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Eco-friendly concrete: Using fly ash and shredded corn cob ash as sustainable partial substitutes

ABSTRACT

In this research seven concrete mixes were designed and prepared, of which one was a control mix (CC) and six were SCCA mixes (SCC1-SCC6). The fresh concrete characteristics were determined by slump and compaction factor tests, which indicated a progressive diminish in workability with an enrich in SCCA content due to the porous and irregular nature of corn cob ash. The density of concrete diminishd from 2178 kg/m³ for CC to 1770 kg/m³ for SCC6. The results of mechanical tests indicated that the compressive, split tensile, and flexural strengths of concrete diminishd with an enrich in SCCA content, with SCC6 showing a diminish of about 22%, 22.5%, and 18% at 28 days, respectively. The saturated water absorption and acid resistance tests indicated a marginal enrich in permeability and susceptibility with an enrich in SCCA content. Strength and durability trends were explained by SEM analysis, which showed that fly ash boostd matrix densification while excessive SCCA produced void formation and weak interfacial transition zones. Overall, the study shows that substituting 15% fly ash for 4–12% SCCA achieves the best possible balance between durability, mechanical performance, offering a practical way to produce environmentally friendly concrete using agricultural waste.

***Keywords**: Shredded corn cob ash, Water absorption, Acid resistance, SEM*

1. INTRODUCTION

The production of OPC accounts for about 8% of total anthropogenic CO_2 emissions, and thus the need for low-carbon concrete is an important research area. Partial substitution of cement and natural aggregates with industrial by-products and agricultural wastes has been found to be an effective way to diminish the environmental footprint without compromising performance. Of these, fly ash (FA) and corn cob ash (CCA) have received considerable attention owing to their potential use as pozzolans and their role in waste management.

Fly ash, a potential supplementryto enhance the fresh and hardened properties of concrete. Various studies have shown that the substitution of cement with FA at 10-30% by weight can help retain or even enrich workability because of its spherical particle shape and lower water demand [1].

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In conventional and high-strength concrete, the 28-day compressive strength can be retained or enrichd at FA levels of 10-20%, with enrichs in strength of up to 20-30% in optimized mixes [2]. At levels above 30% substitution, the loss of early-age strength becomes substantial because of the dilution effect of the clinker phases, although strength may recover with time. [3] At higher FA levels above 15% in pervious and highly porous concrete, permeability and void content have been found to diminish because of pore filling, suggesting that FA dosage needs to be optimized depending on the type of concrete. [4]

Conversely, corn cob ash, produced from the controlled combustion of agricultural waste, has been found to have strongly contrasting physical properties. The irregular, porous, and highly absorbent nature of CCA particles leads to higher water demand and lower workability. [5] Laboratory trials have found slump values to diminish by 15-40% with enrichingCCA proportions from 5% to 15%, along with a diminish in fresh density because of the lower relative density of the ash. [6] As a partial substitution for cement, various studies have found 5-10% CCA by weight of cement to be an optimal range, wherein compressive and flexural strengths can be preserved or even enhanced slightly [7]. Strength increments of 6-7% and water absorption reduction of 10% have been observed in concretes containing 8-10% CCA, due to filler effects and partial pozzolanic activity [8].

However, the use of CCA is very sensitive to its chemical composition and processing conditions. Research on unprocessed or high-alkali CCA has shown accelerated hydration but marked reductions in compressive strength of up to 20-30% lower than control mixes at 28 days, along with lower durability indicators of enrichd chloride charge passed and reduced electrical resistivity. [9,10]. These results indicate that unprocessed or poorly processed CCA could act mainly as an inert or weak filler material and could even be harmful to durability [11]. When CCA is used as a fine aggregate substitute at substitution ratios of 5-20% by volume of sand, the compressive strength is generally reduced with enriching amounts of CCA; a 28-day strength of about 22 MPa has been reported for concrete containing 10% CCA sand substitute, compared to higher strengths in control mixes, although strength development with age is still apparent [12].

From the point of view of durability, FA is always linked to enhanced resistance to aggressive environments [13]. Optimized FA concretes show 15-25% permeability reduction, reduced chloride diffusion, and optimized pore structure because of the secondary C-S-H gel formation [14]. Agrowaste ashes, such as CCA, can also boost durability if used optimally. Optimized CCA with ≤10% cement substitution has been demonstrated to reduce water absorption by 8-12% [15]. However, the conflicting durability results for CCA indicate the need for a detailed study, especially in relation to transport properties and microstructural evolution [16].

Microstructural analysis carried out using scanning electron microscopy indicates that FA helps to create a denser cement matrix and a better interfacial transition zone by decreasing the amount of calcium hydroxide and creating a finer pore connectivity [17]. Microstructural refinement is only seen in CCA-based systems when the ash is sufficiently burned and finely ground; otherwise, the matrix is dominated by unreacted particles and microvoids [18]. According to recent research, hybrid or ternary systems that combine FA with small amounts of agro-ashes may be able to achieve better particle packing and balanced SiO_2–Al_2O_3 chemistry, which would produce a denser microstructure [19]. Nevertheless, there is still a dearth of experimental data on OPC–FA–CCA blended concretes, especially when it comes to linking microstructural characteristics to mechanical and durability performance [20].

