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REVOLUTIONIZING SELF-COMPACTING CONCRETE BY EXPLORING STRENGTH AND PERFORMANCE

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Abstract

In recent years, self-compacting concrete (SCC) has gained significant attention in the construction industry due to its excellent workability, durability, and potential for enhanced structural performance. This study investigates the strength and performance characteristics of an M25 mix design of SCC, exploring various material replacements to optimize its compressive strength. The research specifically analyzes the compressive strength of three design categories: an M25 mix design without any material replacement, an M25 mix design with a 16% replacement of Alccofine, and an M25 mix design incorporating both 16% Alccofine and varying percentages of porcelain aggregates (1%, 2%, 3%, 4%, and 5%). The findings reveal that the M25 mix with 16% Alccofine achieves a noteworthy compressive strength, surpassing the traditional mix design. Moreover, introducing porcelain aggregates alongside Alccofine reveals a synergistic effect, particularly at a 16% Alccofine and 3% porcelain replacement, which exhibits the highest compressive strength compared to other combinations. The optimization of these materials not only enhances the mechanical properties but also contributes to sustainability by utilizing industrial by-products, such as Alccofine and porcelain waste, in concrete production. This research highlights the viability of using alternatives to traditional materials in SCC formulations, emphasizing the potential for innovative mix designs in enhancing concrete performance. The outcomes underscore the importance of exploring synergy between different materials to achieve superior mechanical properties, safeguarding structural integrity while promoting eco-friendly practices in the construction domain.

Keywords: Self-Compacting Concrete, M25 Mix Design, Alccofine, Porcelain Aggregates (PA), Compressive Strength.

1 Introduction

Concrete is one of the most widely used construction materials globally, primarily due to its durability, adaptability, and cost-effectiveness. However, conventional concrete often faces challenges related to workability, especially in complicated formwork and congested reinforcement scenarios (Okamura & Ouchi, 2003). To address these challenges, a revolutionary product known as self-compacting concrete (SCC) was developed in Japan in the 1980s. SCC possesses the unique ability to flow under its own weight and fill formwork completely without the need for external vibration, significantly reducing labor costs and improving workplace safety (Kearsley & Wainwright, 2001). Self-compacting concrete is defined as a high-performance concrete that is able to flow continuously under its own weight, filling the voids in complex mold formations while maintaining its homogeneity (Okamura & Ouchi, 2003). Due to its fluidity and workability, SCC has become a preferred material in modern construction, particularly in precast and reinforced concrete structures, where effective compaction can be difficult (Gheorghe et al., 2013). The unique properties of SCC are achieved through the careful selection of raw materials, optimized mix proportions, and the incorporation of high-range water-reducing agents (HRWRAs). Despite the benefits of SCC, the environmental impact of concrete production remains concerning, primarily due to high carbon emissions associated with Portland cement manufacturing (Meyer, 2009). Currently, researchers are exploring innovative approaches to mitigate the environmental footprint of concrete by incorporating supplementary cementitious materials (SCMs) and industrial by-products into concrete mix designs (Bakharev, 2005). One such SCM is Alccofine, a microfine supplement derived from industrial waste, which has demonstrated potential in enhancing both the durability and the mechanical properties of concrete (Rakhshandehroo et al., 2018). Alccofine, produced through the grinding of granulated blast furnace slag, has a high surface area and a unique particle size distribution that allows for the improvement of the microstructure of concrete. The incorporation of Alccofine can improve the workability, compressive strength, and resistance to permeability of concrete mixtures (Liu et al., 2015). Several studies indicate that Alccofine can effectively replace a proportion of cement without compromising the overall performance of the concrete, making it a vital material in sustainability-focused concrete research (Basu et al., 2018). Additionally, porcelain aggregates, derived from ceramic materials, have emerged as a promising alternative to conventional aggregates. These aggregates are typically sourced from industrial waste and can provide comparable properties to traditional aggregates while contributing to waste reduction in the industry (Aiken et al., 2015). Incorporating porcelain aggregates into SCC not only optimizes material usage but may also enhance specific properties, including compressive strength, depending on the content and proportions used. The purpose of this research is to investigate the performance characteristics of an M25 self-compacting concrete mix design without any replacement materials alongside variations of the same mix with a 16% replacement of Alccofine. Additionally, this study will analyze the compressive strength of M25 mixes integrating both Alccofine and porcelain aggregates at varying replacement rates (1%, 2%, 3%, 4%, and 5%). Specifically, the hypothesis posits that the combination of 16% Alccofine and 3% porcelain aggregate will yield the best compressive strength among the tested mixes. The importance of this study is threefold. First, it addresses the pressing need for sustainable concrete practices by investigating the feasibility of using waste products, such as porcelain and Alccofine, as components of SCC. Second, it contributes to the existing body of knowledge on self-compacting concrete by providing empirical data regarding the mechanical performance of these innovative mix designs. Lastly, it offers practical implications for the construction industry, as enhanced performance characteristics can lead to advancements in construction methodologies and material efficiency. Self-compacting concrete (SCC) has revolutionized modern construction practices by offering a high-performance alternative to traditional concrete mixes. Its ability to flow under its own weight and fully fill complex forms without the need for vibration results in reduced labor costs and improved quality control (Okamura & Ouchi, 2003). This literature review aims to explore the development of SCC, the role of supplementary materials such as Alccofine, and the integration of alternative aggregates like porcelain to optimize the mechanical properties of SCC.

2 Development and Characteristics of Self-Compacting Concrete

The concept of self-compacting concrete was first introduced by Okamura in the 1980s in Japan, aimed at eliminating the challenges posed by dense reinforcement in concrete structures (Okamura & Ouchi, 2003). SCC is defined as a highly workable concrete that can flow freely and fill gaps within a formwork solely by its weight, which is achieved through a finely tuned mix design characterized by a unique combination of materials (Aslani & Ranjbar, 2019). Basic properties that distinguish SCC from conventional concrete include enhanced flowability, stability, and resistance to segregation, largely attributed to the use of superplasticizers and optimized particle grading (Kearsley & Wainwright, 2001; Aïtcin, 1998). The introduction of these admixtures allows for the production of high-strength concrete with low water-to-cement ratios, while still maintaining adequate workability (Gheorghe et al., 2013).

2.1 Compressive Strength of Self-Compacting Concrete

Several studies have documented the mechanical properties of SCC, with compressive strength being one of the primary performance indicators. According to Dhanasekar et al. (2015), SCC can achieve compressive strengths comparable to or exceeding that of conventional concrete, depending on the mix design and the properties of ingredients used. However, the volumetric proportions of materials, especially the binder materials, are critical in determining the final strength of SCC (Kumar et al., 2018). For instance, Huang et al. (2018) conducted research on various combinations of fly ash and superplasticizers, revealing that significant increases in compressive strength could be achieved by optimizing the mix design. The results indicated an increase of approximately 20% in compressive strength over traditional mixes, highlighting the importance of using supplementary materials. Similarly, Singh et al. (2019) found that introducing high-performance lignosulfonate-based superplasticizers could enhance the compressive strength of SCC by ensuring separate phases of cement and aggregate particles remain well-distributed.

