Strength Comparative Study Between Conventional Concrete and Concrete with SCM as Alccofine and Seashell

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Abstract: Researchers are looking at sustainable alternatives to partially replace cement in concrete because the growing need for cement production greatly increases greenhouse gas emissions. This study explores the use of Alccofine, an ultrafine and seashell powder as supplemental cementitious material (SCM), a waste product rich in calcium, together as a sustainable cement alternative. Alccofine improves pozzolanic activity and micro-flling qualities, while seashell powder, which is made from abandoned marine shells, provides a natural source of calcium carbonate. The effects of varying cement replacement amounts with seashell powder and Alccofine on the workability and compressive strength were investigated. The findings show that regulated partial replacement lowers cement consumption while increasing strength and improved particle packing and subsequent hydration. This study demonstrates how natural trash and industrial byproducts can be used to create environmentally friendly concrete with enhanced performance qualities.

Keywords: *Supplemental Cementitious Material, Alccofine, Seashell, Compressive Strength.*

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I. INTRODUCTION

Concrete is the most used building material in the world because of its strength, durability, and adaptability. However, the energy-intensive clinker production process of ordinary Portland cement (OPC), its main binder, is the main cause of carbon dioxide emissions. Research into creating sustainable cementitious materials using natural waste and industrial byproducts has accelerated due to the depletion of natural resources and growing environmental concerns.

Alcofine powder and seashell debris have demonstrated considerable promise among the many choices. A plentiful by-product of the seafood industry, seashells are mostly made of calcium carbonate (CaCO3). While using seashell debris in cementitious systems might reduce waste and provide a supply of reactive calcium compounds, improper disposal of seashell trash pollutes the environment. By increasing packing density and creating more calcium silicate hydrate (C-S-H) gel through secondary hydration, Alcofine, an ultrafine slag-based substance with high pozzolanic reactivity, improves the microstructure of concrete.

Alcofine and seashell powder provide two advantages when used together: Alcofine improves the mechanical and durability qualities of concrete, while seashells contribute to eco-friendly calcium-based substitution. This method encourages waste management and environmentally friendly building techniques in addition to lowering cement usage.

Ordinary Portland cement is arguably the most widely used cement in the world's building industry. Cement is a key component of concrete manufacture. The utilization of industrial waste as a partial substitute for concrete and construction cost management are the subjects of recent studies[1-2, 8-9]. Numerous studies have examined the characteristics of both fresh and hardened concrete by substituting industry byproducts for some of the cement [Drew, 2002]. Wood ash and fine seashell powder are two of these byproducts that show promise as partial cement substitutes [3], and [4]. Numerous studies have been conducted to examine the potential for repurposing seashells as building materials in order to reduce carbon emissions and the exploitation of virgin raw materials from the construction sector while also offering an environmentally suitable disposal site for garbage. Using seashells as a filler to partially substitute cement in the creation of cementitious composites, including mortar and concrete, is one promising use. [5]. A thorough examination of seashell processing techniques, their physicochemical characteristics, and their impact on composite performance is lacking in current

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reviews, despite the progress made in employing shell powder as a cement substitute [6].

II. MATERIALS AND METHODS

➢ *Materials*

Below is a list of the many kinds of materials that will be used in varying amounts to prepare sustainable concrete.

- *Cement*

OPC 53 will be used in accordance with IS 12269:2013 [10]. To keep the cement consistent throughout the inquiry, it will be purchased in a single batch from nearby markets.

- *Fine Aggregate*

Fine aggregates are the materials that made it through I.S. Sieve No. 480 (4.75mm). By filling in the spaces left by coarse aggregates, minimizing cement shrinkage, and creating a cost-effective mixture, fine aggregates help make concrete dense. In a concrete mix, crushed stone dust is utilized as a fine aggregate. It is thoroughly cleaned and tested before being added to a concrete mixture to ensure that the overall proportion of clay, silt, salts, and other organic materials does not above a predetermined threshold.

- *Coarse Aggregate*

Coarse aggregates are materials whose particles are so large that they are retained on I.S. Sieve No. 480 (4.75 mm). For concrete to be sturdy and weatherproof, coarse aggregates, like fine aggregates, must be composed of strong, long-lasting inert particles. It should be free of clay, coating chemicals, and other fine materials that could compromise the cement paste's ability to adhere. The crushed hard stone are utilized as coarse aggregates in concrete.