FA and CCA provide complementary environmental benefits from a sustainability perspective. While CCAvalorizes agricultural residues and lessens open burning practices, FA minimizes the use of clinker and keeps industrial waste out of landfills [21]. Durability studies suggest that the use of FA to replace cement at 15-30% can lower CO2 emissions by 20-40%, and the addition of agro-waste ash like CCA at 10% substitution rate further boosts resource utilization [22].

Despite these benefits, the majority of current research looks at FA and CCA separately, and it is still unclear how FA and CCA together affect workability, strength, durability, and microstructural features. Specifically, integrated experimental studies that measure both fresh and hardened performance and establish a direct connection between observed trends and microstructural evolution are lacking. Thus, the current study intends to examine environmentally friendly concrete that uses fly ash and corn cob ash as partial substitutions for cement with a methodical assessment of workability, mechanical strength, durability qualities, and microstructural features. By determining the ideal substitution levels that strike a balance between sustainability and performance, the study hopes to advance the creation of low-carbon, structurally sound concrete.

2. MATERIALS

The material properties of OPC 33, M-sand, coarse aggregates, fly ash, and shredded corn cob ash (SCCA) are very important in determining the strength, durability, and performance of concrete. Each material has a unique role to play in the composite behavior of the material [23]. OPC 33 is a general-purpose cement that has a compressive strength of 33 MPa at 28 days and is thus suitable for low to moderate strength applications like residential construction and pavement construction. It has moderate heat of hydration, which is easily manageable in normal conditions but may need control in mass concrete to prevent thermal cracking [24]. With an initial and final setting time of about 58 and 458 minutes, OPC 33 is suitable for general construction purposes, although it is less resistant to aggressive chemical environments than higher-grade cements.

Manufactured sand (M-sand), made by crushing hard rocks like granite or basalt, is a more sustainable substitute for river sand. The well-defined particle size distribution (0.075-1.15 mm) and angular particle shape enrich inter-particle friction and cement paste bonding, resulting in higher strength. The application of M-sand also overcomes the environmental issues associated with the exhaustion of natural sand deposits. Coarse aggregates, with a maximum size of 20 mm, contribute to concrete's volume, strength, and stability. The angular particles enhance mechanical interlocking, and grading ensures a dense arrangement with minimal voids and optimal cement content [25]. Clean and durable aggregates are critical, as any contamination can negatively impact concrete's long-term performance.

Fly ash, a by-product of coal combustion, and Corn cob ash, an agricultural waste product, also has pozzolanic activity. Its use enrichs sustainability by reducing landfill disposal and substituting for cement in the production of eco-friendly concrete. Table 1 lists the properties

Table 1. Material properties

Material	Key Physical Properties	Functional Characteristics
OPC 33	Grade: 33 MPa; SG: ~3.15; IST: ~58 min; FST: ~458 min; Moderate heat of hydration	Primary binder; moderate chemical resistance
M-Sand	Size: 0.075–1.15 mm; FM: 2.6–3.1; SG: 2.60–2.70; Absorption: <2.5%	Angular texture; enhanced interlocking and paste bonding
Coarse Aggregate	Max size: 20 mm; SG: 2.65–2.75; Absorption: <2.0%; Bulk density: 1500–1700 kg/m³	Load transfer; strength and dimensional stability
Fly Ash (FA)	Class F/C; Size: <45 µm; SG: 2.1–2.4; SiO_2: >50% (Class F)	PozzolanicSCM; boostd workability, durability, pore refinement
Shredded Corn Cob Ash (SCCA)	Porous, irregular particles; SG: 1.8–2.2; High surface area	Pozzolanic micro-filler; sustainability enhancement; enrichd water demand at higher dosage

3. MIX DESIGNATION

The concrete mixtures studied in this research work were identified according to the type and amount of binder and fine aggregate modification. A total of seven concrete mixes were studied, one control mix and six sustainable concrete mixes containing fly ash and shredded corn cob as partial substitutes. The control mix (CC) was made up of conventional concrete made from 100% OPC as binder, natural fine aggregate, and coarse aggregate. It was used as a basis of comparison for the performance of the modified mixes [27].

All sustainable concrete mixes were identified as SCC, which stands for concrete with supplementary cementitious material and corn cob. In these concrete mixes, 15% of OPC was replaced with fly ash for cement, as reported to be optimal for strength and durability. The coarse aggregate was kept constant at 100% for all mixes to study the effect of modification in fine aggregate alone. SCC was used as a partial substitution of fine aggregate at 4%, 8%, 12%, 16%, 20%, and 24% by volume, and the rest of the fine aggregate was adjusted to keep the total aggregate content constant. These mixes were identified as SCC1 to SCC6, respectively, with an enrich in the amount of shredded corn cob. Table 2 shows the composition of some mixtures.

