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A Review Paper On Pozzolana And Non - Pozzolana Materials Used In Self Compacting Concrete

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Abstract: Self-Compacting Concrete (SCC) is a novel concrete that can fully compact without vibration by flowing under its own weight. Its performance characteristics are greatly improved by the addition of additional materials. Because pozzolanic reactions can improve workability, decrease permeability, and increase long-term strength, pozzolanic materials like fly ash, silica fume, metakolin, and ground granulated blast furnace slag (GGBS) are frequently utilized in SCC. However, non-pozzolanic materials such as marble dust, quarry dust, and limestone powder mainly serve as inert fillers, adding to the mix's rheological characteristics and packing density without chemically reacting. In SCC formulations, the combination of pozzolanic and non-pozzolanic materials promotes environmental sustainability, cost effectiveness, and optimal performance. In order provide a comprehensive understanding of their impact on the properties of both fresh and hardened concrete, this paper examines the roles, advantages and shortcomings of both material types in SCC.

Key words– Self Compacting Concrete, Mineral Admixtures, Concrete, Pozzolanic.

I. Introduction

Nowadays, cement concrete is the preferred building material. Concrete is favored over other alternative building materials due to its ease of production from locally accessible raw materials, its adaptability, and how easily it can be molded into many shapes and forms. Concrete scientists are faced with a dilemma in creating a sustainable material that is both performance-oriented and environm entally conscious, as demands for high-height and lean structures grow along with environmental concerns. Pozolona are derived from by-products of industrial and agro-industrial operations. They lower the energy needed for clinker manufacturing, minimizing environmental impact. Pozzolan, a siliceous or siliceous and aluminous substance, has little cementitious value on its own. However, when finely split and combined with calcium hydroxide (lime) at room temperature, it reacts to generate cementitious compounds.(Sánchez de Rojas et al., 2013) [19].When pozzolan combines with lime in water, it releases OH^- ions, increasing the pH to around 12.4. Pozzolanic reactions combine silicon and aluminum with available calcium to form cementitious compounds known as calcium silicate hydrates (CSH) and calcium aluminate hydrates (CAH). These reactions are summarized in summary form below. These chemicals increase the mechanical characteristics of mixtures by promoting Pozzolanic reactions (Pourakbar S,et al.,2017) [20].

$$C\,(OH)_2 \rightarrow Ca_2^{+} + 2\,OH^{-} \text{ (Hydrolysis)} \qquad (1.1)$$

$$Ca_2^{+} + 2\,OH^{-} + SIO_2 \rightarrow CSH \text{ (Pozolona with High Silica Content)} \qquad (1.2)$$

$$Ca_2^{+} + 2\,OH^{-} + AL_2O_3 \rightarrow CAH \text{ (Pozzolona with High Alumina Content)} \qquad (1.3)$$

The inclusion of sulfate (SO_4^{2-}) in pozzolans inhibits pozzolanic processes by forming ettringite, a highly hydrated mineral ($Ca_6Al_2\,(SO_4)_3(OH)_{12}{\cdot}26H_2O$). Ettringite creation requires soluble aluminum, calcium, and sulfate, a high pH, and a sufficient volume of water. High temperatures expedite the development of ettringite, which can form within seconds depending on environmental circumstances. Ettringite, which contains 26 water molecules, may degrade cementitious materials made by pozzolanic processes (Seco A,et al.,2012) [19].

$$CaO + H_2O \rightarrow C\,(OH)^{2} \qquad (1.4)$$

$$C\,(OH)^{2} \rightarrow Ca2^{+} + 2(OH)^{-} \qquad (1.5)$$

$$Al_2Si_4O_{10}\,(OH)_2{\cdot}nH_2O + 2(OH)^{-} + 10\,H_2O \rightarrow 2\{2Al(OH)_4{}^{-} + 4H_4SiO_4\} + nH_2O \qquad (1.6)$$

$$MxSO_4 \cdot nH_2O \rightarrow x\ M\ y + SO_4 + nH2O \qquad (1.7)$$

$$\text{Where: } x{=}1,\ y{=}2\ or\ x{=}2,\ y{=}1 \qquad (1.8)$$

$$6\,Ca^{2+} + 2Al\,(OH)^{4-} + 4\,OH^{-} + 3(SO_4{}^{2-}) + 26H_2O \rightarrow Ca_6Al_2\,(SO_4)_3\,(OH)^{12} \cdot 26\,H_2 \qquad (1.8)$$

