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Use of Alccofine and Porcelain Waste Aggregate in Concrete Composite for Strength Enhancement

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Abstract

Building construction applications benefit from recent studies on alumino-silicate alkaline activation geo-polymers and their supplementary modifier alccofine as well as new process advancements characteristics including flexural strength and split tensile strength determine structural performance and durability. The construction sector utilizes supplementary cementitious materials, waste materials, and Geo Polymer Concrete (GPC) for concrete composites because it requires environmental sustainability along with better functionality and longer service life of concrete structures. This research explores the combined effect of using 16% alccofine cement replacement alongside porcelain waste aggregate as a substitute for coarse and fine aggregates at various percentages between 1% to 5% in self-compacting concrete composite(SCC). The research analyzes how varying percentages of PWA (1% to 5%) together with 16% Alccofine affect the tensile strength in split and flexural testing of SCC. The investigation determine the PWA replacement ratio which maximizes the mechanical qualities and durability of SCC to enable sustainable and long-lasting structures. Researchers created concrete composite mixes through the combination of 16% Alccofine cement substitutions with PWA that replaced coarse and fine aggregates at five different percentages between 1% and 5%. The mechanical properties strength and tensile strength were assessed by following recognized testing procedures. The researchers tested specimens through four stages of curing which lasted for 7, 28, 56 and 90 days comparing control samples with no alccofine or PWA. The combination of 16% Alccofine with 3% PWA produced the best outcomes in Geo Polymer Concrete (GPC) by strengthening both flexural and split tensile strength measurements. The composite material reached outstanding mechanical achievements and structural resilience benefits through adding 3% PWA yet replacements below this amount demonstrated minimal effect.

Keywords: Alccofine (AL), porcelain waste aggregate (PWA), self-compacting concrete composites (SCC), geo polymer concrete (GPC)

INTRODUCTION

Under its own weight Self-compacting concrete (SCC) performs self-consolidation without demanding mechanical vibration. The use of SCC produces significant advantages for filling heavy structural components including beams and slabs as well as columns and shear walls and foundations. Its advantages have led to widespread adoption in structural engineering, including reduced construction time, noise-free application, and improved structural integrity by effectively filling gaps [1]. Disposing industrial wastes demands significant amounts of available land space resulting in major environmental disruptions to the land. Researchers have produced Substitute binder materials which aim to solve existing challenges. The alkali activation process of silica and alumina

