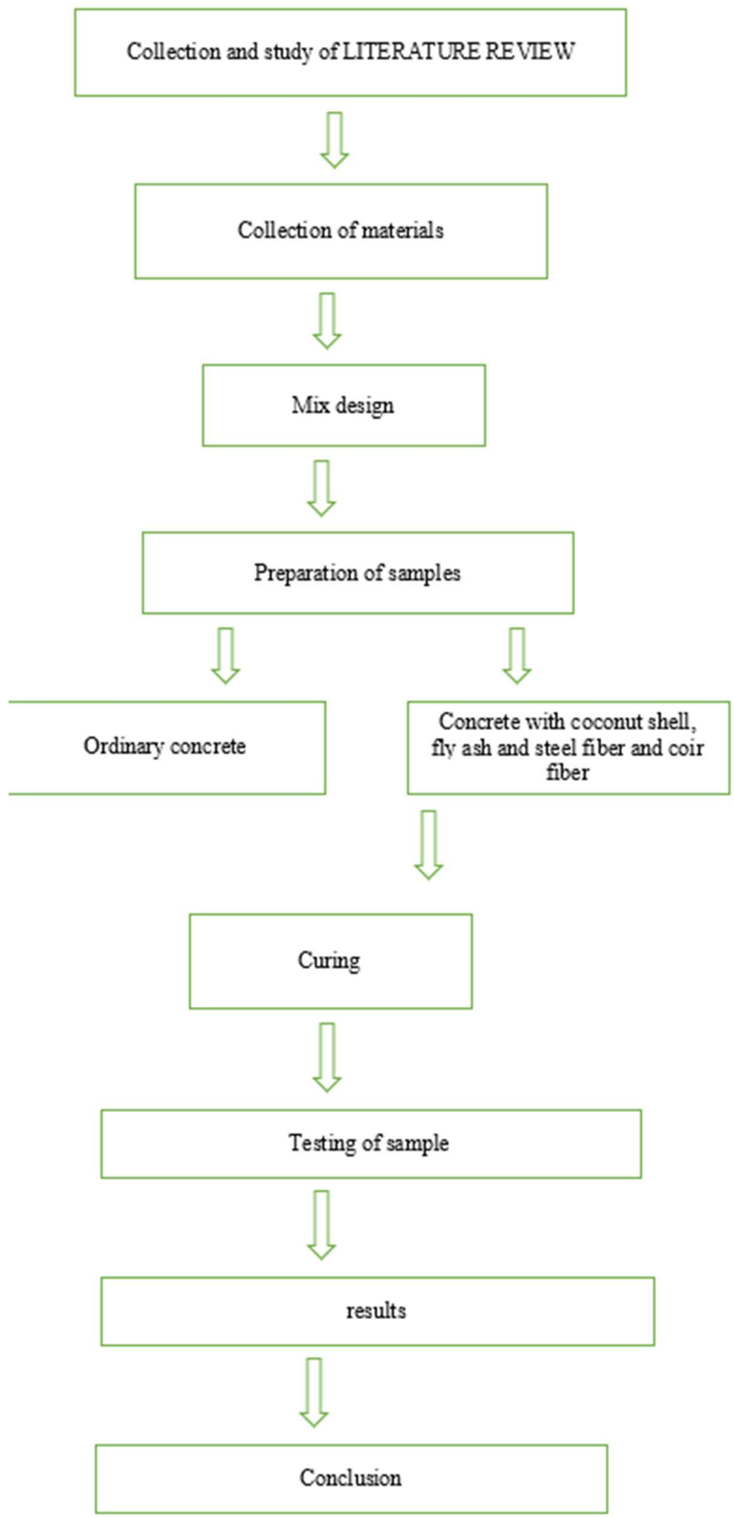
A "meaning of life," "ruler of a tropical vegetation," and "person's greatest beneficial plants" are all terms used to describe coconuts. One of most significant and extensively scattered of all farmed plants is the coconut, and its scientifically known, cocos nucifera. Coconut shells are inexpensive and widely accessible. To extract the water, the coconut palms had to be physically split. Day of in the sunlight used to dry the coconut halves

1) S.No	2) Description	3) Value
4) 1	5) Length, mm	6) 50
7) 2	8) Dia, mm	9) 0.1
10) 3	11) Aspect ratio (l/d)	12) 500
13) 4	14) Strength in Tensile, N/mm2	15) 620
16) 5	17) Modulus of Elasticity, N/mm2	18) 169240

Table 10: Testing results on aggregates made of coconut shells

Sl. No.	Characteristics	Investigation Outcomes
1	Specific Gravity	1.32
2	Water Absorption (%)	20
3	Density(kg/m^3)	850
4	Shell Thickness	(3-8)mm