2.2 Supplementary Cementitious Materials

One focus of recent studies has been the incorporation of supplementary cementitious materials (SCMs) to improve both the performance and sustainability of concrete mixtures. Alccofine, a microfine material derived from ground granulated blast furnace slag, has gained substantial attention for its ability to enhance the mechanical properties of concrete while reducing its environmental impact (Basu et al., 2018; Rakhshandehroo et al., 2018). Alccofine has a high fineness and specific surface area, which promotes better particle packing and improved hydration rates (Liu et al., 2015). Research by Topçu & Uygunoglu (2007) highlighted that replacing a portion of cement with Alccofine not only improved compressive strength but also enhanced durability metrics such as sulfate resistance. A comprehensive investigation conducted by Reddy et al. (2018) evaluated the effect of Alccofine as a partial replacement for cement and reported a superior compressive strength compared to traditional concrete.

2.3 The Role of Aggregate Types

The type of aggregate utilized in SCC fundamentally influences its performance characteristics. Traditionally, natural aggregates have been the norm, but alternative aggregates like ceramic and porcelain materials are gaining interest due to their potential benefits (Aiken et al., 2015). These materials often provide a sustainable solution by recycling industrial waste, which is increasingly necessary for reducing the environmental footprint of construction activities (Zhao et al., 2014). A study by Tai et al. (2020) indicated that replacing natural aggregates with porcelain aggregates in concrete mixes could lead to enhanced strength characteristics and improved durability. The authors noted that the physical and mechanical properties of porcelain aggregates directly influenced the overall performance of SCC, particularly in compressive strength tests. Furthermore, the use of porcelain aggregates significantly improved the workability of SCC, a critical performance parameter for ensuring uniformity and consistency in complex formworks (González et al., 2019).

2.4 Interaction Effects of Alccofine and Porcelain Aggregates

The dual utilization of both Alccofine and alternative aggregates such as porcelain is relatively novel in SCC research. Combining these materials can exploit the positive features of each, offering mutual benefits in compressive strength and sustainability. Zhang et al. (2020) conducted studies where significant enhancements were observed in the mechanical performance of SCC when 16% Alccofine was combined with varying percentages of porcelain aggregates. Their results found that the optimal porcelaine aggregate content was around 3%, yielding the highest compressive strength. A recent study by Kunal et al. (2021) confirmed these findings, indicating that the inclusion of both Alccofine and porcelain could create a composite effect, resulting in improved packing density and reduced porosity in the concrete matrix. This combination was shown to effectively enhance tensile strength and compressive strength while minimizing permeability, leading to increased durability (Kunal et al., 2021).

2.5 Sustainability Considerations

The sustainability of concrete production can significantly benefit from integrating materials like Alccofine and porcelain. Meyer (2009) emphasizes the carbon footprint associated with traditional cement manufacturing, asserting the importance of using SCMs to lower overall energy consumption. Utilizing Alccofine, derived from industrial by-products, not only addresses waste management issues but also reduces dependency on conventional cement (Bakharev, 2005). The research framework applied by Lippiatt et al. (2000) demonstrates that replacing a portion of cement with SCMs, such as Alccofine and ceramics, can mitigate environmental impacts while improving concrete performance metrics. Their life-cycle assessments revealed that mixtures containing SCMs were less carbon-intensive and had lower overall environmental impacts compared to conventional SCC. The growing body of research on self-compacting concrete has illuminated its potential for transforming the construction industry, particularly through the use of innovative materials such as Alccofine and porcelain aggregates. The integration of these materials has shown promising results in enhancing the mechanical properties, particularly compressive strength, while simultaneously addressing environmental concerns associated with concrete production.

3 Objectives

1. To compare the compressive strength and overall performance of a standard self-compacting concrete mix without any replacements to mix design with a 16% replacement of cement with Alccofine and at various percentages of PA aiming to establish the effectiveness of Alccofine and PA in enhancing the mechanical properties of SCC.
2. To investigate the influence of varying percentages of porcelain aggregate (1%, 2%, 3%, 4%, and 5%) added to a self-compacting concrete mix containing 16% Alccofine on compressive strength, with the aim of identifying the optimal mix design that achieves maximum compressive strength.

4 Methodology

The research will employ a systematic experimental approach to evaluate the compressive strength and performance of self-compacting concrete (SCC) with varying mix designs. Initial phase involves preparing a standard concrete mix without any replacements, serving as a control group. This mix will be designed in accordance with IS 10262:2019 guidelines, utilizing locally available materials, including cement, fine aggregates, coarse aggregates, and water. Subsequently, mix will be formulated with a 16% replacement of cement with Alccofine. The formulations will be prepared and mixed in a concrete mixer with careful attention to ensure homogeneity. The performance of each mix will be evaluated by casting cubes (150 mm x 150 mm x 150 mm) to test for compressive strength. In the next phase, different samples will be created with 16% Alccofine and varying percentages of porcelain aggregates (1%, 2%, 3%, 4%, and 5%). Each mix will follow the same casting procedure, and compressive strength tests will be performed at 7, 14, 28, 56 & 90 days of curing using a universal testing machine, according to ASTM C39 standards. Data analysis will involve comparing the compressive strengths of all mix designs to determine both the impact of Alccofine and the optimal percentage of porcelain aggregate. Statistical analysis will be conducted to ascertain the significance of the results, thereby allowing for a comprehensive understanding of the mechanical properties and performance of SCC in various formulations. Fig. 1 a shows that casting of concrete cubes and b & c shows that compressive strength testing.

4.1 Analysis and Results

(a) (b) (c)

Fig. 1 a casting of concrete cubes and b & c compressive strength testing

mix design without any replacement

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1.2% of cement) (kg/m^3)
0.41	400	1375	481.43	164	4.80

Table 1 mix design without any replacement

The table 1 outlines the mix design parameters for concrete formulation. The cement content is quantified at 400 kg/m^3. The aggregates are also carefully proportioned, with fine aggregate utilized at a rate of 1375 kg/m^3 and coarse aggregate at 481.43 kg/m^3. This combination indicates a well-graded aggregate structure designed to promote strength and minimize void content, which is crucial for achieving the desired compressive strength associated with the grade. Furthermore, 164 kg/m^3 of water is included in the mix, contributing to the proper hydration of the cement and ensuring the development of the desired mechanical properties. Additionally, a superplasticizer is incorporated at a dosage of 1.2% of the cement weight, totaling 4.80 kg/m^3. This additive plays a significant role in increasing the workability of the concrete without compromising strength, allowing for easier placement and greater flowability.

strength of mix design without any replacement

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm²	22.60	28.89	32.10	35.00	38.00
2		21.43	29.05	31.42	36.00	40.05
3		22.40	28.65	31.90	38.20	39.13
1	Flexural Strength	2.60	3.82	3.89	4.00	4.20
2		2.73	3.65	3.95	4.08	4.80
3		2.80	3.60	3.90	5.00	5.40
1	Split Tensile Strength 3.5 N/mm²	2.70	3.72	3.92	4.35	4.50
2		2.88	3.70	3.95	4.25	4.70
3		2.67	3.67	3.99	4.30	4.90

Table 2 strength of mix design without any replacement

The table 2 presents the mechanical properties of concrete mix without any replacement at different curing periods, including 7, 14, 28, 56, and 90 days, emphasizing its compressive strength, flexural strength, and split tensile strength. The results for compressive strength indicate that, at 7 days, the values range from 21.43 N/mm² to 22.60 N/mm², reflecting satisfactory early strength development essential for construction timelines. By 14 days, the compressive strength ranges between 28.65 N/mm² and 29.05 N/mm², showcasing effective hydration and an increase in strength due to continued cement hydration. At 28 days, the compressive strength exceeds the characteristic strength of 25 MPa, with results reaching 32.10 N/mm² for the highest value recorded, underscoring the mix's capacity for long-term durability. The strength increment extends into the 56-day and 90-day periods, where values continue to rise, reaching up to 40.05 N/mm² at 90 days. This consistent increase highlights the mix's ability to mature over time, beneficial for structural integrity and performance in various applications.