Table 2. Mix description of various mix

SI.No.	Trail	Mix Description
1	CC	Conventional Concrete
2	SCC1	85% OPC + 15% Flyash + 100% Coarse Aggregate + 4% Shredded Corn Cob + 96% Fine aggregate
3	SCC2	85% OPC + 15% Flyash + 100% Coarse Aggregate + 8% Shredded Corn Cob + 92% Fine aggregate
4	SCC3	85% OPC + 15% Flyash + 100% Coarse Aggregate + 12% Shredded Corn Cob + 88% Fine aggregate
5	SCC4	85% OPC + 15% Flyash + 100% Coarse Aggregate + 16% Shredded Corn Cob + 84% Fine aggregate
6	SCC5	85% OPC + 15% Flyash + 100% Coarse Aggregate + 20% Shredded Corn Cob + 80% Fine aggregate

4. EXPERIMENTAL INVESTIGATION

After curing, the concrete samples were oven-dried at 110 ± 5 °C for a period of a day to remove free moisture. The dry weight was determined using a calibrated digital balance, while the volume of the samples was determined using dimensions. The density of concrete was derived as the ratio of dry weight to volume [30].The slump test was conducted using a standard cone, filling the cone in three layers and compacting each layer uniformly.

The vertical displacement after removing the cone was measured as the slump. For mixes with low to medium workability, the compaction factor test was used with a two-hopper setup and a cylindrical container.

The compressive strength was measured on 150mm cube specimens at 7, 14, and 28 days using a compression testing machine with a uniform loading rate. Split tensile strength was measured on 150mm×300mm cylindrical specimens subjected to diametral loading. Flexural strength was measured on 100mm × 100mm × 500mm prisms using a third-point loading technique.The durability of the specimens was tested by conducting water absorption and sulfuric acid resistance tests. The microstructure was analyzed using SEM to study the hydration products, pore structure, and matrix densification due to the addition of fly ash and shredded corn cob.

5. RESULTS AND DISCUSSION

5.1. Density Test

Analysis of the density values after 28 days shows a gradual diminish in the density of concrete with an enrich in the SCCcontent. The control mix (CC) had the highest density of 2178 kg/m³, which is normal concrete density. Adding 15% fly ash and 4% shredded corn cob (SCC1) diminishd the density to 2088 kg/m³, indicating a diminish of about 4.1% compared to the control mix. Further addition of shredded corn cob content led to a successive diminish in density, with SCC3 (12% corn cob) having a density of 1988 kg/m³ and SCC6 (24% corn cob) having the lowest density of 1770 kg/m³, indicating a cumulative diminish of about 18.7% compared to CC.

This can be mainly ascribed to the lower relative density and porous nature of shredded corn cob, which acts as a substitute for the denser natural fine aggregate. The addition of fly ash also marginally helps in decreasing the density due to its lower relative density compared to OPC. Although the diminish in density may have a slight effect on strength, it has several benefits in the production of lightweight and eco-friendly concrete, which can be used for non-structural and semi-structural purposes. The result of the density test is shown in Figure 1.

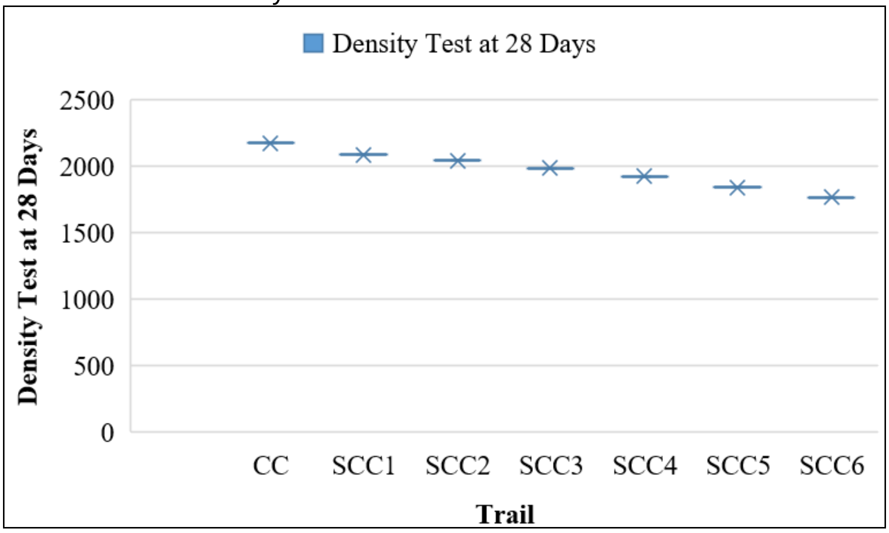


Figure 1: Density

5.2 .Slump Cone Test

The results of the slump test clearly show that the workability diminishs with the enrich in the shredded corn cob content. The control mix (CC) had the highest slump of 116 mm, which is quite workable. The addition of 15% fly ash and 4% shredded corn cob (SCC1) showed a slump of 109 mm, which is a marginal diminish of about 6% over the control mix. With an enrich in the shredded corn cob content, a continuous diminish in the slump value was noticed, and SCC3 (12% corn cob) showed a slump of 93 mm, while SCC6 (24% corn cob) showed the lowest slump of 75 mm, which is an overall diminish of about 35% compared to CC.

The diminish in workability is mainly due to the porous, irregular, and absorptive nature of the shredded corn cob. Although fly ash is known to enrich the workability of concrete due to its spherical shape, the beneficial effect was not sufficient to completely counteract the effect of enriched corn cob. However, all mixes had medium workability, which is adequate for conventional placement with slight mix modification. The slump cone test result is shown in Figure 2.