4. METHODOLOGY


Collection and study of LITERATURE REVIEW
Collection of materials
Mix design
Preparation of samples
Ordinary concrete
Concrete with coconut shell, fly ash and steel fiber and coir fiber
Curing
Testing of sample
results
Conclusion

4.1 Sorptivity test

The Sorptivity may be determined by measuring the capillary rise absorption rate on suitably uniform material. Water was used as the test fluid. The cubes were cured in water for 28 days after casting. The 100mm x 100mm specimen was submerged in water that didn't rise more than 5 mm beyond its base, and the flow from the peripheral surface was successfully prevented by covering it with non-absorbent material. The amount of water absorbed over the duration of 30 minutes was estimated by weighing the sample on a top pan balance that has a 0.1 mg maximum holding capacity. Using a wet tissue to remove the specimen's surface water, each weighted procedure was completed in less than 30 seconds.

A porous substance's propensity to absorb and transfer water through capillarity is characterized by its Sorptivity (S), which is a material attribute.

As the square root of the amount of time passes, the total water absorption (per area of the input surface) rises. (t) $I=S.t^{½}$

Therefore $S=I/ t^{½}$

Where; S= Sorptivity in mm,

t= elapsed time in mint,

$I=\Delta w/Ad$

ΔW= change in weight = W2-W1,

W1 = Oven dry weight of cube in grams,

W2 = Weight of cube after 30 minutes capillary suction of water in grams,

A= surface area of the specimen through which water penetrated,

d= density of water.

4.2 Rapid Chloride Permeability Test

The rapid chloride permeability test (RCPT) was developed to gauge how quickly chloride ions penetrate concrete. ASTM C 1202-94 was followed in performing the test. 100 mm in diameter and 50 mm in thickness were the measurements of the cast concrete discs that were employed. After curing, the concrete samples underwent RCPT by being impressed with 60V. A 90mm-diameter PVC receptacle connects the sample' two pieces. In the experimental setup used to determine chloride using RCPT, sodium hydroxide solution was put on one side of the container and connected to the anode terminal, while the other side of the container was filled with a 3% sodium chloride solution. On one side of the cell, sodium hydroxide solution was poured and linked to the anode terminal (that side of the cell will be connected to the cathode terminal of the power supply).

The required quantities of rubber and brass oaring were added to the examples before they were put into the chamber. A steady 60 V current is passed while the log time is set to 6 hours, 30 minutes, and the record time is 30 minutes. The data logger logs the initial readings of the associated cells each time a record is created. At the conclusion of the log time, the system shuts down after obtaining the final reading.The average current across a single cell is computed using

I = 900 * 2 * I Cumulative coulombs

I CUMMULATIVE = I0+ I30+ I60+ I90+ I120+ I150+ I180+ I210+ I240+ I270+ I300+ I330 + I360
I0 = Initial current reading in mA.
I30 is the current value in mA after 30 minutes.
I60 is the current value in mA after 60 minutes
I90 is the current value in mA after 90 minutes
I120 is the current value in mA after 120 minutes.
I150 is the current value in mA after 150 minutes.
I180 is the current value in mA after 180 minutes
I210 is the current value in mA after 210 minutes.
I240 is the current value in mA after 240 minutes.
I270 is the current value in mA after 270 minutes
I300 is the current value in mA after 300 minutes.
I330 is the current value in mA after 330 minutes.
I360 is the current value in mA after 360 minutes

5. Results and Discussions

5.1 Sample evaluation

In order to evaluate the volumes of permeability spaces (VPS), a total of 24 samples were made, and concrete moisture content tests were performed in line with ASTM standards. Using 24 distinct samples, the sorptivity was measured in accordance with ASTM (ASTM, 1995). According to ASTM, 24 test samples were used in the chloride penetration permeability experiment (RCPT) (ASTM, 1998). The acidity test was conducted in accordance with ASTM C 288.

5.2 Volumes of permeability spaces(VPS)

Figure 2 depicts the VPS of CSFCC and CSFCS mixtures with about 30% FA-Fly ash replacement. The change in VPS during the first few days of therapy (i.e., three and seven weeks) was scarcely perceptible in both CSFCC and CSFCS mixes.