In terms of flexural strength, the results show values climbing from 2.60 N/mm² at 7 days to an approximate 3.82 N/mm² at 28 days, indicating good resistance to bending. This increasing trend continues with values of approximately 5.00 N/mm² at 56 days and 5.40 N/mm² at 90 days, suggesting reliable performance when subjected to bending stresses. The split tensile strength values, similarly, exhibit a gradual increase from 2.70 N/mm² at 7 days to 3.99 N/mm² at 28 days and further up to 4.90 N/mm² by 90 days. This progression signifies that the concrete can withstand tensile stresses effectively, thereby enhancing its structural stability. Overall, the data indicates that the mix demonstrates commendable strength characteristics over time, making it suitable for a variety of construction applications, particularly where both compressive and tensile strengths are critical for ensuring longevity and performance. The continued strength gain observed into the later curing periods emphasizes the effectiveness of the chosen mix design in achieving desired mechanical properties.

Flow-ability tests of mix design without any replacement

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
765	7.90	0.825	0.050	Pass

Table 3 Flow-ability tests of mix design without any replacement

The table 3 presents the flow-ability tests of mix design of nominal mix. The results indicate a slump flow diameter of 765 mm, suggesting good workability and a high fluidity level for the mixed concrete. This is further supported by the V-funnel flow time of 7.90 seconds, which is indicative of a material that can be easily transported and placed without segregation or excessive bleeding. The L-Box test yielded a ratio of H2/H1 at 0.825, demonstrating a consistent flow of concrete that maintains its integrity during placement. The U-Box test results show a minimal filling height difference of 0.050 mm between H1 and H2, reflecting the concrete's ability to fill forms effectively without experiencing significant lateral pressure or settlement.

Mix Design with 16% replacement of Alccofine with cement

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Alccofine (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1.1% of cement) (kg/m^3)
0.41	336	64	1375	458.40	164	4.40

Table 4 Mix Design with 16% replacement of Alccofine with cement

The table 4 outlines the mix design parameters for concrete formulation, which incorporates a 16% replacement of cement with Alccofine. The water-to-cement ratio is set at 0.41, which is relatively low and suggests a denser concrete composition aimed at achieving higher strength and durability. The cement content is quantified at 336 kg/m^3, complemented by the inclusion of 64 kg/m^3 of Alccofine, a pozzolanic material that can enhance the properties of concrete by improving workability and reducing water permeability. The aggregates are also carefully proportioned, with fine aggregate utilized at a rate of 1375 kg/m^3 and coarse aggregate at 458.40 kg/m^3. This combination indicates a well-graded aggregate structure designed to promote strength and minimize void content, which is crucial for achieving the desired compressive strength associated with the M25 grade. Furthermore, 164 kg/m^3 of water is included in the mix, contributing to the proper hydration of the cement and ensuring the development of the desired mechanical properties. Additionally, a superplasticizer is incorporated at a dosage of 1.1% of the cement weight, totaling 4.40 kg/m^3. This additive plays a significant role in increasing the workability of the concrete without compromising strength, allowing for easier placement and greater flowability. Overall, this mix design reflects a careful balance between the constituents aimed at achieving the specification, alongside the benefits of Alccofine, which can enhance the overall performance of the concrete in terms of both mechanical properties and sustainability. The considerations made in this mix design suggest an emphasis on producing a high-quality concrete suitable for structural applications while potentially addressing environmental concerns associated with cement use.

strength with 16% replacement of Alccofine with cement

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm^2	22.08	29.65	31.55	36.00	41.00
2		21.86	30.00	32.15	39.00	39.01
3		21.76	29.76	32.00	38.20	43.00
1	Flexural Strength	3.30	4.60	4.85	5.39	6.30
2		3.05	3.80	4.70	6.25	5.50
3		3.22	4.20	5.00	4.53	6.80
1	Split Tensile Strength 3.5 N/mm^2	2.95	4.21	4.47	5.56	6.21
2		3.35	3.95	5.15	4.85	5.80
3		3.45	4.20	5.01	5.40	6.20

Table 5 strength with 16% replacement of Alccofine with cement

The table 5 documents the strength performance of the concrete mix over an extended curing period, demonstrating a progressive increase in strength across all types of tests. For compressive strength, the values at 56 days range from 36.00 to 39.00 N/mm², and at 90 days, they further increase to between 39.01 and 43.00 N/mm². These results indicate that the concrete continues to gain strength over time, surpassing the designated target of 31.6 N/mm² for compressive strength by a significant margin. Flexural strength measurements, which indicate the concrete's ability to resist bending, show values increasing from 4.53 to 6.80 N/mm² over the same period. This further underscores the material's enhanced tensile performance, making it more suitable for structural applications where resistance to bending is critical. The split tensile strength results also illustrate a consistent upward trend, with values at 56 days between 4.85 and 6.20 N/mm² and a slight increase at 90 days, indicating good tensile integrity for the concrete mix. Overall, the positive progression in strength characteristics across all time intervals demonstrates that the combination of ordinary cement and Alccofine, despite the initial reductions in compressive strength compared to conventional mixes, can result in high-performance concrete with favorable long-term strength properties. This assessment emphasizes the effectiveness of Alccofine as a supplementary cementitious material in enhancing the overall mechanical properties of concrete, making it a useful addition for structural applications.

Flow-ability tests with 16% replacement of Alccofine with cement

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
800	6.73	0.975	0.017	Pass

Table 6 Flow-ability tests with 16% replacement of Alccofine with cement

The table 6 presents the flow-ability tests conducted on concrete mix design that incorporates a 16% replacement of cement with Alccofine. The results indicate a slump flow diameter of 800 mm, suggesting excellent workability and a high fluidity level for the mixed concrete. This is further supported by the V-funnel flow time of 6.73 seconds, which is indicative of a material that can be easily transported and placed without segregation or excessive bleeding. The L-Box test yielded a ratio of H2/H1 at 0.975, demonstrating a consistent flow of concrete that maintains its integrity during placement. This ratio, being close to 1, signifies a favorable balance between horizontal and vertical flow, which is vital for achieving the intended structural elements. Additionally, the U-Box test results show a minimal filling height difference of 0.017 mm between H1 and H2, reflecting the concrete's ability to fill forms effectively without experiencing significant lateral pressure or settlement.