Pozzolana minerals have high concentrations of silicon, iron, and aluminum oxide, with a minimum weight percentage of 70% (ASTM et al., 2019) [24]. These chemical ingredients generate a cementitious gel (C-S-H). The amount of gel in a combination depends on several aspects, including the pozzolan's surface, properties, chemical components, method of preparation, and reactive silicon concentration. Pozzolana are classified as either natural or modified by industrial process (Davraz M,et al., 2018) [23].The broad categorization of pozzolan's, and some of them are discussed in the next section (Aref M,et al., 2018) [22]. Natural Pozzolana are (igneous rocks created by the buildup of volcanic ash), volcanic ash, volcanic slag, obsidian, and pumice stone (a grey-colored vitreous volcanic igneous rock), diatomaceous earth, cherts (silica-rich sedimentary rocks), opaline silica, and clays spontaneously calcined by the passage of burning lava process (Davraz M et al.,2018) [23] .Natural pozzolan's require no chemical treatment other than grinding to react with lime. Growing cost outlays and strict schedule constraints for construction projects have led to an increase in the use of HPC. (ACI 1998) defines high-performance concrete (HPC) as concrete that satisfies a special set of performance and uniformity standards that aren't always achievable with traditional materials and mixing, placing, and curing methods (Mehta P. K.et al.,2006)[1].Such high-performance concrete may have improved resistance to permeability, high density, improved toughness, long life in harsh environments, volume stability, early age strength, compaction without segregation, and long-term strength and mechanical properties (Gołaszewski J.et al.,2004) [2].To achieve the proper workability, a large dosage of super plasticizer was added to this concrete. Concrete that self-compacts (SCC) or self-solidifies (SCC). (Neville A. M.et al., 2010) [3]. Belongs to the class of High Performance Concrete (HPC) (Türkel S.et al.,2010) [4].Due to its simplicity of placement in heavily fortified areas and ability to compress under its own weight without segregation, SCC is categorized as an HPC.(Sideris K.et al., 2007,Ghafoori N.et al., 2010) [5,6]..and better resilience than ordinary concrete in the face of severe environmental conditions(Naik T.R.et al., 2012, Kwan A.K.H.et al., 2010) [7,8]. Studies on the laying of concrete underwater are the source of SCC(Mehta P. K.et al., 2006, Rob Gaimster.et al., 2003)[1, 9]. Concurrent and independent research has been carried out in Europe, North America, and Japan since the 1970s (EFNARC.et al.,2006) [10] to develop high workability concrete mixtures that are referred to as self-compacting, self-consolidating, self-leveling, or rheo plastic concrete. The mid-1980s saw the introduction and development of the modern SCC concept in Japan. The first SCC mix design model was developed by (Rob Gaimster.et al., 2003) [9].By making changes to the mix design process, several researchers have attempted to enhance SCC mixes notable examples include (O. Gencel et al, . 2011) [11] and (Domone P.L, et al., 2007) [12]. According to Domone, SCC was first applied in the 1990s in the construction industry, and by 2003, the precast and pre stressed concrete sectors were using it extensively. There are several reasons why large-scale construction operations prefer SCC over conventional concrete, including benefits to the environment, economy, and technology (Domone P.L, et al., 2006) [13], all of which are outlined in Table 1

Table 1: Showing Benefits of SCC

Assistance of SCC		
Technical	Economic	Environmental
Making concrete in highly reinforced chunks	Shorter duration of construction.	A secure setting at work
Thin-section prefabricated extensions can be adopted.	Reduced payroll costs. Safe practices	There is plenty of room for the usage of garbage.
Entities with any configuration are able to generate.	The use of waste from factories contributes to compensating the high input the cost.	Reducing the ecological impact of concrete.

The use of SCMs in SCC is essential for both economic and environmental reasons. SCC concrete contains high cement content. Cement is an energy-intensive material. The cement sector accounts for 7% of global CO_2 emissions (Neville A. M.et al., 2012) [14].To decrease the carbon footprint of SCC, it is advised to use powder additives to reduce cement content, which reduces CO_2 emissions. Furthermore, to achieve the needed workability (slump flow) at a lower water cement ratio, HRWR is necessary. Fluidized concrete, with its high cement content and super plasticizer dosage, is prone to segregation and bleeding. This needs the use of VMA. HRWR and VMA, both expensive ingredients, will boost the cost of the SCC mix by 20% to 40% more than the standard concrete. (Nehdi M.et al., 2004) [15].However, several researchers have identified contradicting cost discrepancies for a variety of reasons. (Ho D.et al., 2002)[16], including the fact that SCC is much more expensive than standard concrete in Singapore (80% to 150%), Sweden (10% to 15%), and France (50-100%). According to (Masahiro Ouchi et al., 2010) [17] SCC is just 4% more expensive than normal concrete, but it saves 33% on operating costs .SCC becomes more cost-effective by substituting cement with SCMs. High powder content in the SCC mix minimizes the risk of segregation and bleeding (Yahia A..et al., 2005) [18] In addition to Portland cement,powdered components can improve the properties of concrete in both the fresh and hardened stages. These are referred to as mineral additions or additional cementitious materials. Cementitious chemicals increase concrete strength by chemical or physical processes (Neville A. M.et al., 2010) [3]. Mineral additions in SCC are categorized into three distinct categories in Table 2 [4, 39, 40, and 41].and some of the chemical compositions showed in Table 3.