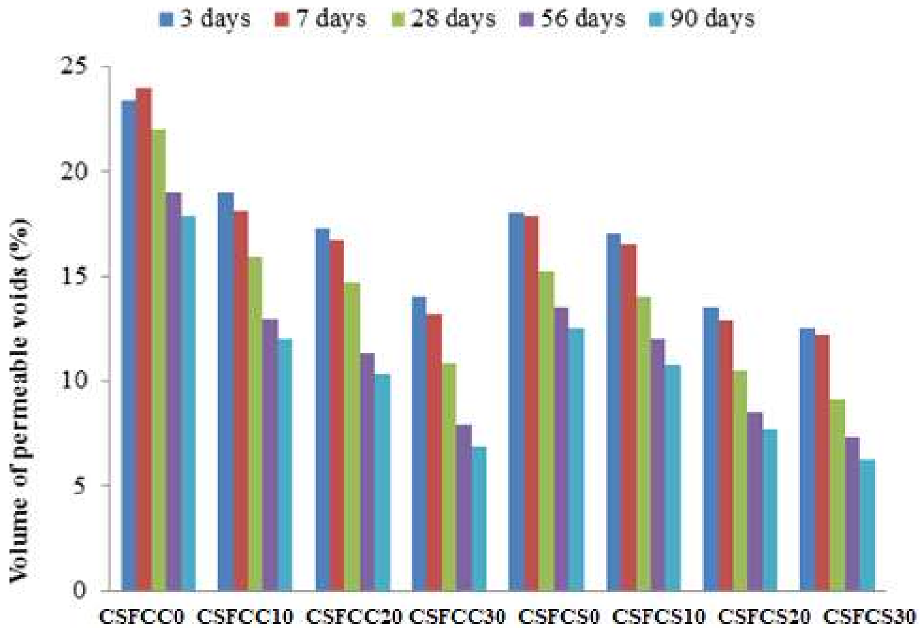


Figure 2.Amount of coconut shell concrete's porous voids

5.3. Counter – attack

A capillary absorption test was done in accordance with ASTM. (Figure 3). Tables 9 show the Sorptivity of a mixtures CSFCC and CSFCS containing FA and without FA, respectively. At ages 14, 28, 56days.

Figure 3.sample being tested for Sorptivity

Table 9 Coconut shell concrete- Sorptivity

Trial Mix	Sorptivity(mm/minute$^{0.5}$)		
	Ages of 14 day	Ages of 28day	Ages of 56day

es	**30 minutes**	**60 minutes**	**90 minutes**	**30 minutes**	**60 minutes**	**90 minutes**	**30 minutes**	**60 minutes**	**90 minutes**
CSFCC 0	0.099	0.098	0.096	0.087	0.086	0.082	0.075	0.074	0.074
CSFCC 10	0.097	0.096	0.094	0.044	0.043	0.041	0.033	0.029	0.025
CSFCC 20	0.096	0.094	0.092	0.043	0.042	0.038	0.032	0.028	0.023
CSFCC 30	0.094	0.092	0.088	0.039	0.040	0.037	0.029	0.027	0.021
CSFCS 0	0.095	0.093	0.089	0.072	0.070	0.061	0.064	0.050	0.049
CSFCS 10	0.093	0.092	0.088	0.043	0.036	0.048	0.028	0.028	0.026
CSFCS 20	0.088	0.085	0.084	0.040	0.038	0.032	0.022	0.022	0.022
CSFCS 30	0.087	0.084	0.083	0.038	0.034	0.030	0.020	0.021	0.024

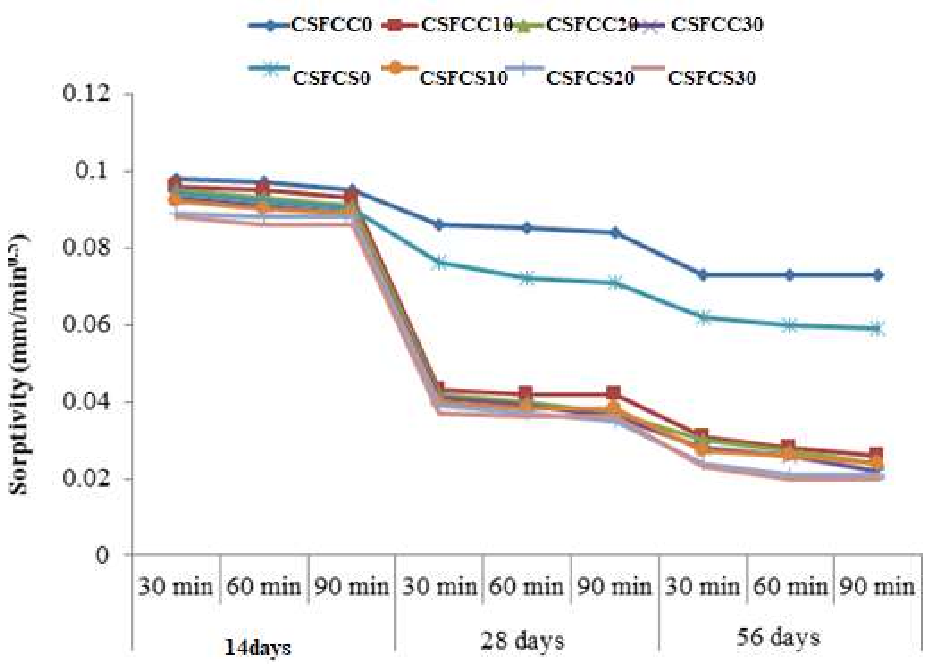


Figure 4. Coconut Shell concrete-Sorptivity

5.4 Rapid Chloride Penetrability Test(RCPT)

The results of the RCPT for the combinations of CSFCC and CSFCS are shown in Figure 6. The RCPT value for the sample CSFCC was found to be 794.7 on day 14, however it slightly decreased at days 28 and 56. A lower value of charges conveyed for FA additions was seen in the CSFCC mixes (CSFCC10, CSFCC20, and CSFCC30), and this value declined with FA content. A significant drop in voltage transmission was seen in CSFCC combinations with FA added at 28 and 56 days..