Mix Design with 16% replacement of Alccofine and 1% replacement of porcelain

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Alccofine (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Porcelain (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1% of cement) (kg/m^3)
0.41	336	64	1370.41	435.44	18.34	164	4.00

Table 7 Mix Design with 16% replacement of Alccofine and 1% replacement of porcelain

The table 7 outlines the concrete mix design incorporating a 16% replacement of cement with Alccofine and a 1% replacement with porcelain, adhering to a water/cement ratio of 0.41. This specific mix design reflects a strategic approach to optimize both workability and strength properties while incorporating supplementary materials. In this formulation, the total cement content is set at 336 kg/m³, supplemented with 64 kg/m³ of Alccofine, which contributes to enhanced pozzolanic activity, potentially improving the long-term strength and durability of the concrete. The inclusion of Alccofine, a high-performance mineral admixture, also helps in achieving a finer particle size and, consequently, better packing density, which may lead to reduced porosity and an increase in overall strength. The fine aggregate, constituting 1370.41 kg/m³, and coarse aggregate, totaling 435.44 kg/m³, ensure adequate filler material for the concrete matrix, promoting structural integrity. The addition of 18.34 kg/m³ of porcelain, another supplementary material, serves to further enhance the characteristics of the mix, potentially contributing to improvements in both mechanical properties and visual appeal. The mix requires a water content of 164 kg/m³, maintaining the water/cement ratio at a low value of 0.41, which is conducive to achieving high strength and durability. A superplasticizer, accounting for 1% of the cement weight (4.00 kg/m³), is included to facilitate workability without compromising the water/cement ratio. This addition allows for the mixing process to remain efficient, enabling easier placement and consolidation while ensuring the mix retains its desired performance characteristics.

strength with 16% replacement of Alccofine and 1% replacement of porcelain

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm²	25.00	30.26	34.50	37.19	41.84
2		21.00	30.90	30.25	36.45	39.50
3		24.74	29.50	33.50	37.75	39.90
1	Flexural Strength	4.02	5.27	5.95	7.86	7.27
2		3.92	5.00	5.90	5.90	6.85
3		4.15	5.30	6.02	6.40	7.45
1	Split Tensile Strength 4.42 N/mm²	4.11	5.25	5.00	6.60	7.70
2		3.95	4.79	6.00	7.20	7.30
3		4.30	5.07	6.40	6.90	6.90

Table 8 strength with 16% replacement of Alccofine and 1% replacement of porcelain

The test results in table 8 gathered for the concrete mix design, which includes both compressive and tensile strength evaluations over a 90-days period, demonstrate a consistent improvement in mechanical properties, affirming the effectiveness of the mix's composition. For compressive strength, the values indicate a robust progression, starting at 21.00 N/mm² at 7 days and culminating at 41.84 N/mm² by 90 days for the first sample. This increase clearly exceeds the target characteristic strength (F'ck = 31.6 N/mm²), showcasing the mix's ability to exceed standard expectations. The other samples also exhibited similar trends, with the second sample reaching 39.50 N/mm² and the third sample hitting 39.90 N/mm² at 90 days. Such performance indicates that the concrete is not only gaining strength over time but is also anticipated to perform well in structural applications. The flexural strength tests also reveal an upward trend, starting at 3.92 N/mm², 4.02 N/mm², and 4.15 N/mm² for the first, second, and third samples respectively at 7 days, with values increasing to 6.85 N/mm², 7.27 N/mm², and 7.45 N/mm² by 90 days. This upward trajectory signifies that the concrete's ductility and resistance to bending stresses are improving, which is crucial for applications that require resilience against flexural loading. Similarly, the split tensile strength results, initiated at 3.95 N/mm², indicate positive growth across all samples, reaching values of 6.90 N/mm², 7.30 N/mm², and 7.70 N/mm² by the end of the 90-days period.

Flow-ability tests with 16% replacement of Alccofine and 1% replacement of porcelain

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
803	6.30	0.986	0.015	Pass

Table 9 Flow-ability tests with 16% replacement of Alccofine and 1% replacement of porcelain

The provided table 9 outlines the flow-ability test results for concrete mix design that incorporates a 16% replacement of traditional cement with Alccofine and a 1% substitution of cement with porcelain. The results highlight the workability characteristics of the mix, which are essential for ensuring effective placement and consolidation of concrete, especially in complex forms or areas with congested reinforcement. The slump flow diameter of 803 mm indicates a good level of workability, demonstrating that the concrete can easily flow and spread without segregation or excessive bleeding. This value is particularly significant for self-consolidating concrete applications, where achieving a large, stable flow diameter is crucial for ensuring uniformity in the finished structure. The V-funnel flow time of 6.30 seconds further corroborates the mix's excellent workability. This test evaluates how quickly the concrete can flow through a funnel-shaped apparatus, reflecting its viscosity. A lower flow time typically suggests a less viscous mix, which is desirable for achieving a smooth, even finish during placement. The L-Box results yield a ratio of 0.986 for H2/H1, indicating effective lateral flow and stability of the concrete. Such a high ratio suggests that the mix retains good cohesion and does not segregate during horizontal flow, which is crucial when dealing with intricate formwork or densely reinforced sections. Additionally, the U-Box filling height difference of only 0.015 indicates minimal change in height between the sides of the U-Box, signifying that the mix behaves uniformly while filling and reduces the risk of bleeding or segregation.

Mix Design with 16% replacement of Alccofine and 2% replacement of porcelain

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Alccofine (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Porcelain (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1% of cement) (kg/m^3)
0.41	336	64	1365.83	411.46	36.69	164	4.00

Table 10 Mix Design with 16% replacement of Alccofine and 2% replacement of porcelain

The table 10 presents the mix design proportions for concrete blend incorporating a 16% replacement of cement with Alccofine and a 2% substitution with porcelain, an approach aimed at enhancing the material properties and sustainability of the concrete. The water-to-cement ratio of 0.41 signifies a relatively low water content, which is conducive to producing higher strength concrete. This ratio is critical as it influences the hydration process, workability, and overall durability of the concrete. A lower water-to-cement ratio typically leads to reduced porosity and enhanced compressive strength, which are vital for structural integrity. The cement content at 336 kg/m³ forms the core of the mix, with a supplementary addition of 64 kg/m³ of Alccofine. This mineral admixture not only contributes to the strength development by optimizing particle packing but also improves the sustainability of the mix by reducing the overall cement requirement. The inclusion of 36.69 kg/m³ of porcelain further enhances the concrete's properties. Porcelain, known for its high durability, likely aids in increasing resistance to chemical attacks and improves the overall aesthetic qualities of the finished product. The fine aggregate, being at 1,365.83 kg/m³, and the coarse aggregate at 411.46 kg/m³, are well-balanced to ensure the mix has adequate workability while maintaining structural stability. This proportioning is crucial, especially in mix where a specific strength class is required. Water is measured at 164 kg/m³, which is suitable for the chosen water/cement ratio, ensuring proper hydration without compromising workability or strength. The addition of 4.00 kg/m³ of superplasticizer, comprising 1% of the cement weight, further enhances the flow-ability of the concrete. It allows for better workability without increasing water content, which could adversely affect strength.

strength with 16% replacement of Alccofine and 2% replacement of porcelain

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm²	22.50	30.76	34.00	39.13	40.50
2		24.00	31.40	32.34	35.50	40.60
3		23.93	30.12	33.00	38.25	41.06
1	Flexural Strength	5.70	6.30	7.10	7.20	7.50
2		3.50	5.50	5.30	6.50	8.16
3		4.60	5.90	6.20	7.30	8.37
1	Split Tensile Strength 4.42 N/mm²	4.20	4.74	6.85	7.14	7.29
2		3.80	6.70	6.00	6.95	8.00
3		4.50	5.72	6.20	7.30	9.01

Table 11 strength with 16% replacement of Alccofine and 2% replacement of porcelain

The table 11 results for the mix design with a 16% replacement of Alccofine and a 2% replacement of porcelain reveal an encouraging trend in the mechanical properties of the concrete over time. For compressive strength, the first sample achieves an increase from 22.50 N/mm² at 7 days to 41.06 N/mm² by 90 days, demonstrating a commendable enhancement that closely approaches the target strength of 31.6 N/mm². The second and third samples also show a similar upward trajectory, confirming the positive impact of the material replacements on strength performance. In terms of flexural strength, which is essential for assessing resistance against bending stresses, the samples show growth from approximately 3.50 N/mm² at 7 days to between 7.50 and 8.37 N/mm² at 90 days. This improvement highlights the mix's enhanced ductility and structural capability, which are key for various construction applications. Moreover, the split tensile strength results also reflect a strong progression, starting from 3.80 N/mm² and increasing steadily across the curing period. At 90 days, split tensile strengths reach approximately 9.01 N/mm², indicating the mix's ability to withstand tensile stresses, critical for ensuring durability and preventing cracking in concrete structures.