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rich compounds known as Geo Polymer Concrete (GPC) and Earth Friendly Concrete (EFC) stands as one of these prominent materials [2]. The addition of a superplasticizer enhances the workability of SCC and prevents segregation. The global use of cement has increased significantly, with an estimated demand of around 5 billion metric tons. Cement production consumes a vast amount of raw materials and contributes to a significant release of CO2 in atmosphere, account for approximately 5% to 7% man-made CO2 emissions. The scientific community directs research to reduce environmental effects by implementing supplementary cementitious materials for substituting cement constituents in construction materials. Industrial by-products such as metakaolin (MK) have been studied for their effectiveness in refining the microstructure of SCC, reducing permeability, and minimizing chloride ion ingress, investigated effects of MK on the fresh, durability, mechanical and properties of SCC with varying MK content (0%, 5%, 10%, and 15%) [3, 4]. The various heat curing temperatures with different silica fume amounts and confirmed heat curing provided the best results for GPC [5]. Their findings indicated that a 10% MK mix exhibited optimal properties, including improved strength and reduced energy consumption. However, SCC, like conventional cement-based matrices, is susceptible to brittle failure under tensile stress or impact loading. The incorporation of fibers can enhance the tensile strength of SCC and mitigate its brittleness, thus extending the lifespan of reinforced concrete structures while reducing maintenance costs [6]. Several studies have explored the benefits of fiber reinforcement in SCC. The impact of fiber inclusion on SCC's compressive, split tensile, and flexural strength and while effect of alkali-resistant (AR) glass fiber reinforcement (0%, 0.03%, 0.06% & 0.1%) on concrete durability. The optimal durability improvement occurred at 0.1% fiber content. The AR glass fibers enhanced the crack resistance and temperature resilience lightweight concrete, leading to better serviceability and durability and further demonstrated that AR glass fibers effectively controlled cracking in SCC without significantly altering its flow-ability or mechanical properties [7, 8]. The practice of using industrial and agricultural waste materials such as fly ash, rice husk ash, and ground granulated blast furnace slag for partial substitution of ordinary Portland cement has become traditional because all these materials display pozzolanic properties. Pozzolans enhance concrete's mechanical strength and durability by refining interfacial transition zone (ITZ) & reducing porosity through pozzolanic reactions. Changing concrete performance standards require modern SCMs because they improve resistance against environmental pressures. Alccofine is new-generation ultra-fine SCM, has demonstrated superior strength and durability improvements compared to conventional SCMs like fly ash and silica fume derived from iron &steel industries [8]. Alccofine composed of ultra-fine glass-based particles with a high specific surface area, significantly influencing both fresh and hardened concrete properties. The pozzolanic nature of most SCMs contributes to increased strength and durability over time, while their integration with cement offers benefits such as reduced cement consumption, recycling of industrial waste, improved physical properties, and enhanced rheological and mechanical characteristics [10]. The production process with GPC/EFC yields affordable solutions that decrease CO2 emissions and produce sustainable materials [9]. The research determines how the combination of Alccofine with fly ash affects SCC strength properties. SCC specimens, including beams, cylinders, and cubes, were cast using a constant fly ash content (25% of the total mass) and varying Alccofine dosages (5%, 10%, and 15%). The laboratory conducted tests which measured modulus of rupture combined with tensile strength and compressive strength of the specimens. The construction industry widely applies pozzolanic materials which consist of silica fume (SF) and GGBS and rice husk ash (RHA) alongside fly ash (FA) as cement alternatives to decrease cement quantities while strengthening concrete resistance against damage. [11, 12]. The advent of SCC has revolutionized concrete placement by eliminating the need for mechanical compaction, leading to improved construction quality, especially in congested reinforcement zones. The fluidity and cohesiveness of SCC are achieved through the use of superplasticizers and fine powder materials. Pozzolans serve as an optimal alternative to cement, providing adequate strength, improved durability, cost reduction, energy efficiency, and lower greenhouse gas emissions [13]. Investigations demonstrate that MK as an ingredient in SCC alongside rice husk shows improved pozzolanic reaction capabilities because of its high silica content which benefits strength and durability [14]. The tensile strength of areca fiber /glass fiber/ epoxy resin combination observed significant improvement in the strength with hybrid fiber incorporation and alkali treatment. The combination of areca fiber (10 wt%)/glass fibers (10 wt%)

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observed 23.8 MPa of tensile properties compared to untreated fibers with 15.5 MPa [15]. Since the fibers began breaking down at 308°C, they might be suitable in composites with an oil-based and perhaps a bio-based matrix. However, since their surface is rough and they are prone to splitting, treatment should be done to clean away the loose parts and leave equally shaped fibers, lowering the chances of splitting [16]. Grewia Monticola Sond (GMS) fibers are suited for reinforcement in bio-composites as they contain a lot of cellulose and degrade at suitable temperatures for polymer processing. Even though it lower activation energy, this textile often experience damages during manufacturing. Even though GMS fibers aren't very rough and need little to no chemical processing, strengthening the fibers would decrease splitting under stress [17]. This paper found that the fibers taken from FRL aerial roots have a high amount of cellulose and a low content of lignin, which adds strength to the composites made from them. Because of their high value of 465.45 MPa, 5.81 GPa modulus, and only 1376 kg/m³, the fibers are ideal for use in both structures and textiles [18]. Epoxy composites made from the untreated bark of Acacia caesia were the focus of this study. Regardless of having irregular shapes, fibers 20 mm in size increased the composite's tensile, flexural, impact strength, and hardness. During molding, a little air got into the product, which showed that there is an area worth improvement in bonding the fibers with the matrix. None of the thermal changes were significant, suggesting Acacia caesia is an attractive support material compared to other bark [19]. The tribological behavior of these composites indicates that the introduction of this amount of fibers also offers the most limited wear [20]. Even after water has saturated the disc brakes made with this hybrid, its mechanical strength is strong enough to function normally. Such composites work better than jute/banana and hemp types when they are properly reinforced. With the outcomes of this investigation, we are more prepared to upgrade the process by, for example, working with hard filler components and bio-epoxy resins [21]. MK inclusion enhances sulfate resistance in concrete. The development of self-compacting concrete (SCC) and upcoming advances in concrete technology happen through supplementary cementitious material and Geo Polymer Concrete (GPC) usage in composite mixtures which deliver sustainable high-performance solutions that address present construction requirements.