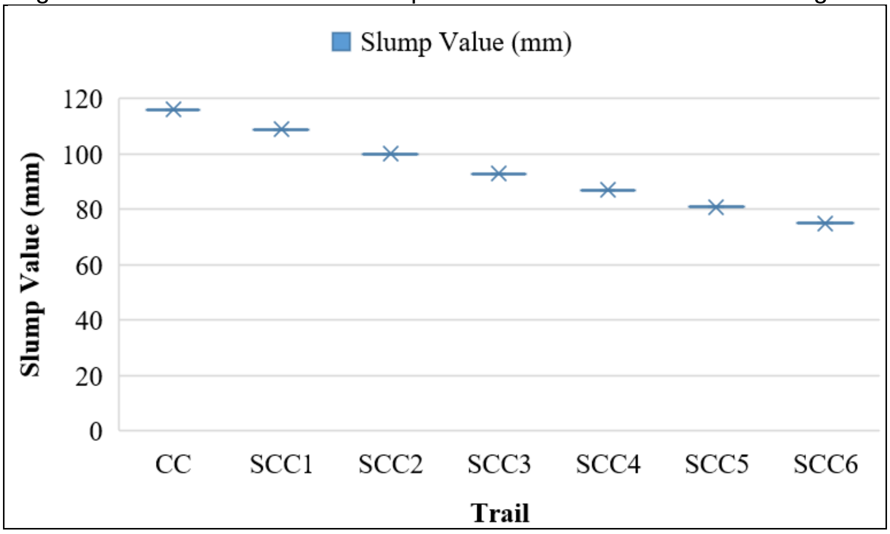


Figure 2. Slump Cone

5.3. Compaction Factor Test

The results of the compaction factor test show a systematic diminish in workability with an enrich in the shredded corn cob content. The control mix (CC) had the highest compaction factor of 0.955, indicating excellent compactability. With the addition of 15% fly ash and 4% shredded corn cob (SCC1), the compaction factor slightly reduced to 0.937, indicating a reduction of about 1.9% compared to the control mix. However, a continuous reduction was noticed with an enrich in the shredded corn cob content, with SCC3 (12% corn cob) having a compaction factor of 0.896 and SCC6 (24% corn cob) having the lowest value of 0.833, indicating an overall reduction of about 12.8%.

The main reason for this reduction is the high porosity and rough surface texture of shredded corn cob, which results in enrichd internal friction and absorbs a portion of the mixing water, thus reducing workability. Although fly ash is known to boost workability due to its spherical shape, its beneficial effect was progressively offset by the enriching amount of shredded corn cob. Although there was a diminish, all mixes were still within the acceptable limit for medium workability concrete. The results of the compaction factor test are shown in Figure 3.

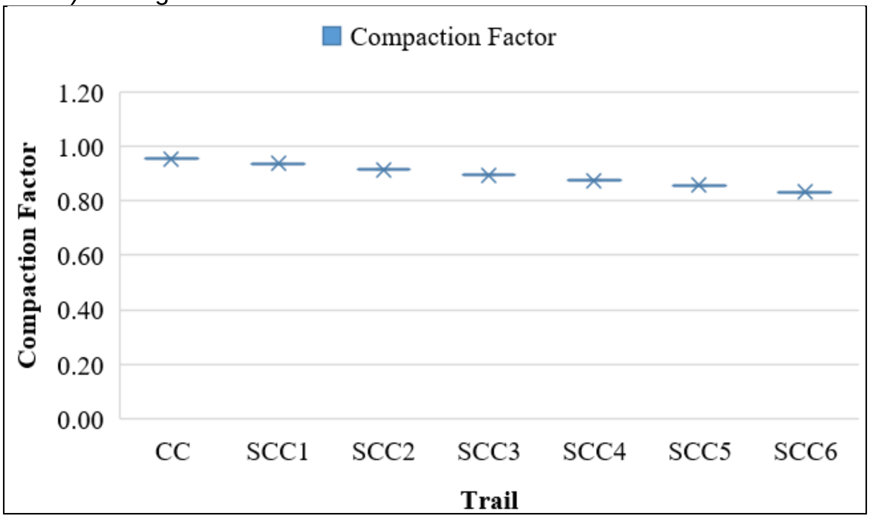


Figure 3. Compaction factor

5.4. Compressive Strength Test

The compressive strength results reveal a clear declining trend as the proportion of shredded corn cob enrichs across all curing periods. The conventional concrete mix (CC) achieved strengths of 18.90 MPa, 26.22 MPa, and 29.22 MPa at 7, 14, and 28 days, respectively. The SCC1 mixture, containing 15% fly ash and 4% shredded corn cob, exhibited comparable performance, reaching 28.54 MPa at 28 days, which represents a marginal reduction of approximately 2.3% relative to the control mix.Whileenriched in shredded corn cob content led to noticeable reductions in compressive strength. At 28 days, SCC3, incorporating 12% shredded corn cob, recorded a strength of 26.37 MPa. The highest substitution level, SCC6 with 24% shredded corn cob, showed the least strength value of 22.60 MPa at 28 days. This corresponds to an overall diminish of nearly 22.7% when compared with the control concrete.These findings suggest that while limited incorporation of shredded corn cob has a negligible effect on compressive strength, higher substitution levels.

The loss in strength is due to the lower stiffness and porous structure of shredded corn cob, which reduces the efficiency of the load transfer process in the concrete matrix. Although fly ash helps in the development of strength at a later stage due to pozzolanic reactions, its beneficial effect was not adequate to overcome the strength loss at higher levels of shredded corn cob substitution. The result of the compressive strength results is shown in Figure 4.