Table 2: includes the mineral additions that are often used in SCC mixtures by researchers

Type 1	The deliberate inclusion is inert or inactive (for example, limestone powder).
Type 2	addition includes pozzolanic or reactive elements such as flyash, silica fume, metakaolin, and blast furnace slag
Type 3	Additions include industrial waste such as granite fillers, marble dust, and quarry dust

Table 3: includes the mineral composition s that are often used in SCC mixtures by researcher

Sample	Author	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	SO_3	$CACO_3$	SiO_2	L.O.I	P_2O_5	K_2O	Na_2O	TIO_2	BaO	ZnO	SrO
Lime Stone Powder	Saeed Bozorgmehr Nia[81]	0.1	3.19	-	0.02	-	-	99.3	0.3	-	-	-	-	-	-	-	-
Metakolin	Hamdy El-Diadamony[82]	34.10	5.24	-	0.25	0.28	0.01	-	55.1	2.73	1.00	0.02	0.10	-	-	-	-
Silica Fume	Aleš Frýbort [83]	2.81	2.11	0.14	0.65	64.75	3.20	-	20.4	-	0.00	0.91	0.09	0.00	-	-	-
Fly Ash	Seham S[84]	21.00	3.70	-	1.40	6.90	1.00	-	59.0	4.62	-	0.90		-	-	-	-
GGBS	G.Shiva Prasad[85]	18.3	-	0.43	1.0	11.6	0.7	-	33.2	-	-	0.91	0.21	-	-	-	-
Quarry Dust	Luqman Adedeji Taiwo[87]	11.04	2.40	0.31	3.73	1.65	0.04	-	47.8	-	0.43	2.88	-	0.37	0.041	0.01	6.41
Marble Waste Powder	El-Mandouh, M.A[86]	5.50	3.65	-	2.65	62..24	2.99	-	21.4	-	-	0.60	0.90	-	-	-	-

II. LITERATURE REVIEW

(O. M. A. Daoud et al., 2021)[25]Investigated that Lime Stone Powder accounted for up to 30% of the cement weight, lowering costs and improving SCC performance in both the fresh and hardened phases. The results of the testing revealed that the concrete's workability increased. The capacity to fill and flow was increased, while segregation was minimized. LSP-containing SCC combinations flow slower than reference mixes, indicating that they are more viscous. Limestone powder can replace up to 20% of the cement in a project, improving self-compatibility while maintaining SCC ratings. While limestone powder has little effect on the late strength of concrete, it can improve the early strength of SCC.(Gołaszewski J et al., 2022)[26] the investigations primarily focused on the properties of conventional and self-compacting concrete with the addition of lime powder. The type of limestone used has a significant impact on concrete's compressive strength and strength loss. Finer particles have higher strength and lower porosity. Vibrating and self-compacting limestone concretes with and without an air-entraining admixture demonstrated mass loss of less than 5% after 100 and 200 freeze-thaw cycles, meeting frost-resistant standards.(Taku J et al., 2021)[27]As concrete ages, ternary SCC's durability increases, as do permeation qualities like as sorpitivity and water absorption. Concrete strengthens with age due to the filler effect, Pozzolanic reaction, and cement hydration, all of which result in a thick microstructure and enhanced mineralogical distribution. Prolonged self-compacting concrete is made by combining powdered limestone and calcined clay. W/C ratio has a significant impact on SCCs' rheological characteristics and stability. The W/C ratio influences SCC fluidity linearly and viscosity and stability exponentially. The ideal W/C ratio for achieving self-flowing and stability qualities in cementitious mortars appears to be around 0.4. Adding more than 30% LP to SCCs improves packing density and cement hydration, leading to a modest improvement in compressive strength. The test results indicated the feasibility of employing limestone powder in SCC. The study found that limestone powder improves technical and performance aspects. The resultant composition was optimized using a mathematical planning approach. The ideal dosage of limestone powder in the developed SCC is 38% to meet technological criteria (690 mm of slump flow) and cement consumption of 570 kg/m^3. Adding 38% limestone powder to SCC with super plasticizer increases compressive strength by 41.3, 56.5, 59.3, and 69.0 MPa in 3, 7, 14, and 28 days, which is consistent with existing SCC with other fillers.(Ifrah Mushtaq i et al., 2018)[28]