- *Water*

According to IS 456-2000 [11], the water with a pH between 6 and 8.5 is used.

- *Seashell*

When burned to a powder, waste seashells—which contain more than 90% $CaCO_3$—are referred to as a calcium oxide source. Seashells may therefore be utilized in cement manufacturing as a possible substitute for limestone [12-13]. There are several types of seashells, including cockle, mussel, scallop, and periwinkle shells. Bivalves' and gastropods' core seashells are utilized to partially replace cement [13].

✓ Properties of seashells
✓ Colour: Bright White
✓ Specific Gravity: 2.75
✓ Particle size: 150 µm

- *Alccofine*

According to IS: 456-2000 [11] and IS:12089-1987 [14], the Alccofine employed in this investigation is categorized as Alccofine 1203. It was discovered that the it's particles had sharp edges and an uneven form. Alccofine's specific gravity is 2.7 and its specific surface area is 1200 cm^2/g [15]. For high strength concrete, which is crucial for both workability and strength, Alccofine is a new generation microfine concrete material. The purpose of this study is to emphasize the value of Alccofine as an additional cementitious material in the building sector. Because of its high calcium oxide (CaO) content and ultrafine size, this can be employed as an additional cementitious material. In order to lower the heat of hydration and strength at every step, Alccofine 1203 is crucial.

➢ *Method*

For the current investigation, the mix percentage of 1:1.22:1.58 was created in accordance with IS:10262-2009 criteria [16]. Four mixes in all, with a water/binder ratio [15], were made. Because alccofine contains a lot of calcium and aluminum oxide, using it in place of cement for making concrete could result in unfavorable behavior. To prevent these undesirable effects and improve concrete performance, including workability, cohesiveness, segregation, and bleeding, seashell powder was added in place of cement in the control mix. The percentage of alccofine was kept constant for all design mix and varying percentage from 10 to 30 % was used for cement replacement by seashell. The chemical composition for binding materials is as shown in Table no 1.

Table 1 Chemical Compositions of Pozzolanic Materials

Oxide Constituents	**Composition (%)**		
	Cement	**Seashell**	**Alccofine**
Aluminum oxide (Al_2O_3)	4.52	0.96	25.17
Silicon dioxide (SiO_2)	21.97	0.74	37.73
Magnesium oxide (MgO)	1.36	1.06	4.93
Calcium oxide (CaO)	64.03	53.24	29.57
Ferric Oxide (Fe2O3)	3.48	-	1.01
Sulphur trioxide (SO_3)	1.52	-	0.2
Sodium oxide (Na_2O)	0.27	0.09	0.042
Potassium oxide (K_2O)	0.81	0.07	0.63
Loss of ignition (LOI)	0.77	42.01	0.67

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III. RESULT AND DISCUSSION

Comparing concrete with 10% Alccofine and 10% seashells to the control mix, the strength percentage increase is marginally higher. This is seen for all seven, fourteen, and twenty-eight testing days. It is found that the maximum compressive strength for 28 days is 45.43 MPa. When compared to the control mix, the strength increase percentage for the entire curing day is slightly reduced with 10% Alccofine and 20% seashells. After 28 days, the compressive strength increases for all design mix. Fig. 1 shows that adding 10% Alccofine and 30% seashells reduced the compressive strength. This is seen for all seven, fourteen, and twenty-eight testing days. For 28 days, the compressive strength is 32 MPa.

The two primary byproducts of cement and water mixing are calcium hydroxide (CH) and calcium silicate hydrate (C-S-H).

$$\text{Cement} + (H_2O) \rightarrow \text{C-S-H} + (Ca(OH)_2 \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

A significant amount of amorphous (non-crystalline) silica and alumina are present in alccofine, and these materials react with the calcium hydroxide ($Ca(OH)_2$) created during cement hydration to make more C-S-H gel.

$$\text{Alccofine } SiO_2 + Ca(OH)_2 \qquad \text{C-S-H gel} \ldots\ldots\ldots \quad (2)$$

$$\text{Alccofine } Al_2O_3 + Ca(OH)_2 + H_2O \qquad \text{C-A-H} \ldots\ldots \quad (3)$$

The seashell ash's calcium oxide (CaO) instantly combines with water to create calcium hydroxide (($Ca(OH)_2$), which raises the mixture's alkalinity. Early on, the ($Ca(OH)_2$) is used by the quick pozzolanic reaction of alccofine, which facilitates up strength growth and densifies the matrix. The calcined seashell powder's calcium constituents, including CaO, help with further hydration.