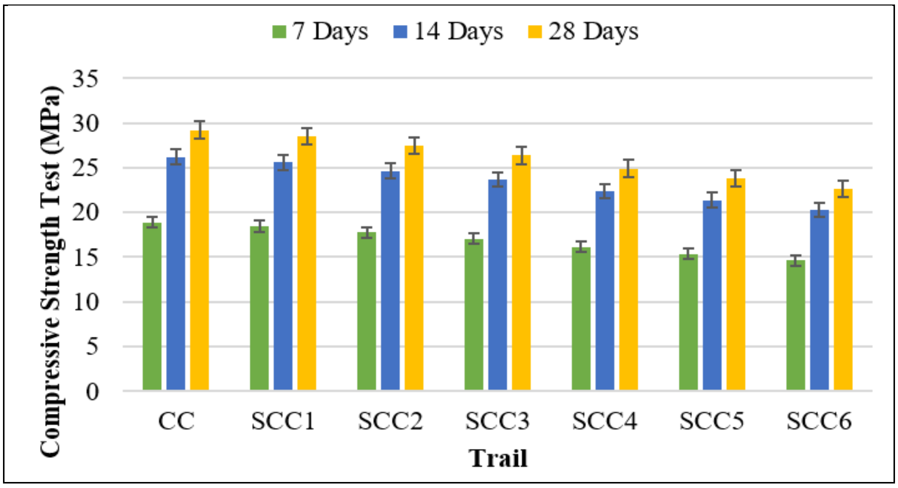


Figure 4. Compressive strength

5.5. Split Tensile Strength Test

The split tensile strength results show a consistent reduction with the increase in the amount of shredded corn cob. The control concrete (CC) had a tensile strength of 1.44 MPa, 2.00 MPa, and 2.22 MPa at 7, 14, and 28 days, respectively. At a lower level of replacement, the SCC1 mix with 4% shredded corn cob showed similar results, with a 28-day tensile strength of 2.17 MPa. This is a marginal reduction of about 2.3% compared to the control concrete and indicates that the use of shredded corn cob has no effect at this stage. With an enrich in the substitution level, a continuous reduction in tensile strength was noticed. At 28 days, SCC2 with 8% and SCC3 with 12% shredded corn cob recorded tensile strengths of 2.09 MPa and 2.01 MPa, respectively. The maximum reduction was noticed in SCC6 with 24% shredded corn cob, which had the lowest tensile strength of 1.72 MPa at 28 days, indicating a reduction of about 22.5% compared to CC. This may be due to the poor tensile properties of corn cob particles and the degradation of the interfacial transition zone at higher substitution levels, despite the positive pozzolanic effect of fly ash.The result of the split tensile strength results is shown in Figure 5.

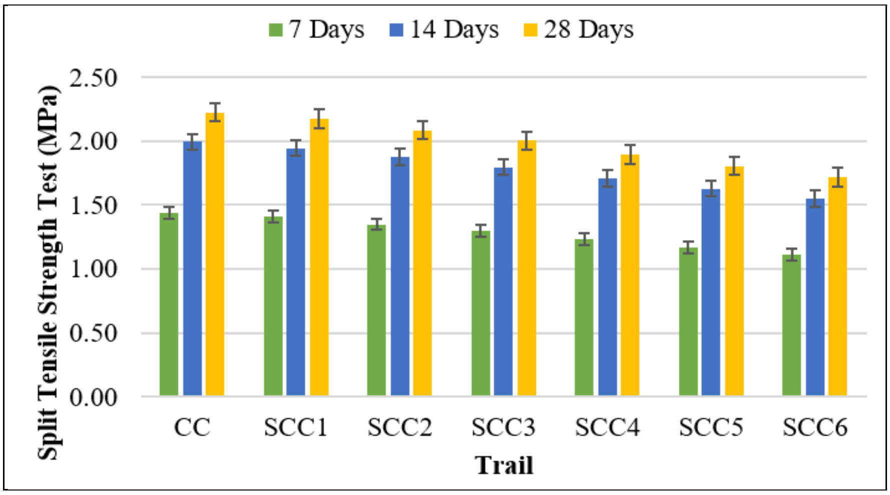


Figure 5. Split tensile strength

5.6. Flexural Strength Test

The results for flexural strength show a steady diminish with an enrich in the content of shredded corn cob at all ages of curing. The control mix (CC) had flexural strengths of 2.28 MPa, 3.16 MPa, and 3.52 MPa at 7, 14, and 28 days, respectively, which is an indication of good load transfer and a compact microstructure. The SCC1 mix containing 4% shredded corn cob showed a negligible loss of strength, with a value of 3.44 MPa at 28 days, which is a marginal diminish of about 2.3% compared to CC.

With an enrich in the content of corn cob, a corresponding diminish in flexural strength was noticed. At 28 days, SCC2 (8%) and SCC3 (12%) showed strengths of 3.30 MPa and 3.19 MPa, respectively. A substantial diminish was noticed at higher levels of substitution, with SCC6 (24%) showing the lowest value of flexural strength of 2.88 MPa at 28 days, which is an 18.2% diminish compared to the control mix. This is largely due to the reduced stiffness and poor bonding between corn cob particles, which are less resistant to cracks and bending forces despite the addition of fly ash. The flexural strength test result is shown in Figure 6.