MATERIALS USED

Cement, Fine Aggregate and Coarse Aggregate

The research utilized commercially obtained Portland Pozzolana Cement (PPC) with a specific gravity value at 3.11 according to BIS: 8112 (BIS 2013). The setting process of the cement started at 45 minutes and ended after 8 hours 50 minutes. The two technical timeframes represent cement hardening onset and cement stiffness achievement duration. The fine aggregate followed IS 383:2016 to establish its characteristics as ordinary siliceous sand with a fineness modulus of 2.62 and a specific gravity of 2.46. The fineness modulus evaluates aggregate particle size distribution by showing higher values equal to larger particles. Any construction work which utilizes 20 mm native Basalt as coarse aggregate must adhere to IS 383 – 1970 specifications. The specific gravity test showed the coarse aggregate had a measurement of 2.74. Water absorption measurement of the coarse aggregate under SSD (Saturated Surface Dry) conditions produced a result of 1.01%. When SSD occurs the pores within the aggregate are completely water saturated while the surface stays free of any additional water. As per Indian Standard IS 383 – 1970 the coarse aggregate met all specified criteria for concrete aggregates. Table 1 presents the summary of cement test results which provides additional information about its properties.

Table 1. Properties of cement.

Test	Results
Specific gravity	3.11
Initial and final setting time	45 minutes & 8 hours 50 minutes
Compressive strength after 28 days	33 MPa
Standard consistency	32%
Soundness	1.9 mm
Fineness	99%

Table 2. Alccofine chemical properties (% by mass).

S no.	Characteristics	Test results	Requirement as per IS 16715:2018	Test reference
1	Manganese Oxide (MnO)	1.18	5.5 Max	IS 4032
2	Magnesium Oxide (MgO)	6.7	17.0 Max	
3	Sulphide Sulphur (S)	0.5	2.0 Max	
4	Sulphate (SO_3)	0.14	3.0 Max	
5	Insoluble residue	0.5	3.0 Max	
6	Chloride content	0.01	0.1 Max	
7	Loss on ignition	+0.43	3.0 Max	
8	(CaO+MgO+Al2O3)/SiO2	1.85	1.0 Min	
9	Moisture content	0.1	1 Max	IS: 16715:2018
10	Glass Content	94	85 Min	

Table 3. Physical properties of alccofine.

S. no.	Characteristics	Test results	Requirement as perIS 16715:2018	Test reference
1	D_{10}	1.8	----	IS: 16715:2018
2	D_{50}	4.7	5 Max.	
3	D_{90}	9.3	----	
4	D_{95}	10.8	15 Max	

Alccofine

The proprietary and patented product Alccofine 1203 contains low-calcium silicate-based mineral components. Under controlled granulation production Alccofine 1203 achieves its unique particle structure. Alccofine 1203 improves Geo Polymer Concrete (GPC) and composite construction performance through its contribution to enhanced hydration based on its latent hydraulic features and pozzolan characteristics. [22, 23]. In this research, AL 1203, this complies with the ASTM C989-1999.

Alccofine 1203 improves the packing capability of paste material to lower water consumption while decreasing admixture usage. The strength and durability characteristics of concrete composite at every age improve when alccofine 1203 is added [24]. Alccofine 1203's chemical and physical properties are detailed in Tables 2 and 3 according to the standards of IS 16715:2018 and testing references IS 4032.