When 30% fly ash was substituted, fresh properties increased compared to the previous levels (10%, 15%, 20%, and 25%). The test results show that raising the amount of fly ash component improves compressive strength. After five trial mixes, the mix containing 30% fly ash instead of cement fulfilled compatibility criteria and had the maximum strength. Slump flow of SCC combinations ranged from 650 to 710, flow time for all mixes was shorter than 4.8 seconds, V funnel duration was between 8.35 and 11 seconds, and L box ratio was more than 0.8 for all mixes. It has been discovered that the incorporation of fly ash in SCC has superior performance attributes (strength and workability) than standard concrete.(E G Velichko et al., 2020)[21] . Mineral modifiers, such as granular blast furnace slag and fly ash from thermal power plants, can cut Portland cement use in concrete by 43-48% by forming a thick, multi component binder with less disorder. SCC with certain MM parameters has low water content, high viscosity, and low ultimate shear stress, leading in high-quality compaction. Using TPP fly ash instead of fine aggregate increases concrete strength by(Abdul Bari J et al., 2023)[30] The current study explored a variety of characteristics. Various strengths were investigated at different phases of development. The study reveals that employing a cement alternative can enhance SCC characteristics. The fly ash content of the mixture changed its characteristics.The experiment revealed that replacing fly ash with cement improves the workability of SCC. Increasing the quantity in the mix resulted in an increase in flow and T_{50} time (4.1–9.2%). This study looked at the long-term strength development of concrete. The study discovered that employing fly ash can reduce the heat of hydration, slow the growth of strength, and boost ultimate strength. The study implies that utilizing fly ash instead of cement might result in a more homogenous and solid microstructure. The phenomenon is thought to be caused by Pozzolanic reactions. (Vemula Aravind et al., 2020)[31]. as fly ash content rose, compressive, split tensile, and flexural strengths dropped. Calcium content decreases as the amount of fly ash increases. As a result, strength will decrease. Beyond 30% fly ash substitution, SCC's strength decreased dramatically. More than 50% replacement with fly ash will not fulfill the M20 grade criteria of IS 456:2000.(Arie Wardhono et al., 2020)[32]. This study investigates the strength and flow properties of a huge volume of fly ash in self-compacting concrete. Based on the discussion, it can be concluded that employing 50% fly ash as an OPC replacement material resulted in the strongest and most flow able HVFA-SCC specimen. HVFA-SCC2 with 50% fly ash had the highest compressive strength. It also demonstrated a denser HVFA-SCC than other specimens, with a porosity of 0.48. HVFA-SCC2 satisfied EFNARC requirements, with a slump test result of 26.1 cm and a flow diameter of 656.9 mm in 2.37 seconds. Fly ash can be used as a substitute for OPC in self-compacting concrete to help minimize global warming produced by the manufacturing process. Using fly ash as a partial replacement for cement or fine or coarse aggregate can enhance the characteristics of concrete in 7, 28, and 56 days. The ideal proportion is 10%, which increases compressive strength while meeting ASTM C-618 criteria. The study compares the resistances of the reference and experimental materials at 62.478 MPa and 276.77 kg/cm^2 FA replacement to 66,756, and finds a 1% improvement.(Ahmed M et al., 2019)[33].