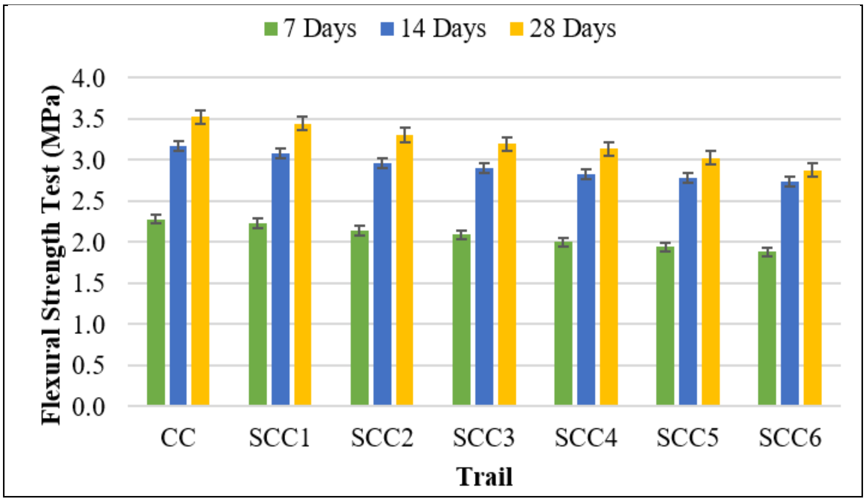


Figure 6. Flexural strength

5.7. Saturated Water Absorption Test(SWA)

The results for SWA show an enrich in absorption with an enrich in the shredded corn cob content at all curing ages. The control mix (CC) had an absorption capacity of 3.15%, 2.88%, and 2.56% at 28, 56, and 90 days, respectively, which continuously reduced with time due to continuous hydration and pore refinement. The mixes containing corn cob had a slightly higher absorption capacity; SCC1 (4%) had an absorption capacity of 3.18%, 2.91%, and 2.58%, respectively, which was comparable to that of CC. As the substitution percentage enrichd, the absorption capacity also marginally enrichd to 3.33%, 3.04%, and 2.70% for SCC6 (24%) at respective ages, which was an enrich of about 5.7% at 28 days compared to CC.

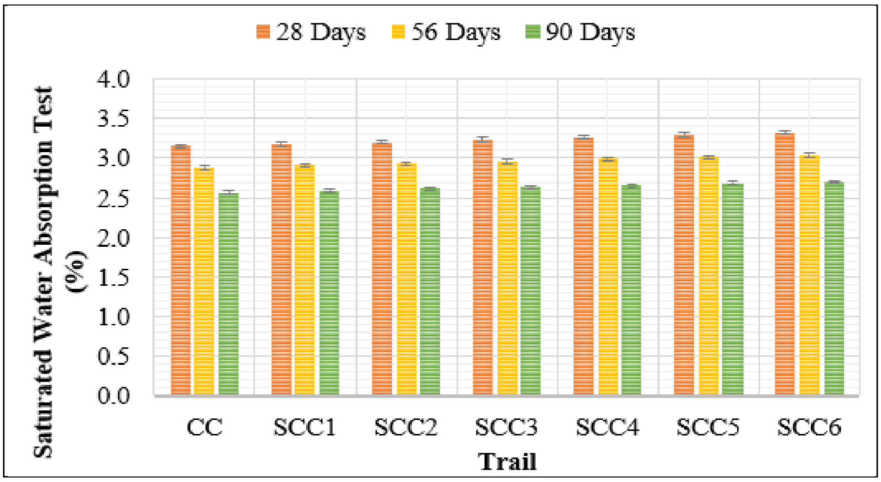


Figure 7. Saturated water absorption

The diminish in absorption with age for all mixes emphasizes the positive effect of fly ash on densification. Nevertheless, the hygroscopic property and porous nature of corn cob particles result in higher water absorption at higher levels of addition, which affects durability-related performance. The SWA test results are shown in Figure 7.

5.8. Acid Resistance Test

The control mix (CC) had a weight loss of 5.27%, 5.02%, and 3.90% and strength loss of 6.13%, 5.83%, and 4.53% at 28, 56, and 90 days, respectively. SCC1 (4% corn cob) had a slightly higher loss of 5.31% and 6.18% at 28 days for weight and strength, respectively, which is a marginal enrich over CC.With the enrich in the amount of corn cob, SCC6 (24%) showed the maximum loss of 5.56% in weight and 6.46% in strength at 28 days, which is equivalent to an enrich of about 5.5% and 5.3% over CC. The data indicate that the addition of fly ash helps in enhancing the long-term resistance to acid attack, while the porous property of shredded corn cob slightly affects the resistance to acid attack. However, the durability of all mixes was found to be reasonable, which indicates that the addition of corn cob up to 24% does not adversely affect the resistance to chemical attack. Figure 8 & 9 illustrate the loss of weight and strength in the acid resistance test.