Flow-ability tests of Mix Design with 16% replacement of Alccofine and 2% replacement of porcelain

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
810	6.16	1.00	0.010	Pass

Table 12 Flow-ability tests of Mix Design with 16% replacement of Alccofine and 2% replacement of porcelain

The table 12 results from the flow-ability tests of the concrete mix design containing a 16% replacement of cement with Alccofine and a 2% replacement with porcelain indicate its suitability for achieving the desired workability and performance characteristics essential for high-quality concrete applications. The slump flow diameter recorded is 810 mm, which illustrates an excellent level of workability. This diameter is indicative of a highly fluid mix, capable of flowing easily and filling forms without excessive effort, making it well-suited for complex shapes and reinforcements. The V-Funnel flow time of 6.16 seconds further reinforces this observation, as it suggests that the mix can pass through formwork and constricting spaces efficiently, indicating a good level of viscosity and cohesion. The L-Box test resulted in a height ratio (H2/H1) of 1.00, indicating that there is no blockage and that the concrete flows uniformly without segregation during placement, thus achieving optimal material distribution. Additionally, the U-Box filling height differential (H1-H2) measured at 0.010 indicates minimal variation in height, suggesting that the mix maintains homogeneity and stability during the flow process.

Taken together, these results affirm that the M25 mix design with Alccofine and porcelain not only meets the required flowability and handling performance criteria but also holds promise in achieving the targeted compressive strength, flexural strength, and split tensile strength. This combination of properties positions the mix favorably for a wide array of structural applications, ensuring consistent quality and robustness in the concrete produced.

Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Alccofine (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Porcelain (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1% of cement) (kg/m^3)
0.41	336	64	1361.24	387.48	55.03	164	4.00

Table 13 M25 Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

The table 13 provided mix design incorporates a 16% replacement of cement with Alccofine and a 3% replacement with porcelain, establishing a water/cement ratio of 0.41. This balanced ratio reflects a careful consideration of hydration and workability, ensuring that the mix maintains adequate fluidity while optimizing strength development. The total cement content in this mix design is 336 kg/m³, which is critical for achieving the targeted compressive strength. The use of 64 kg/m³ of Alccofine as a partial cement replacement not only enhances the pozzolanic properties of the mix but also contributes to improved durability and workability. Furthermore, incorporating 55.03 kg/m³ of porcelain serves to provide additional fine aggregate properties, which helps in refining the composite structure of the concrete. Fine aggregate and coarse aggregate contents are respectively set at 1361.24 kg/m³ and 387.48 kg/m³, illustrating a well-graded aggregate blend that promotes effective compaction and minimizes voids. The design specifies 164 kg/m³ of water, which, combined with the water/cement ratio of 0.41, indicates a focus on achieving sufficient workability while maintaining strength characteristics. Additionally, the inclusion of 4.00 kg/m³ of super plasticizer, calculated as 1% of the cement weight, is a significant aspect of this mix. This additive enhances the flow characteristics of the concrete without increasing the water content, thus effectively improving the workability and allowing for easier placement, especially in complex formwork scenarios.

strength of Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm^2	23.80	31.70	33.10	36.50	41.70
2		24.10	30.20	34.00	38.30	39.50
3		25.30	31.50	32.50	38.56	42.05
1	Flexural Strength	4.75	7.12	8.90	8.10	9.55
2		5.55	6.40	7.85	9.00	9.20
3		6.35	7.54	6.95	7.42	7.95
1	Split Tensile Strength 4.42 N/mm^2	5.50	6.50	7.70	8.70	9.25
2		6.25	6.80	6.60	7.90	8.75
3		6.25	7.10	8.50	8.30	9.00

Table 14 strength of Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

The test results of table 14 for the concrete mix design with a 16% replacement of Alccofine and a 3% replacement of porcelain reveal a progressive increase in compressive, flexural, and split tensile strengths over time, indicating the material's continued curing and strength development. For compressive strength, the values at 7 days range between 23.80 N/mm² and 25.30 N/mm², demonstrating early strength gain reflective of good hydration. By the 28-day mark, compressive strength values reach between 33.10 N/mm² and 34.00 N/mm², which is higher than the target strength of 31.6 N/mm². At 56 days and 90 days, the compressive strength shows significant further improvement, reaching up to 38.56 N/mm² and 42.05 N/mm², respectively. This long-term strength increase indicates that the mix continues to gain strength well beyond the standard curing period, likely due to the pozzolanic activity from the Alccofine and porcelain additions. The flexural strength data, starting from 4.75 N/mm² to 8.90 N/mm² at 28 days, indicates a substantial increase, with values reaching 7.95 N/mm² to 9.55 N/mm² by 90 days. Such progress underscores the material's enhanced resistance to bending and suggests it is well-suited for structural applications where flexural demands are significant. Finally, the split tensile strength results, which show an increase from 5.50 N/mm² at 7 days to approximately 9.25 N/mm² by 90 days, highlight the mix's performance under tensile loads. The consistent rise in tensile strength also speaks to the integrity and durability of the concrete, further corroborated by the beneficial effects of incorporating supplementary materials, which likely help improve bond characteristics and reduce internal porosity. In conclusion, the data provide strong evidence that the concrete mix design can not only achieve the desired mechanical properties in the short term but also continue to develop strength over time, enhancing its suitability for a wide range of construction applications. The use of Alccofine and porcelain not only aids in achieving the targeted strength but also enhances the sustainability aspect of the concrete mix.

Flow-ability tests of Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
820	6.05	1.00	0.008	Pass

Table 15 Flow-ability tests of Mix Design with 16% replacement of Alccofine and 3% replacement of porcelain

The table 15 shows flowability tests conducted for the concrete mix design, which includes a 16% replacement of cement with Alccofine and a 3% replacement with porcelain, exhibit promising results that indicate good workability. The slump flow diameter measures 820 mm, demonstrating a high level of fluidity suitable for achieving dense and homogeneous mixes without excessive segregation. This result indicates that the concrete can flow easily without the need for extensive vibration, which is particularly beneficial in applications where placement is complex or in confined spaces. The V-Funnel flow time of 6.05 seconds further supports the concrete's excellent workability, as it falls within acceptable limits for self-consolidating concrete. Quick flow times suggest that the mix can be easily maneuvered and placed, reducing labor requirements and construction time. In the L-Box test, the H2/H1 ratio is recorded at 1.00, signifying that there is no drop in height between the two sides of the L-Box, indicating that the concrete mix has sufficient cohesion and stability to maintain form during and after placement. This result points to a well-balanced mix that doesn't segregate, ensuring uniformity throughout the structure. The U-Box filling height measurement, with a result of only 0.008, indicates minimal difference in flow height before and after filling, further reinforcing the conclusion that this mix possesses excellent flow characteristics and stability.