Alccofine Influence on Pozzolanic Activity

The high-performance level of Alccofine as a pozzolan mainly comes from its fine particle size and the right combination of chemical qualities. Because OPC contains many ultrafine particles, it surfaces support plenty of places for more hydration reactions with calcium hydroxide [$Ca(OH)_2$]. Consequently, the cement starts to harden immediately, hydrates faster, and grows notably sturdy at an early stage. Moreover, small particles inside the mixture make the concrete's pore structure more solid and long-lasting. Since Al_2O_3 + CaO + MgO accounts for 1.85 times as much as SiO_2, the concrete is highly pozzolanic and extra C-S-H gel helps it stay strong for a long period. Chemical stability and durability are ensured if there are low levels of chlorides, sulphates, and loss on ignition (LOI). The reason Alccofine acts as a strong admixture for concrete is its high purity composition and chemical structure.

Porcelain Waste Aggregate

Porcelain waste aggregate in SCC refers to the use of crushed or ground porcelain waste materials as a partial replacement of 1% to 5% for conventional aggregates (such as natural sand or gravel) in the production of SCC. Porcelain waste typically comes from discarded ceramic products like tiles, sanitary ware, or other porcelain-based materials. GPC combined with porcelain waste aggregate helps reach dual objectives of waste recycling and decreases building material environmental footprint by removing refuse from landfills. This application helps protect natural resources because it decreases the need for traditional virgin aggregates. The necessary particulars can be adjusted through crushing followed by processing to convert waste porcelain into aggregate materials. Addition of recycled materials to GPC results in sustainable construction while preserving or improving composite structures' technical results. [25, 26].

Impact of Waste Material on Envirnoment

- *Reduction in landfill waste*: Porcelain waste (from discarded tiles, sanitary ware, etc.) is non-biodegradable and occupies large landfill spaces.
- *Conservation of natural resources*: Traditional concrete production relies heavily on mining natural aggregates, leading to habitat destruction, soil erosion, and resource depletion.
- *Lower carbon footprint*: it takes a lot of energy to produce cement, this process represents 8% of the world's CO_2 output. Because PWA does not replace cement, it makes it possible to create concrete with less aggregates, which reduces embedded energy.
- *Reduction in energy consumption*: It takes crushing, washing, and transporting natural aggregates, and these actions are very energy-consuming. If porcelain waste is flowed straight into road-building without much treatment, it can help reduce energy resources over those used for classic aggregates.
- *Potential for improved concrete durability*: Experts state that adding PWA to concrete may increase strength, toughness, and durability, which help ensure that structures are durable, need less frequent restoration, and are environmentally friendly over time.

Super-Plasticizer

5202 NS is a HRWR admixture by Sika Plast is typically based on poly-carboxylate ether (PCE) technology, its density 1.08/L at 25 ^{0}C and pH value ≥ 6. Which is a type of polymer. It complies with IS 9103 and ASTM C494 standards, ensuring its suitability for high-range water-reducing applications [27]. The carboxylate (-COO$^-$) groups in the PCE backbone create a negative charge on cement particles leads to electrostatic repulsion, preventing cement particles from clumping together.

PCE (SikaPlast-5202 NS) + Cement Particles → Adsorbed Layer + Dispersion Effect

MIX PROPORTIONS

Design specifications for the mix ratios of nominal concrete along with Alccofine concrete adopting 16% cement substitution followed by Alccofine concrete containing porcelain waste aggregate at different levels between 1% to 5% originated from IS:10262-2019 standards. Table 4 contains mix proportions for concrete of various types.

- Nominal Concrete (SCC0) Standard concrete mix without any replacements.
- The concrete product SCC1 contains Alccofine as a micro-fine material that replaces 16% of cement to improve material strength and durability.
- Alccofine with Porcelain Waste Aggregate (PWA) Concrete (SCC2 to SCC6) – Concrete incorporating 16% Alccofine and varying percentages of porcelain waste aggregate (1% to 5%) respectively, which partially replaces conventional coarse aggregates.

These mix designs ensure optimal performance, workability, and strength characteristics while making use of supplementary materials like Alccofine and porcelain waste, which contribute to sustainability and material efficiency.

Table 4. Nominal concrete mix proportion (in Kg/m^3), concrete incorporating 16% alccofine and varying PWA from 1% to 5%.