The addition of silica fume to SCC improves durability by lowering permeability and refining pore structure, leading in greater resistance to salt attack. Incorporating silica fume with various percentages of cement (8, 12, 16, and 20%) decreases slump flow by 2.05%, 4.79%, 6.85%, and 10.96%, respectively, while boosting passing ability by 3.66%, 7.32%, 9.76%, and 15.85%, and segregation resistance by 11.88%, 24.47%, 5.66%, and 38.46%, respectively. Adding silica fume increases compressive strength, with a 16% substitution of SF by cement weight producing the best results after 7, 28, and 90 days. However, raising SF to 20% of the cement weight decreased compressive strength. (Ade Lisantono1 et al., 2019)[34] The addition of silica fume to SCC improves durability by decreasing permeability and refining the pore structure, leading in greater resistance to salt attack, while boosting passing ability by 3.66%, 7.32%, 9.76%, and 15.85%, and segregation resistance by 11.88%, 24.47%, 5.66%, and 38.46%. Adding silica fume increases compressive strength, with 16% SF replacement by cement weight producing the best results after 7, 28, and 90 days. However, raising SF to 20% of the cement weight reduced compressive strength. (V. Sre Adethya et al., 2021)[35]Our investigations show that silica fume may be employed up to 15% without affecting the rheology or mechanical characteristics of SCCs. Adding silica fume diminishes rheology, which affects stability and fill capacity.(Salem Alsanusi et al., 2022)[36]Silica fume is a potential secondary mineral source. The research recommends substituting no more than 6% silica with mass to get a higher modulus value. The prescribed rheological tests were sufficient to evaluate if the mix possessed all of the criteria of SCC. The new concrete test evaluated filling and passing capabilities. Laboratory verification testing should include the Slump, UBox, and L-box tests. Both mixtures' strength grows with increasing temperature cycles, but the percentage gain decreases over the 28-day curing period. The BP mix, which contains 90% cement and 10% silica fume, offers higher flexural and compressive strength. The weight of the specimens reduces with increasing temperature and number of heat cycles. Specimens treated for 28 days exhibit a larger percentage weight reduction than those cured for only seven days .(Eltahir Elshaikh et al., 2022)[37].The slump flow test demonstrated that MK-included SCC could be made and used effectively in many common applications, as well as vertical applications in severely packed structures. The successful trial exceeded the target strength, as evidenced by the 28-day compressive strength test, and the tested trials' viscosity values indicated a medium rate flow. Slump flow values range from 520 to 790 mm however the specifications I read said that they should be between 550 and 850 mm. Because of this, the mixed experiment with a slump flow of less than 550 was excluded. MK dose increases slump flow but decreases compressive strength above 30%. For trial 2, 33% MK, the greatest slump flow value recorded was 790 mm. (Nazrin Fathima Fazil M et al., 2023) [38].Cement-like material. Increasing the metakaolin content significantly improved the compressive, tensile, and flexural strengths of self-compacted concrete at 7 and 28 days of age. Samples with a metakaolin replacement ranging from 10% to 20% by weight of cement demonstrate higher strength than samples without metakaolin component. The highest strength may be achieved by replacing 15% of the cement with metakaolin. However, adding metakaolin to concrete reduces its workability. To alleviate the problem, superplasticizer is mixed into concrete to form SCC. Metakaolin applied at a 15% rate to SCC mixes kept some of the self-compaction features, such as filling capacity, passage capacity, and resistance to segregation. When extensive reinforcing, such as beams and columns, makes compaction particularly difficult, fly ash-based self-compacting concrete with 15% metakaolin in cement can be used. (Peerzada Danish M et al., 2020)[39] The integration of MK in the SCC reduced workability, however this may be remedied by increasing the minor dose of Poly Carboxylate Ether (PCE) based superplasticizer, using FA as a cement substitute, and adding WMP as a filler material. The use of MK and FA provides a great alternative for reducing cement use, making the SCC an environmentally friendly concrete. (Alice T M et al., 2020)[40] According to the findings provided in this work, adding up to 20% metakaolin to concrete improves its potential durability. Metakaolin is non-toxic and lowers permeability; therefore it may be utilized safely in water-retaining structures. It can also be used to suppress ASR in areas where non-reactive aggregates are scarce and to slow the rate of carbon dioxide ingress when carbonation control is required, as long as the physical improvement to the microstructure outweighs the reduced buffer capacity. In the midst of the Durability index test findings, metakaolin often provided excellent-quality concrete that improved with the addition of metakaolin. This might be attributed to the concrete's pozzolanic and filler effects, which thicken the microstructure while decreasing gas permeability, water sorptivity, and chloride conductivity.(A Vittalaiah et al., 2020)[41]