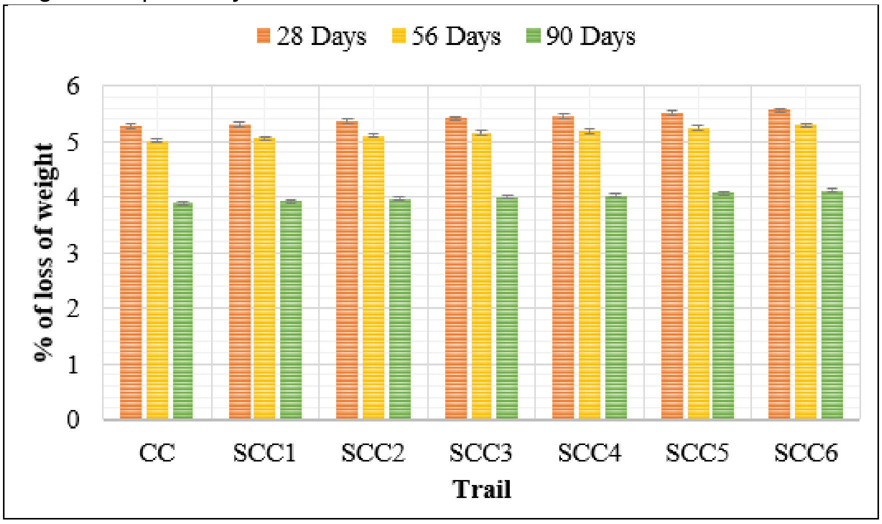


Figure 8. % of weight loss in acid resistance test

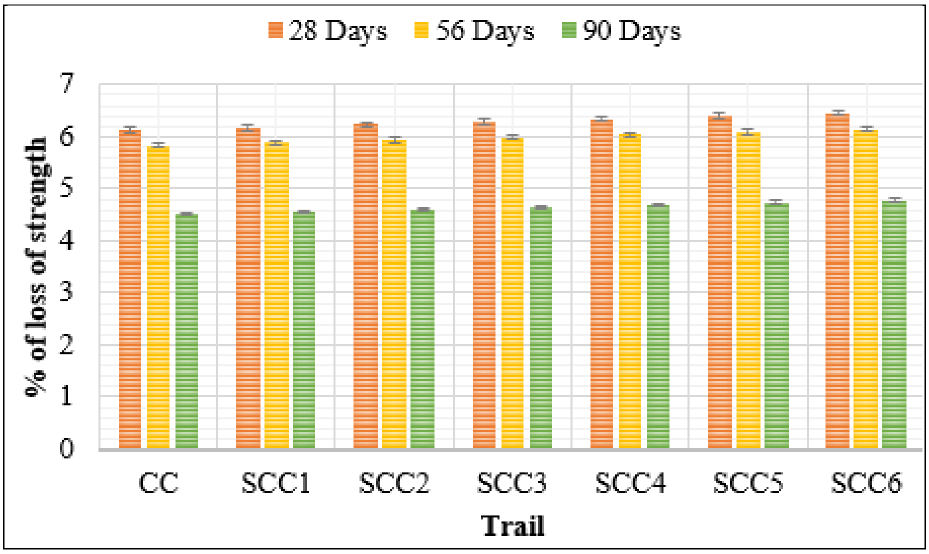
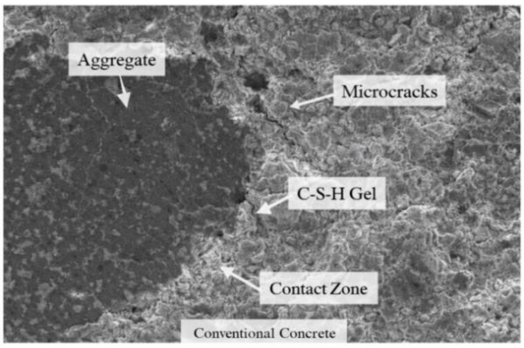


Figure 9. & loss of strength in acid resistance test

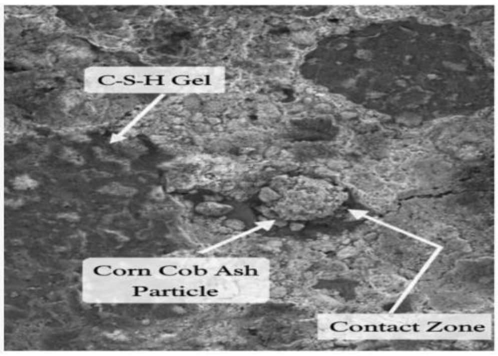
5.9. SEM Analysis

The SEM micrograph of Conventional Concrete (CC) shows a relatively dense and homogeneous cementitious matrix with well-developed C-S-H gel. The ITZ between the aggregate and paste is compact with minimal microcracks and fine pores. This compact microstructure is responsible for the higher density and better mechanical properties of the control mix. In SCC1 with 4% shredded corn cob and 15% fly ash, the microstructure is relatively dense, but there is a slight rise in fine pores. The fly ash particles help in better packing and secondary C-S-H gel formation, which partly mitigates the effects of the porous corn cob ash. The ITZ is still continuous, which is responsible for the marginal diminish in strength and durability compared to CC.