Compared to CSFCC blends, CSFCS combinations transferred power at much lower levels. Generally speaking, these resources degrade as the age of the concrete rises. A significant decrease was found in FA additional CSFCS mixes (CSFCS10, CSFCS20 and CSFCS30).

Both the CSFCC and CSFCS combinations have relatively little chloride-ion permeability, per ASTM (Table 11). and Table 10. It was also observed that the temperatures of the samples were increasing during the test. Physical examination of the samples revealed higher temperatures on the investigated samples after the experiment was completed.

Figure 5.Rapid chloride permeability test

Table 10 Grading of coconut shell concrete by RCPT

MixID	Charge Passed(coulombs)		
	Age of 14day	Age of 28day	Age of 56day
CSFCC0	794.7	768.3	744.5
CSFCC10	704.3	662.5	622.4
CSFCC20	643.5	599.6	556.2

CSFCC30	598.6	548.8	507.4
CSFCS0	553.1	535.6	519.8
CSFCS10	503.3	473.5	444.6
CSFCS20	466.4	433.8	404.3
CSFCS30	413.2	382.1	349.7

Table 11.RCPT Standard (as per ASTM)

PassedCharges (clmbs)	**Absorptivity of Chloride**
Greaterthan 3,500	Extraordinary
2,500to3,500	Reasonable
1,500to2,500	Near to the ground
150to1,500	Low
<150	No need to consider

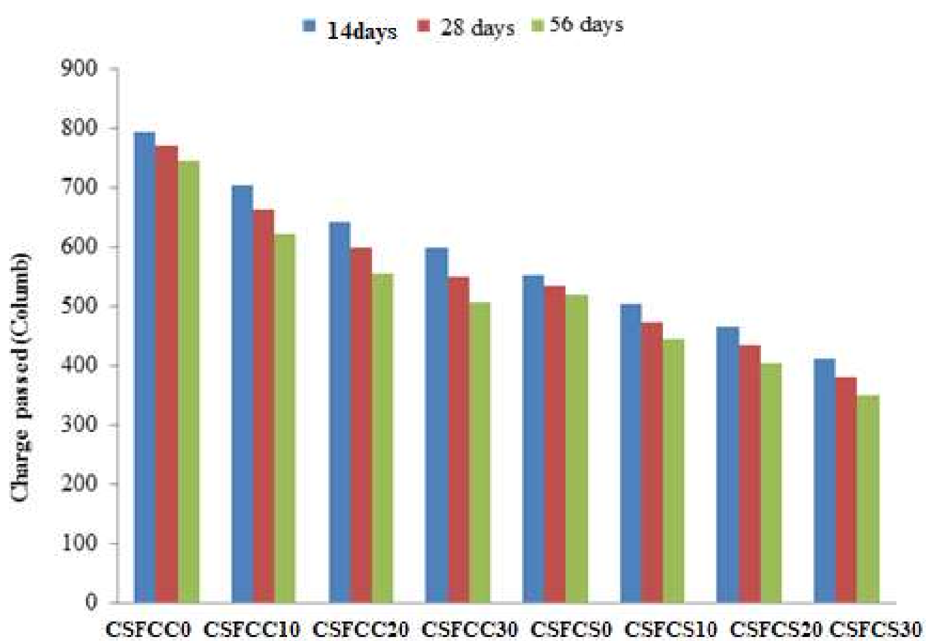


Figure 6. RCPT results for coconut shell concrete

6.CONCLUSIONS

1. The VPS of combinations of CSFCC and CSFCS frequently decreased when FA was substituted. When the CSFCCC combination comprised 10, 20, or 30% FA 2, the VPS of the CSFCS0 sample at 28 days was 15.2 percent lower than that of the CSFCC0 sample.
3.VPS drastically dropped with the replacement of 30% FA; the difference was 6.1 percent as opposed to 15.2 percent without the replacement of 30% FA (CSFCS0).
4. As a result of the big and high-quality cement particles generated with both a lower w/c ratio of 0.33, CSFCC and CSFCS mixes have comparatively low Sorptivity
5. The RCPT value for the sample CSFCC was determined to be 794.7 on day 14, although it significantly declined on days 28 and 56.

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