Mix ID	Cement	Alccofine	Fine aggregate	Coarse aggregate	PWA	Water	Super plasticizer
SCC 0	410	0	1125	730.92	0	164	4.92
SCC 1	344.40	65.60	1125	707.32	0	164	4.51
SCC 2	344.40	65.60	1120.42	684.39	18.33	164	4.10
SCC3	344.40	65.60	1115.83	660.42	36.67	164	4.10
SCC4	344.40	65.60	1111.25	636.46	55.00	164	4.10
SCC5	344.40	65.60	1106.67	612.49	73.33	164	4.10
SCC 6	344.40	65.60	1102.08	588.53	91.67	164	4.10

EXPERIMENTAL METHODOLOGY

Prior to the primary casting phase, multiple trial concrete mixes were prepared and evaluated to determine workability. Once the Geo Polymer Concrete (GPC) demonstrated satisfactory workability, further investigations were conducted. Manual mixing occurred on a non-porous surface for the production of homogenous mixtures in compliance with IS: 516–1959. Initially, the cement and coarse and fine aggregates were dry-mixed to achieve uniform dispersion. Subsequently, alccofine and PWA were incorporated and blended thoroughly to ensure even distribution within the matrix. A precisely measured quantity of water and a HRWR admixture (superplasticizer) were then introduced into the dry mix to facilitate proper hydration and enhance the rheological properties of the concrete. This experimental research study investigated the standard water curing effects on the mechanical properties and durability features of concrete containing alccofine and porcelain waste aggregates. The analysis of performance used physical and mechanical tests which included compressive strength assessment combined with flexural strength evaluation and splitting tensile strength testing to measure the structural integrity and load-bearing ability of the modified Geo Polymer Concrete (GPC) mix.

ANALYSIS OF RESULTS

Self Compacting Concrete

Self-Compacting Concrete represents a flowable concrete that does not segregate while it automatically distributes into position to fill formwork while encapsulating steel reinforcements without requiring any mechanical consolidation. The incorporation of alccofine (a high-performance micro-fine supplementary cementitious material) and PWA a sustainable alternative of natural aggregates) can enhance the performance and sustainability of SCC [28]. Table 5 shows flow-ability properties of various mixes. The SCC4 mix demonstrates significantly enhanced flow-ability compared to SCC0 and SCC1, as evidenced by its superior performance in key SCC workability assessments, including the concrete flow test, U-box test, L-box test, and V-funnel test. This improved performance suggests that SCC4 incorporates a more refined mix design, optimizing parameters such as the water binder (w/b) ratio, superplasticizer dosage & fine aggregate content. These modifications contribute to enhanced passing ability, improved filling capability, and greater resistance to segregation, ensuring superior workability and homogeneity in self-compacting concrete composite applications.

Compressive Strength

As per IS 456:2000, the mix ID SCC0 made with conventional concrete had a 90-day compressive strength of 47.08 MPa as the main reference for the study. In all curing times, SCC1 (geo-polymer concrete), performed slightly better than SCC0, ending with a 90-day strength of 47.90 MPa and proving the worth of using alkali-activated binders instead of OPC. SCC2 to SCC6 are made as geo-polymer composite concretes, by mixing geo-polymer binders with mineral additives or industrial wastes like alccofine & porcelain waste. Among all the samples, SCC4 had the highest compressive strength of 48.83 MPa after 90 days because its microstructure was more closely packed and beneficial chemical interactions augmented its strength. At only 7 days, the strength of the SCC1 was higher than that of the other mixes, but SCC 5 was very close. Table 6 presents the compressive strength results while in Figure 1, the comparison of strength between SCC0, SCC1 & SCC4. All the GPCC mixes (SCC2 to SCC6) as well as the GPC mix (SCC1) were better than the traditional mix (SCC0) at all curing ages. But, although SCC6 is a GPCC, the overall strength was lower than SCC0's, which might indicate either inadequate proportions or poor matching among the molecules.

Table 5. Flow-ability properties.