The new attributes revealed for 30% GGBFS substitution levels were superior than 10%, 20%, 40%, and 50% GGBFS replacement. As a result, increasing the GGBFS replacement may improve the strength and effectiveness of self-compacting concrete. Mineral admixture replacement rates improve split and flexural strength while lowering compressive strength. In terms of endurance, GGBFS raises the water absorption percentage in SCC from 0% to 50%. The optimal porosity ranges for SCC mixes with GGBFS are 20% to 30%. In terms of pH, alkalinity levels increased by 0% while decreasing by 50%.In the sulfate attack test, the average weight loss is 2.18 and 2.80 for 28, 56 days to 0%, with ideal values for 30% and and reduced for 50%. In the carbonation test. (J.Vengadesh Marshall Raman et al., 2017) [42] .With 25% GGBS, the compressive strength at the end of 7, 14, and 28 days was 32.1, 39.94, and 47.56N/mm2. When the GGBS percentage exceeds 40%, compressive strength diminishes after 28 days. However, the compressive strength of M30 concrete after 28 days of 40% substitution of GGBS is 43.26 N/mm2. When the GGBS proportion was raised, the compressive strength decreased significantly. A comparable rise in split tensile strength was seen when the GGBS was increased by 25% (5.55 N/mm^2 at the end of 28 days). The split tensile strength at the end of 28 days diminishes as the GGBS percentage exceeds 40%. However, the split tensile strength of M30 concrete after 28 days of 40% replacement of GGBS is 5.01 N/mm^2. When the GGBS percentage exceeded 40%, the split tensile strength decreased significantly. Flexural strength increased similarly when the GGBS was increased by 25% (10.1N/mm2 at the end of 28 days). Flexural strength at the end of 28 days declines as the GGBS percentage exceeds 40%. However, the flexural strength of M30 concrete after 28 days of 40% replacement with GGBS is 7.67 N/mm^2.(Peng Zhang et al., 2024) [43]At a short age (0-14d), granulated blast furnace slag self-compacting concrete has lower compressive strength, splitting tensile strength, and elastic modulus than regular self-compacting concrete. However, after a lengthy period of normal curing (14-180 days), the strength and strength growth rate of granulated blast furnace slag self-compacting concrete improve. This is because granulated blast furnace slag has a certain potential hydraulicity, and it will continue to develop additional hydration products after normal curing, improving compressive strength and strength growth rate to some extent.After normal curing, the pore structure parameters of typical SCC exhibit rather stable variations. The air content, pore spacing coefficient, and average chord length of GBFS-SCC decrease, whereas the specific surface area grows significantly, the pore radius progressively declines, and the number of pores reduces marginally. GBFS-SCC provides a better hydration impact than standard SCC, which improves the internal pore structure of concrete to some extent.Using the grey correlation analysis approach, compressive strength is connected with gas content, specific surface area, pore spacing coefficient, pore frequency, and average pore chord length. It is determined that the specific surface area and average chord length of bubbles are strongly connected to the compressive strength of GBFS-SCC and are generally stable. These two points are the most important influences on the mechanical characteristics of GBFS-SCC.(S.P.Kanniyappan et al., 2022) [44]The following findings were obtained from the research into GGBS as a partial substitute for cement, and they are appropriate to the characteristics and materials employed in this study. The durability of GGBS concrete has increased significantly. Overall, the experimental analysis demonstrated that the concrete performed better in terms of acid attack, sulphate resistance, alkali attack, and fast chloride penetration testing. SCC produced with GGBS has better workability than regular concrete. The weight loss due to acid attack of 40%, 50%, and 60% replacement of GGBS concrete after 30 and 60 days is much lower than that of regular concrete. Weight loss due to sulphate attack of 40%, 50%, and 60% replacement of GGBS concrete after 30 and 60 days is relatively modest when compared to ordinary concrete. Similarly, weight loss due to alkali attack of 40%, 50%, and 60% replacement of GGBS concrete after 30 and 60 days is minimal when compared to regular concrete. The rapid chloride penetration test results indicated that the charge transmitted to the concrete specimen is lower for 40%, 50%, and 60% replacement of GGBS when compared to conventional concrete, and that the chloride permeability conditions are mild for all types of concrete. Thus, based on the results, it was established that the substitution of GGBS up to 60% in concrete is found to be good. (Eskinder Desta Shumuye et al., 2018) [45],All Pozzolanic compounds are effective in lowering the permeability of concrete much below the regulated level. Concrete's workability improves as the degree of GGBFS replacement increases. As the GGBS content grows, the water/binder ratio lowers for the same workability, indicating that GGBS has a beneficial influence on workability. In most situations, compressive strength reduces with an increase in percentage of GGBS at an early age, but increases with an increase in percentage of GGBS at an older age. Split tensile strength and flexural strength both decrease with a rise in GGBS % at an early age, but increase with an increase in GGBS percentage at an older age. The rise in strength is up to a certain limit of replacement, beyond which it begins to decrease, and eventually, in older age, the strength increases. This is owing to the sluggish rate of interaction between GGBS and $Ca(OH)_2$. The heat of hydration is slower in GGBS cement, which reduces the risk of shrinkage cracking and makes it more suitable for high-temperature building locations. Concrete's resistance to chlorides and sulfates rose as the amount of GGBFS increased. GGBS fails the first absorption test, indicating that the surfaces of their concrete mixtures are essentially impervious. The substitution of cement by GGBS helps to reduce the cement content of concrete, thereby lowering the cost of construction because the price of GGBFS is around 25 - 50% less than that of OPC. Reuse of the slag helps to protect the environment• from pollution (reduced CO_2 emission .The study of (Liu et al., 2019) [46] Demonstrates that technological materials may be employed as fillers in SCC, hence tackling environmental concerns logically. The study of