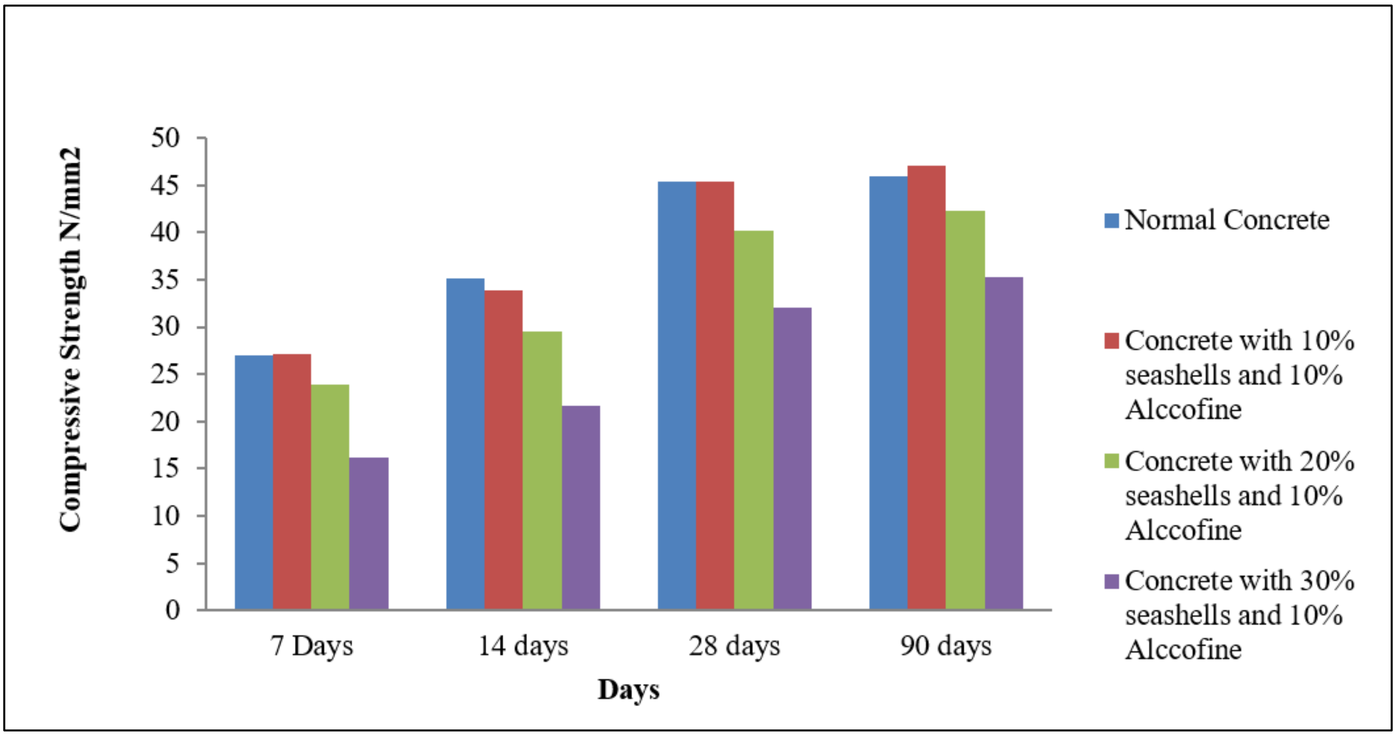

Fig 1 Compressive Strength for Design Mix

IV. CONCLUSION

This investigation indicates that the optimal dosage of Alccofine 1203 is 10%, and the optimal quantity of seashell powder is 10%, yielding an average strength of 45.43 N/mm^2 and 47.12 N/mm^2 for 28 and 90 days respectively. The 28 days strength is near about same as conventional concrete. The 90 days strength is more than strength of conventional concrete. Rate of increase in strength after 90 days is more than conventional concrete for all mixes. The rose in percentage of seashell, reduce in compressive strength. By using this concrete instead of Portland cement, waste output and carbon emissions are decreased.

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