Mix ID	Slump flow dia.(mm)	V-Funnel flow (time S)	L-Box (H_2/H_1) ratio	U-Box filling height (H_1-H_2)
SCC 0	780	7.38	0.839	0.045
SCC 1	801	6.05	0.981	0.034
SCC 2	810	6.00	0.985	0.025
SCC3	815	5.51	0.996	0.014
SCC4	820	5.20	1.00	0.005
SCC5	812	5.80	0.982	0.019
SCC 6	806	6.10	0.973	0.030

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Table 6. Compressive Strength in N/mm$^{2.}$

Mix ID	7 days	28 days	56 days	90 days
SCC 0	27.00	38.40	43.41	47.08
SCC 1	27.50	39.00	44.00	47.90
SCC 2	27.30	38.70	43.91	47.64
SCC3	27.45	39.00	44.08	48.00
SCC4	28.61	39.90	44.95	48.83
SCC5	27.50	38.88	44.11	48.16
SCC 6	26.30	38.45	42.89	47.00

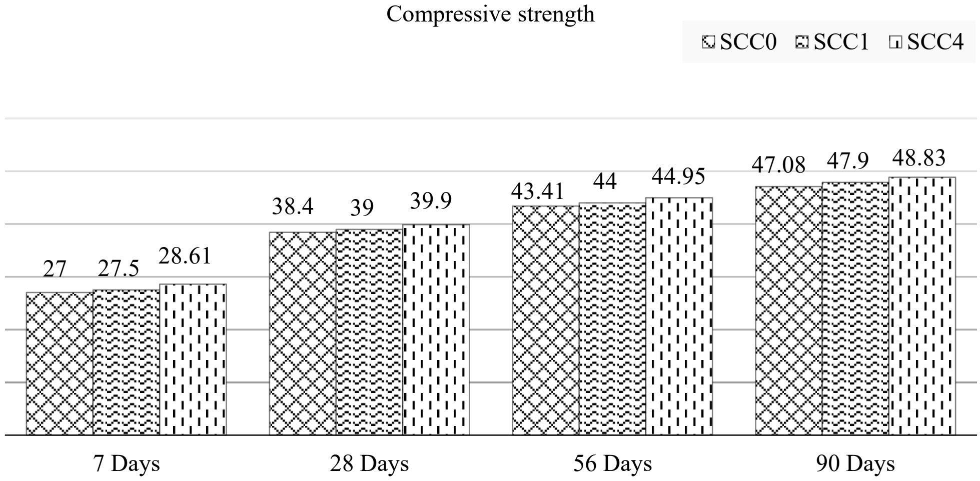

Figure 1. Compressive strength comparison between SCC0, SCC1 & SCC4.

This reveals why geo-polymer and geo-polymer composite concrete systems are important for eco-friendly building, by offering better mechanics and requiring less OPC. To enjoy these benefits with concrete, a person should use the guidelines in IS 10262:2019 (Concrete Mix Proportioning – Guidelines) and evaluate concrete strength by following IS 516:2018 (Methods of Tests for Strength of Concrete).

Flexural Strength

A perpendicular loading system was used to determine the flexural strength from standard-sized beam tests. A three-point load system functioned to evaluate the flexural strength. Testing occurred on beam specimens following IS: 9399–1979 standards with a 10 cm × 10 cm × 50 cm dimension. Table 7 presents the flexural strength test results of the specimens & the flexural strength values as a percentage relative to the control specimen. This test measures a material's ability to resist bending when subjected to perpendicular loads. A testing method where a beam is supported at two ends while a load is applied at the center, inducing bending and determining its flexural strength.