(Prokospkir G et al., 2020) [47] On the use of granite dust as a partial replacement of PC in concrete demonstrates that the fresh qualities of PC(control)mixes and the nature of the strength enhancement differ slightly from mixtures of PC blended with QD. Along the same lines of thinking, the work of (Apeh JA et al., 2020) [48] On the characteristics of SCC including QD examined the fresh and hardened properties of SCC and found an appropriate 20% replacement level of PC with QD. The addition of marble dust and limestone powder to cement mortars and concrete improves their rheological qualities, according to (Arivamangal A et al., 2014) [49] It has also been demonstrated that the inclusion of granite and basalt powder improves the compressive strength of cement mortar and concrete. The dispersion component fills the gap between the sand and cement grains, forming a stiff structure that improves the density and other new features of SCC. (Koura BO A et al., 2019) [50] Demonstrates this. A rise in the solid phase of SCC (aggregate content) results in a low liquid phase (cement phase), which causes high internal friction, increasing the likelihood of blockage (poor passing ability) and therefore reducing flow capacity. This indicates that the solid content of SCC must be determined in this manner as to avoid adverse effect on the Mix. However According to previous research (Alyamac, KE et al., 2018, Koura BO A et al., 2019) [51,52], several types of waste materials, including QD, have been employed as a partial substitute for PC and as a filler, but the effect(s) of their composition on the fresh and hardened characteristics of SCC have yet to be investigated, and this is the topic of the study. The study aimed to determine the optimal QD content to replace PC without negatively impacting SCC properties, including setting times, flow ability, passing ability, water demand, deformability coefficient, compressive and tensile strengths. (Ashish, D et al., 2019) [53] The consistency and setting times of composite cement pastes prepared with marble and regular Portland cement were examined, and their qualities were not negatively impacted by the presence of 15% marble waste. (Toubal Seghir et al., 2019) [54]The decrease in compressive strength appears to be more prominent in air-cured samples. The apparent density of pastes formed by substituting cement with marble slurry in variations of 5%, 10%, and 15% was seen to decrease with a considerable rise in porosity values.

(Li et al., 2018) [55] Replaced cement in mortar manufacturing using marble waste particles finer than 150 microns. They tested four different w/c ratios (0.4, 0.45, 0.5, and 0.55) and substituted cement at 5%, 10%, 15%, and 20%.Durability features such as drying shrinkage, carbonation, and water absorption were investigated in these mortars. By employing marble waste as a binder and lowering the water content using a super plasticizer, the carbonation depth of these mortars was significantly lowered by 30-40%. Water absorption and drying shrinkage were both decreased by more than 40%.(Ahmad et al., 2018) [56] Over the last 30 years, the building industry, notably in the UK, has taken initiatives to reduce the discharge of toxic chemicals during cement manufacture. Alternative solutions include improving clinker grinding efficiency, integrating sustainable cement manufacturing, replacing organic gas for coal in calcinations, and using chemicals to absorb CO2. Using composite materials might be a viable option for lowering carbon emissions significantly. Using manufacturing byproducts like fly ash, metakaolin, waste glass, waste marble, and silica fume instead of cement may significantly reduce greenhouse gas emissions. Academics are exploring the relationship between renewable resource utilization and environmental protection globally. (ASTM et al., 2017) [57] WM is classified as a Pozzolanic material due to its high proportion of amorphous SiO2 and tiny particles. The total of magnesium, alumina, iron, lime, and lime in WM exceeds 70%. According to ASTM (2017), materials containing more than 70% silica, iron, lime, magnesium, and alumina are considered Pozzolanic.(Choudhary et al., 2021) [58] Using WM as filler in the SCC increases intruded pore volume, lowers the proportion of small pores, and improves SCC CS. Micro-fling improves strength by filling gaps between SCC constituents, resulting in compact SCC. Adding extra Pozzolanic components lowered workability by 30%, necessitating more compaction energy. This resulted in larger gaps in the hard pore and lower density of the concrete. Substituting WM in SCC improves chloride penetration resistance, although higher deployment (20% and 30%) reduces in the chloride infiltration depth was somewhat lower (0.5 mm) than the reference mixes with a 10% WM substitution. The penetration depths of the mixes 20% and 30% WM were 2.75 mm and 6 mm higher than the control mixture, respectively .(Ashish et al., 2021) [59] The lack of a binder resulted in increased voids and improved water absorption. Adding 10% WM to SCC instead of cement enhanced its water permeability resistance. The 10% WM mix resulted in an average water penetration depth of 54 mm, 36.47% lower than the control mixture. Enhanced WM replacement in SCC increased water permeability depths. 78. Similar to compressive strength (CS), split tensile strength (STS) reduced with WM replacement in SCC, Some research suggests that using WM can enhance the STS of SCC. The STS of concrete with 0%, 10%, and 15% WM as partial replacement of sand was tested after 7, 28, 56, and 90-day curing periods. The outcome shows the effect of substituting sand with WM. The study found that using 10% WM as a sand replacement resulted in the highest STS, while 15% WM produced somewhat lower results throughout all curing ages. A research indicated that 50% foundry sand may be used to replace concrete without reducing its strength.