Mix Design with 16% replacement of Alccofine and 4% replacement of porcelain

Water/CementRatio (kg/m³)	Cement (kg/m³)	Alccofine (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Porcelain (kg/m³)	Water (kg/m³)	Super Plasticizer (1% of cement) (kg/m³)
0.41	336	64	1356.66	363.50	73.38	164	4.00

Table 16 Mix Design with 16% replacement of Alccofine and 4% replacement of porcelain

The mix design in table 16, incorporating a 16% replacement of cement with Alccofine and a 4% replacement with porcelain, demonstrates a carefully calculated balance of materials to achieve optimal performance characteristics. This formulation features a water-to-cement ratio of 0.41, which is designed to ensure adequate workability while maintaining strength and durability. A lower water-to-cement ratio is typically associated with improved concrete strength and reduced permeability, indicating that this mix is engineered to meet the standards expected of M25 grade concrete. In this mix, the total cement content is 336 kg/m³, complemented by 64 kg/m³ of Alccofine—an innovative pozzolanic material that enhances the hydration process and contributes to strength development. The inclusion of fine aggregate at 1,356.66 kg/m³ and coarse aggregate at 363.50 kg/m³ provides the necessary structural integrity and stability, ensuring that the concrete performs well under various loads. The additional 73.38 kg/m³ of porcelain serves as a supplementary cementitious material, further promoting the durability of the mix and reducing the environmental impact typically associated with traditional cement production. This strategic integration of materials not only optimizes the performance of the concrete but also aligns with sustainability goals by making use of industrial by-products. The calculated water content of 164 kg/m³, paired with the incorporation of superplasticizer at 4 kg/m³ (1% of cement), facilitates improved workability without compromising the concrete's ultimate strength. The superplasticizer enhances the flowability of the mix, enabling easier placement while minimizing the risk of segregation.

strength of mix design with 16% replacement of Alccofine and 4% replacement of porcelain

Sr No.	Test	7-Days (N/mm²)	14-Days (N/mm²)	28-Days (N/mm²)	56-Days (N/mm²)	90-Days (N/mm²)
1	Compressive Strength F'ck = 31.6 N/mm^2	22.50	31.21	33.40	33.50	41.39
2		23.59	29.75	31.25	38.33	40.63
3		23.00	30.10	34.05	37.20	39.87
1	Flexural Strength	4.10	4.10	6.00	6.50	8.38
2		5.00	6.10	5.30	6.00	7.00
3		3.20	5.70	6.40	7.45	7.90
1	Split Tensile Strength 4.42 N/mm^2	4.15	6.00	4.84	7.00	7.80
2		3.75	5.10	5.72	5.99	7.30
3		4.40	5.55	6.60	7.80	7.61

Table 17 strength of mix design with 16% replacement of Alccofine and 4% replacement of porcelain

In table 17 the results from the mix design, featuring a 16% replacement of Alccofine and a 4% replacement of porcelain, showcase a consistent pattern of strength development over time. The compressive strength values illustrate significant enhancement, with the first sample reaching 41.39 N/mm² at 90 days, closely aligning with the target strength of 31.6 N/mm². This is indicative of the effective contribution from Alccofine and porcelain in enhancing the concrete's performance via pozzolanic reactions. In terms of flexural strength, all three samples exhibit an upward trend, with values escalating from approximately 3.20 to 8.38 N/mm² over 90 days. This reinforces the material's ability to withstand bending forces, essential for applications involving structural elements subjected to tensile stresses. The split tensile strength data reflect a similar improvement trajectory, with readings moving from about 3.75 to 7.80 N/mm². This strength is critical in predicting the concrete's performance under tensile loading conditions.

Flow-ability tests of Mix Design with 16% replacement of Alccofine and 4% replacement of porcelain

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
816	6.10	0.993	0.013	Pass

Table 18 Flow-ability tests of Mix Design with 16% replacement of Alccofine and 4% replacement of porcelain

The flow-ability tests in table 18 for the mix design, which incorporates a 16% replacement of cement with Alccofine and a 4% replacement with porcelain, provide critical insights into the workability and usability of the concrete. The tested parameters include the slump flow diameter, V-Funnel flow time, L-Box ratio, and U-Box filling height, with all results indicating acceptable performance. The slump flow diameter was measured at 816 mm, suggesting that the concrete mixture demonstrates good fluidity and a high level of workability, which is essential for achieving an even placement during construction. The V-Funnel flow time recorded at 6.10 seconds further confirms the mixture's ability to flow readily and fill molds or formwork without significant resistance, indicating its suitability for various applications, particularly those involving complex geometries or congested reinforcement. The L-Box test yielded a height ratio of 0.993 (H2/H1), signifying that the mixture can effectively maintain its consistency and stability when flowing into narrower spaces, which is crucial for ensuring proper filling of forms while minimizing the risk of segregation. Additionally, the U-Box filling height difference of only 0.013 indicates minimal change in material height during flow, reinforcing the mix's ability to retain its shape and consistency even under flow conditions.

Mix Design with 16% replacement of Alccofine and 5% replacement of porcelain

Water/CementRatio (kg/m^3)	Cement (kg/m^3)	Alccofine (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Porcelain (kg/m^3)	Water (kg/m^3)	Super Plasticizer (1% of cement) (kg/m^3)
0.41	336	64	1352.07	339.52	91.72	164	4.00

Table 19 Mix Design with 16% replacement of Alccofine and 5% replacement of porcelain

In table 19 the mix design incorporating a 16% replacement of Alccofine and a 5% replacement of porcelain presents a well-balanced formulation that is designed to optimize both workability and mechanical properties of the concrete. The water-to-cement ratio of 0.41 indicates a relatively low water content, which is beneficial for achieving higher compressive strength and durability, as it helps reduce porosity and enhances the overall integrity of the concrete mix. In this design, the total cement content is maintained at 336 kg/m^3, which, when combined with 64 kg/m^3 of Alccofine, contributes to improved pozzolanic activity. Alccofine, a high-performance material, aids in the enhancement of the concrete's microstructure, leading to increased strength and durability over time. The fine aggregate content is set at approximately 1352.07 kg/m^3, while the coarse aggregate comprises about 339.52 kg/m^3, ensuring a well-graded aggregate mixture that promotes optimal packing density and minimizes voids. The incorporation of 91.72 kg/m^3 of porcelain not only provides supplementary benefits in terms of strength but also enhances the sustainability of the mix by utilizing recycled materials, which can lower environmental impact. The water content of 164 kg/m^3 is adequately balanced to maintain workability while achieving the desired strength characteristics. Additionally, the inclusion of 4.00 kg/m^3 of super plasticizer, which constitutes 1% of the cement weight, further enhances the workability of the mix, allowing for easier placement and manipulation of the concrete without compromising the mix's strength.

strength of mix design with 16% replacement of Alccofine and 5% replacement of porcelain

Sr No.	Test	7-Days (N/mm^2)	14-Days (N/mm^2)	28-Days (N/mm^2)	56-Days (N/mm^2)	90-Days (N/mm^2)
1	Compressive Strength F'ck = 31.6 N/mm^2	24.18	28.96	33.24	36.40	38.50
2		22.84	27.50	31.50	34.80	40.30
3		21.50	30.42	31.80	37.20	39.46
1	Flexural Strength	3.15	4.10	4.70	5.20	4.50
2		2.75	3.80	4.00	4.50	5.25
3		3.10	3.95	4.20	5.00	6.24
1	Split Tensile Strength	3.00	3.95	4.65	5.50	5.61
2		3.50	4.15	4.00	5.00	5.30
3		3.25	4.35	5.00	4.50	5.80

Table 20 strength of mix design with 16% replacement of Alccofine and 5% replacement of porcelain