Table 7. Flexural strength in N/mm$^{2.}$

Mix ID	7 days	28 days	56 days	90 days
SCC 0	2.68	3.95	4.77	5.12
SCC 1	3.00	4.20	5.00	5.65
SCC 2	2.65	3.75	4.53	5.05
SCC3	2.74	4.04	4.93	5.29
SCC4	3.35	4.67	6.01	7.00
SCC5	2.70	3.91	4.78	5.07
SCC 6	2.60	3.84	4.67	4.92

An Indian Standard that specifies the procedure for testing the flexural strength of concrete and similar materials. A reference sample used to compare variations in strength due to changes in composition or treatment of other specimens. Table 6 reports absolute values of flexural strength. SCC4 likely has an optimal combination of cementitious materials, aggregates, and admixtures that contribute to superior bonding, dense microstructure, and improved strength. The presence of SCM alccofine (16%) enhances pozzolanic reactions and combination of PWA (3%) increasing strength over time. Increase in strength recorded with PWA concrete from SCC2 to SCC4 as the mix is optimized, a well-balanced water-to-binder (w/b) ratio, leading to improved hydration and densification of the paste. However a downfall of strength was recorded from SCC5 to SCC6. In Figure 2, the flexural strength comparison among SCC0, SCC1, and SCC4 is presented.

Split Tensile Strength

The test procedure requires a 300 mm long cylindrical specimen with a 150 mm diameter that must be placed horizontally between two CTM load surfaces. The experiment continues until the specimen completely fails under the introduced loading conditions. A table containing the strength test results appears in Table 8. The test assesses the strength of the cylindrical specimen by subjecting it to compressive force in a controlled manner.

The CTM applies pressure until the specimen reaches its breaking point, allowing for the determination of its mechanical properties, such as split tensile strength. The data recorded provides insights into the material's ability to withstand load before failure.

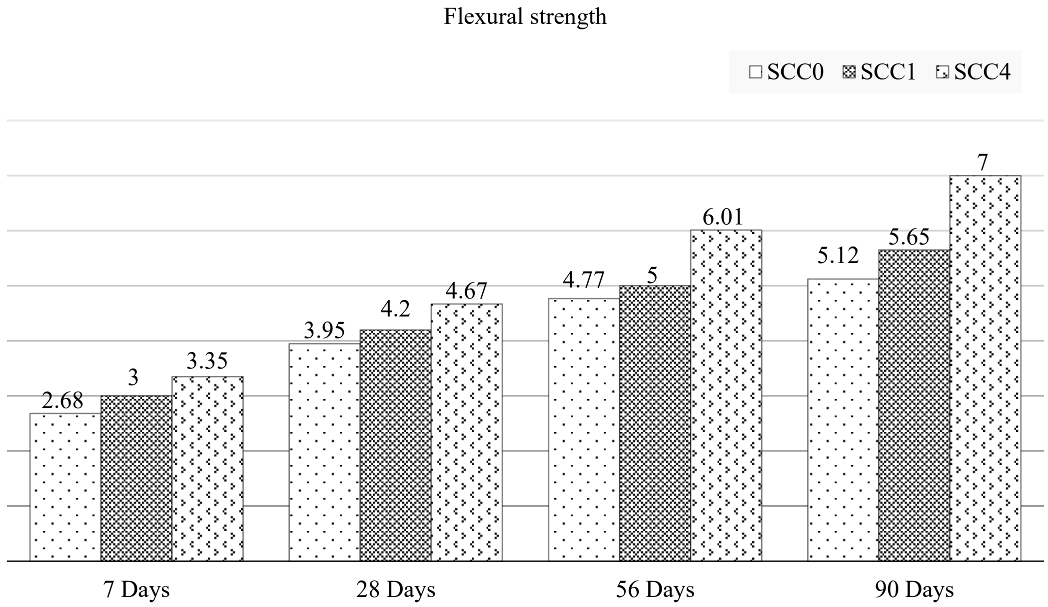

Figure 2. Flexural strength comparison between SCC0, SCC1 & SCC4.

Table 8. Split Tensile strength in N/mm^{2}.

Mix ID	7 days	28 days	56 days	90 days
SCC 0	3.01	4.00	4.60	5.15
SCC 1	3.30	4.44	5.03	5.70
SCC 2	2.79	3.90	4.71	5.10
SCC3	2.83	4.15	4.98	5.41
SCC4	3.60	4.80	6.13	7.07
SCC5	2.72	4.03	4.90	5.20
SCC 6	2.68	4.00	4.76	5.00