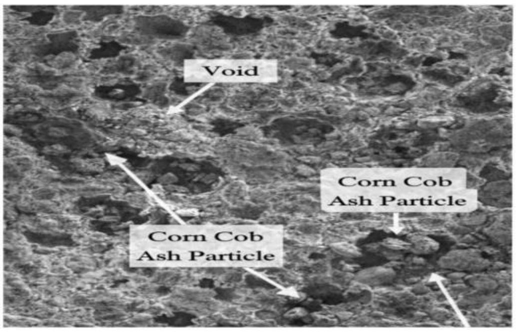
In SCC3 (12% shredded corn cob), the SEM micrographs reveal higher porosity, discontinuous ITZs, and microcracking. The higher corn cob content causes weak interfaces because of the porous and irregular shape of the corn cob particles, thus reducing strength and enriching water absorption. The SCC6 mixture (24% shredded corn cob) has a very porous matrix with unbound particles, large microcracks, and a degraded ITZ. All these characteristics are responsible for the marked diminish in density, strength, and durability, thus proving that a higher amount of corn cob substitution is harmful to concrete. Figure 10 shows the SEM images.



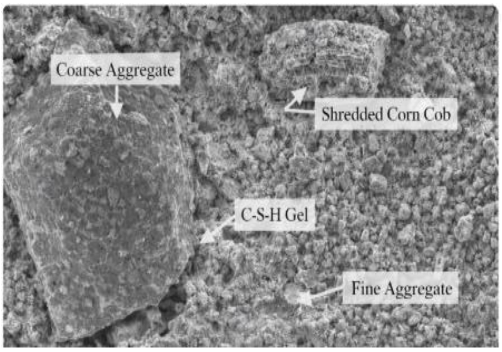
(a) CC



(b) SCC1



(c) SCC3



(d) SCC 6

Figure 10. SEM Analysis

6. CONCLUSION

The experimental study proved that the addition of fly ash (15%) and shredded corn cob ash (SCCA, 4-24%) has a significant effect on the fresh, mechanical, and durability characteristics of concrete. The workability and compaction properties diminishd progressively with an enrich in the SCCA content due to its porous and irregular shape, while the density diminishd by as much as 18.7% for the highest substitution content of 24%. The strengths properties diminishd gradually with an enrich in the SCCA content, with SCC6 showing a diminish of ≈22% in compressive and split tensile strengths and ≈18% in flexural strength compared to the control mix, but with satisfactory performance for lower SCCA contents of 4-12%. The results for saturated water absorption and acid resistance showed that there was a slight enrich in permeability and vulnerability to acid attack with higher levels of SCCA, while the SEM results showed that fly ash enrichd matrix density, and high SCCA content introduced voids and reduced interfacial transition zones. Result: A balanced approach to the production of eco-friendly and structurally sound concrete with high sustainability can be achieved by an optimal substitution of SCCA with 4-12% and 15% fly ash.

In conclusion, the use of shredded corn cob in concrete mixes has a significant effect on the physical properties of concrete. Although it diminishs density, workability, and strength, it does not affect water absorption and acid resistance. This makes it a potential sustainable material for low to medium strength concrete applications, especially where environmental factors and lightness are of prime importance. However, for applications related to high strength concrete, further modifications in the mix, such as boosting the adhesion between corn cob and the cement matrix, would be required to enhance its performance. The practical applications of 10-15% SCCA concrete, especially for non-structural, low-load applications like lightweight embankment blocks and low-traffic sidewalks, support its applicability.

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IZVOD

EKOLOŠKI PRIHVATLJIV BETON: KORIŠĆENJE LETEĆEG PEPELA I PEPELA IZ ISCEPLJENIH KLIPOVA KUKURUZA KAO ODRŽIVIH DELIMIČNIH ZAMENA

U ovom istraživanju je projektovano i pripremljeno sedam betonskih mešavina, odkojih je jedna bila kontrolna mešavina (CC), a šest su bile SCCA mešavine (SCC1-SCC6). Karakteristike svežeg betona određene su testovima faktora sleganja izbijanja, koji su ukazali na progresivno smanjenje obradivosti sa povećanjem sadržaja SCCA zbog porozne i nepravilne prirode pepela od klipa kukuruza. Gustina betona se smanjila sa 2178 kg/m³ za CC na 1770 kg/m³ za SCC6. Rezultati mehaničkihi spitivanja pokazali su da se čvrstoća betona na pritisak, zateznu čvrstoću i čvrstoću na savijanje smanjuju sa povećanjem sadržaja SCCA, pri čemu SCC6 pokazuje smanjenje od oko 22%, 22,5% i 18% nakon 28 dana, respektivno. Testovi apsorpcije vode i otpornosti na kiseline pokazali su marginalno povećanje propustljivosti i osetljivosti sa povećanim sadržajem SCCA. Trendovi čvrstoće i izdržljivosti objašnjeni su SEM analizom, koja je pokazala da leteći pepeo povećava zgušnjavanje matrice, dok prekomerni SCCA dovodi do formiranja šupljina i slabih prelaznih zona na površini. Generalno, studija pokazuje da zamena 15% letećeg pepela sa 4–12% SCCA postiže najbolju moguću ravnotežu između izdržljivosti i mehaničkih performansi, nudeći praktičan način za proizvodnju ekološki prihvatljivog betona korišćenjem poljoprivrednog otpada.

Ključne reči: Pepeo od usitnjenog kukuruznog klipa, Apsorpcija vode, Otpornost na kiseline, SEM,

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