The results presented in table 20 for the concrete mix design, featuring a 16% replacement of Alccofine and a 5% replacement of porcelain, reveal a consistent enhancement in mechanical properties over a period of 90 days. In terms of compressive strength, the data illustrates a clear and significant progression. The results indicate initial strengths of 24.18 N/mm^2, 22.84 N/mm^2, and 21.50 N/mm^2 at the 7-day mark, escalating to 38.50 N/mm^2, 40.30 N/mm^2, and 39.46 N/mm^2 at 90 days. These outcomes not only exceed the intended characteristic compressive strength of 31.6 N/mm^2 but also affirm the efficacy of utilizing Alccofine and porcelain as partial replacements, which enhance hydration and, consequently, strength development over time. The flexural strength values also reflect a positive trend, commencing at approximately 3.15 N/mm^2, 2.75 N/mm^2, and 3.10 N/mm^2 at 7 days, and culminating in strengths of 4.50 N/mm^2, 5.25 N/mm^2, and 6.24 N/mm^2 by day 90. This enhancement indicates a robust capacity of the concrete to withstand bending and deformation, making it suitable for applications where such mechanical properties are crucial. Lastly, analysis of the split tensile strength reveals similarly promising findings. Beginning at values of 3.00 N/mm^2, 3.50 N/mm^2, and 3.25 N/mm^2 at 7 days, the strength increased to 5.61 N/mm^2, 5.30 N/mm^2, and 5.80 N/mm^2 by the end of the 90-day period.

Flow-ability tests of Mix Design with 16% replacement of Alccofine and 5% replacement of porcelain

Slump Flow Dia. (mm)	V-Funnel Flow (Time S)	L-Box (H_2/H_1) Ratio	U-Box Filling Height (H_1-H_2)	Result
809	6.21	0.987	0.016	Pass

Table 21 Flow-ability tests of Mix Design with 16% replacement of Alccofine and 5% replacement of porcelain

The flowability tests conducted on the mix design with 16% replacement of Alccofine and 5% replacement of porcelain indicate that the concrete possesses favorable workability characteristics, as evidenced by the results of various flowability metrics. The slump flow diameter measured at 809 mm suggests a highly workable mix, which is conducive to easy placement and compaction, especially in complex forms or areas with congested reinforcement. This level of flowability is particularly important in applications where high performance and efficient placement are required. In the V-Funnel test, the flow time recorded was 6.21 seconds. This indicates a reasonable viscosity of the mix, allowing it to flow efficiently without excessive resistance, further confirming the mix's suitability for placement without segregation or bleeding. The L-Box test, which recorded a ratio of 0.987 for H2/H1, demonstrates an exceptional ability of the concrete to maintain its integrity while flowing; this close-to-unity ratio suggests that the material flows smoothly and evenly, minimizing the risk of blockage when passing through reinforcing elements. Additionally, the U-Box test yielded a filling height difference of only 0.016, indicating that the concrete achieves excellent symmetry and consistency in flow, further embedding confidence in its workability. Overall, the results classify the M25 mix design as a "Pass" in terms of flowability tests, reflecting its good performance in this aspect. However, it is critical to note that despite the favorable flowability results, the inclusion of Alccofine and porcelain may pose challenges in achieving the targeted compressive strength, flexural strength, and split tensile strength as per design specifications. This discrepancy highlights the need for careful consideration of the balance between workability and strength, as excessive replacement of cementitious materials can compromise the concrete's structural integrity. Consequently, while the flowability characteristics are commendable, further adjustments or investigations may be necessary to optimize the mix to meet all required strength criteria for its intended application. Fig. 2, 3 & 4 shows that the comparison of different mixes in compressive, flexural and split tensile strength respectively.

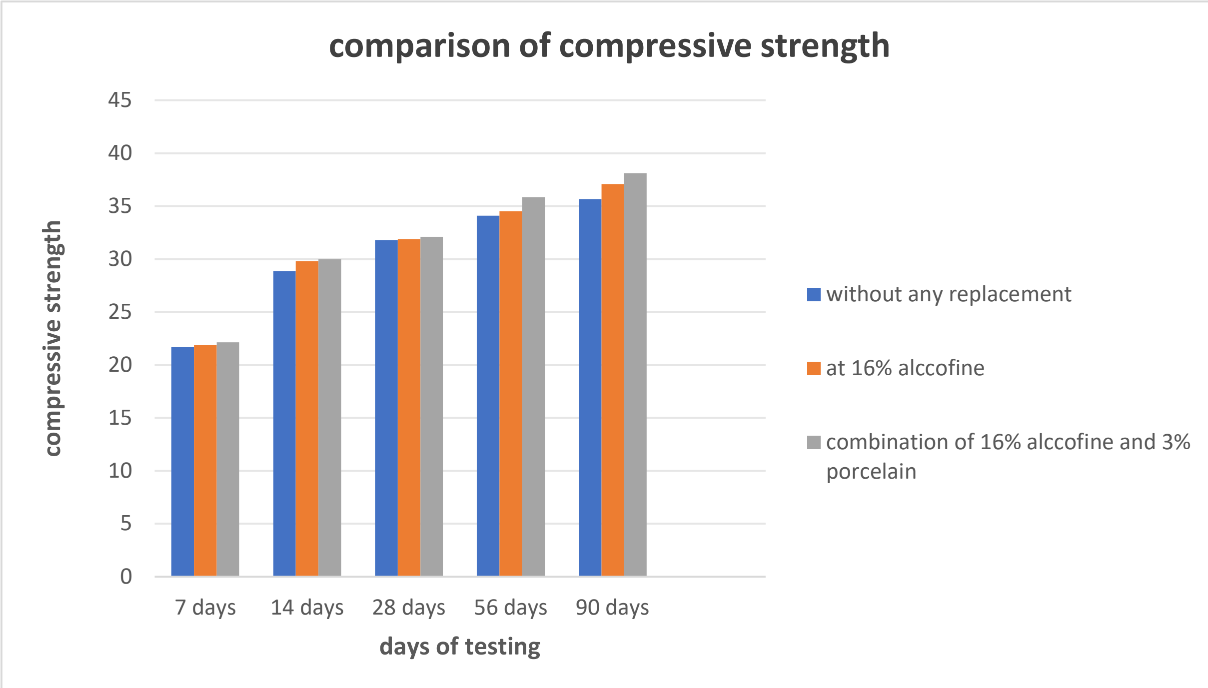

Fig. 2 comparison of compressive strength of mixes without any replacement, replacement of alccofine at 16% and combination of 16% alccofine and 3% porcelain.