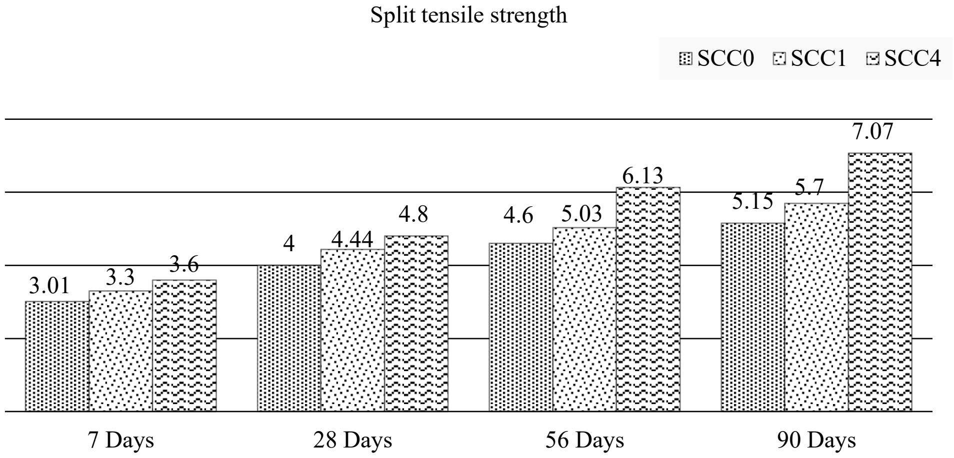

Figure 3. Split tensile strength comparison between SCC0, SCC1 & SCC4.

SCC4 likely exhibits an optimal synergy of cementitious materials, aggregates, and chemical admixtures. The incorporation of SCM Alccofine (16%) significantly accelerates pozzolanic reactions additionally, the inclusion of PWA at 3% further improves long-term strength development. Figure 3 illustrates the comparative split tensile strength performance of SCC0, SCC1, and SCC4. Alccofine reacts with CH to form additional C-S-H, enhancing matrix densification.

$(CaO\text{-}SiO_2\text{-}Al_2O_3) + CH + H \rightarrow$ C-S-H + C-A-H

(Calcium Silicate/Aluminate Hydrate)

CONCLUSION

1. Various proportions of Porcelain Waste Aggregate have been examined in combination with 16% Alccofine as cement replacement and 1% to 5% substitution for both fine and coarse aggregates in Self-Compacting Concrete.
2. The results demonstrate that these materials significantly influence the mechanical properties, particularly split tensile strength and flexural strength. SCC0 (Nominal SCC - Control Mix) this mix, without alccofine or PWA, serves as the baseline and exhibits good strength and self-compacting properties.
3. The inclusion of 16% Alccofine (SCC1) enhances strength compared to SCC0, improving particle packing and microstructure due to its ultrafine nature and pozzolanic activity. It also contributes to the self-compacting ability of the mix by improving workability and reducing segregation.
4. SCC2 to SCC6 (16% Alccofine + 1% to 5% PWA) SCC2 (1% PWA) and SCC3 (2% PWA) show a noticeable improvement in bothsplit tensile and flexural strength, benefiting from the synergistic effect of Alccofine and PWA.
5. SCC4 (3% PWA) achieves the highest strength improvements, demonstrating an optimal balance between self-compacting properties and mechanical performance.
6. SCC5 (4% PWA) and SCC6 (5% PWA) exhibit a decline in strength, likely due to excessive PWA disrupting the cohesiveness of the composite concrete mix and affecting the self-compaction behavior.
7. The combination of 16% Alccofine and 3% PWA (SCC3) provides the best mechanical performance in self-compacting concrete composite, achieving the highest split tensile and flexural strength. Alccofine consistently enhances strength and workability, while moderate PWA replacement (up to 3%) contributes positively to SCC properties.
8. Excessive PWA (above 3%) may reduce strength due to potential issues with bonding, increased porosity, and workability challenges.

This research highlights that self-compacting concrete (SCC4) with 16% Alccofine and 3% PWA optimally improves strength while maintaining good workability. Beyond 3% PWA, a decline in performance suggests a need for careful optimization of PWA content. These findings support the potential of using waste materials in SCC for sustainable construction, with further research needed to assess long-term durability, shrinkage, and real-world applications.

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