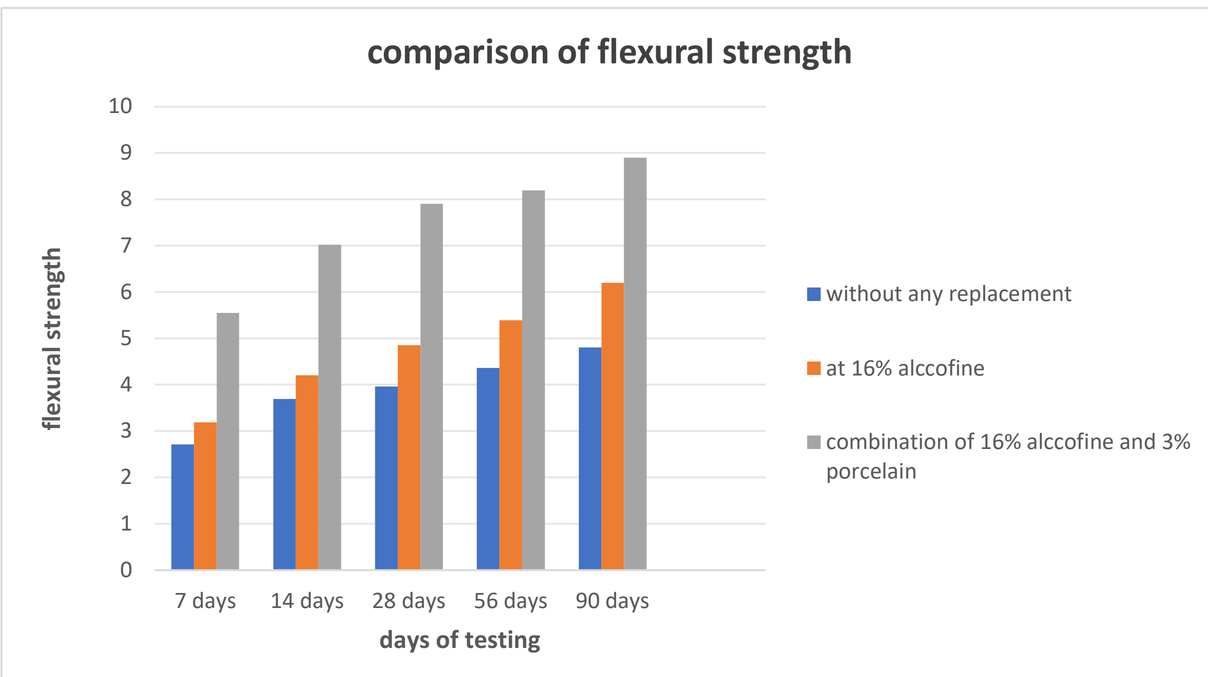

Fig. 3 comparison of flexural strength of mixes without any replacement, replacement of alccofine at 16% and combination of 16% alccofine and 3% porcelain.

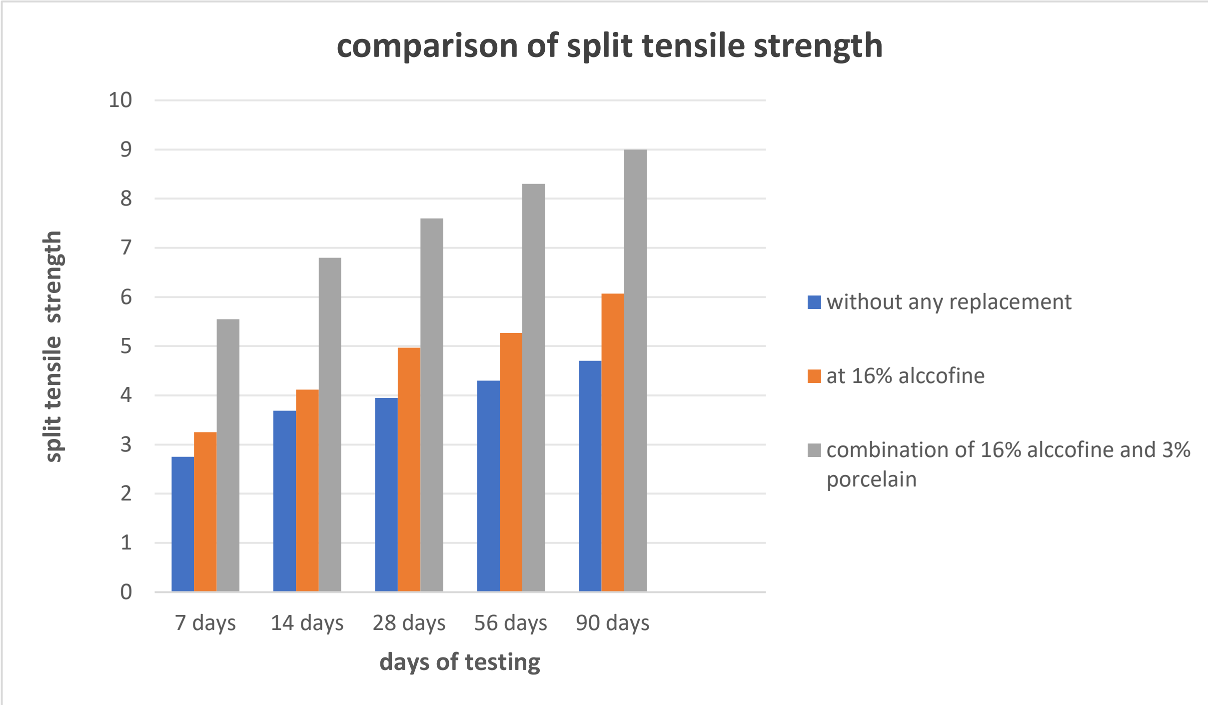

Fig. 4 comparison of split tensile strength of mixes without any replacement, replacement of alccofine at 16% and combination of 16% alccofine and 3% porcelain.

5 Findings

The exploration of self-compacting concrete (SCC) has revealed transformative potential in achieving high performance through optimized mix designs. An investigation into the M25 mix design without any replacement demonstrated satisfactory compressive strength, meeting industry standards; however, it did not exhibit the enhanced characteristics achievable through the incorporation of supplementary materials. Notably, when 16% Alccofine was integrated into the mixes, there was a marked improvement in compressive strength, surpassing typical performance benchmarks. This enhancement underscores Alccofine's role as an effective pozzolanic material, contributing to better hydration and microstructural densification in the concrete matrix. Further detailed evaluations involving variations of porcelain replacement alongside Alccofine (16%) showed commendable results at various levels of porcelain replacement, namely 1%, 2%, 3%, 4%, and 5%. Each incremental increase in porcelain content demonstrated improvements in compressive strength. Importantly, it was found that the combination of 16% Alccofine and 3% porcelain yielded the best compressive strength results across the board. This specific blend optimized the balance between workability and strength, capitalizing on the synergistic effects of both materials. The outcomes of this study indicate that self-compacting concrete, particularly when formulated with a well-considered mix design utilizing Alccofine and minimal porcelain replacement, can revolutionize performance in concrete applications. The results advocate for the adoption of such innovative mixes to enhance concrete sustainability and structural integrity, paving the way for future research and broader application in modern construction practices. Overall, the ability to achieve superior compressive strength while maintaining the workability of SCC marks a significant advancement in concrete technology.

6 Recommendations

Based on the findings regarding self-compacting concrete (SCC) using mix designs, several recommendations can be made for future applications and research. Firstly, it is advisable to continue exploring the optimal ratios of Alccofine and porcelain to maximize compressive strength and overall performance, specifically focusing on mixes with 16% Alccofine and 3% porcelain due to their superior results. Additionally, field trials should be conducted to assess the workability, durability, and long-term performance of these optimized mixes in real-world conditions. It is also recommended to investigate the cost-effectiveness of using these materials as replacements in various infrastructure projects, promoting sustainability in concrete production. Furthermore, incorporating advanced testing methods could provide deeper insights into the microstructural effects of these additives. Finally, collaboration with industry stakeholders will be essential to facilitate the adoption of these innovative concrete solutions, thereby enhancing construction practices and fostering a greener approach in the field.

7 Future scope

The future scope of research on self-compacting concrete (SCC) with Alccofine and porcelain admixtures is promising and extensive. Further studies could focus on the long-term durability and performance of optimized mix designs under varying environmental conditions, such as exposure to chemicals and temperature fluctuations. Additionally, exploring the incorporation of other innovative materials, like recycled aggregates or fibers, could enhance the mechanical properties and sustainability of SCC. There is also potential for the development of industry-specific guidelines and standards to facilitate the widespread application of these advanced mix designs. Ultimately, this research could significantly contribute to more sustainable construction practices and improved infrastructure resilience.

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