IV. RESULTS AND DISCUSSION

- The utilization of limestone powder (LSP) in self-compacting concrete (SCC) presents a cost-effective and performance-enhancing solution. With the ability to replace up to 20% of cement, LSP improves workability, early strength, and durability while meeting frost-resistant standards. Optimal dosage of around 38% LSP, combined with a water-to-cement ratio of 0.4, yields significant increases in compressive strength. These findings underscore LSP's potential to bolster SCC's rheological characteristics and stability, offering a sustainable pathway for efficient concrete construction.
- The addition of fly ash in self-compacting concrete (SCC) improves both fresh properties and compressive strength, with higher substitution levels enhancing workability and strength. However, exceeding 30% substitution leads to a notable decline in strength. Utilizing fly ash up to 50% as an OPC replacement results in strong, flowable SCC, meeting standards and reducing environmental impact. A 10% substitution ratio is optimal for increasing compressive strength while meeting ASTM criteria.

- Incorporating silica fume in SCC improves durability and resistance to salt attack by refining pore structure. Optimal compressive strength is achieved with 16% substitution, but exceeding 20% leads to a decline. Silica fume up to 15% doesn't significantly affect rheology or mechanical properties, but higher substitution may impact stability. Recommendations advise limiting silica fume substitution to 6% for desired properties, with specific tests like Slump, U-Box, and L-Box recommended for verification.
- Incorporating metakaolin (MK) in self-compacting concrete (SCC) boosts strength and durability, with peak benefits at 15% substitution. Higher MK doses reduce workability, but up to 20% improves durability and lowers permeability. MK-treated SCC maintains self-compaction features, resisting segregation, and is advantageous in reinforced structures. Adjusting super plasticizer dosage and using supplementary materials can address reduced workability. Overall, MK integration offers high-performance, sustainable concrete with enhanced durability and reduced environmental impact.
- Increasing GGBFS in SCC beyond 30% enhances strength and effectiveness, affecting split and flexural strength. Despite initial decreases, later-age strengths improve due to slow interaction with $Ca(OH)2$. GGBFS enhances workability, lowers permeability, and improves durability, resisting acid, sulfate, alkali attacks, and chloride penetration. Its slower hydration rate reduces shrinkage cracking risks and enhances resistance to chlorides and sulfates. GGBFS incorporation reduces cement content, cutting costs, and environmental impact, contributing to sustainable construction practices.
- The study highlights the potential of technological fillers in SCC to address environmental concerns effectively. Research demonstrates the positive impact of granite dust (M –sand)) as a partial replacement for PC in concrete, with an optimal 20% replacement level identified. Additionally, the inclusion of marble dust, limestone powder, granite, and basalt powder improves rheological qualities and compressive strength. However, the effect of waste materials like QD on SCC properties requires further investigation, focusing on optimal content to replace PC without compromising essential characteristics.
- The incorporation of waste marble (WM) in concrete offers environmental benefits and improved properties like chloride resistance. WM in self-compacting concrete (SCC) enhances water permeability resistance and reduces absorption, particularly at 20% replacement, but reduces compressive and split tensile strength. As a non Pozzolanic material, WM improves durability by filling gaps but at a certain replacement may decrease workability and increase porosity at higher levels. Optimizing WM content in SCC is crucial to balance property enhancements with potential strength reductions, necessitating further research for optimal performance.

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References

1. Mehta P. K Monteiro, P. J. M. McGraw Hill, 2006, Properties and Materials, Concrete Microstructure, San Francisco, pp. 475-476.
2. Gołaszewski J. and Szwabowski J., 2004, Influence of superplasticizers on rheological behaviour of fresh cement mortars, Cement and Concrete Research, Vol. 34, pp. 235–248.
3. Neville A. M. and Brooks J. J., 2010, Concrete Technology, Prentice Hall (Pearson), Essex, pp. 408-410.
4. Türkel S. and Kandemir A., Fresh and Hardened Properties of SCC Made with Different Aggregate and Mineral Admixtures, Journal. Of Materials.In Civil Engineering, 2010, Vol. 22, pp.1025–1032.
5. Sideris K. 2007,, Mechanical characteristics of self-consolidating concretes exposed to elevated temperatures, Journal of Materials in Civil Engineering, Vol. 19, pp. 648–654.
6. Ghafoori N. and Diawara H., 2010, Influence of temperature on fresh performance of self-consolidating concrete, Construction and Building Materials, 24, pp. 946–955.

7. Naik T.R., Kumar R., Ramme B.W., and Canpolat F., 2012, Development of high-strength, economical self-consolidating concrete, Construction and Building Materials, 30, pp.463–469.
8. Kwan A.K.H., Ivan Y.T. Ng, 2010, Improving performance and robustness of SCC by adding supplementary cementitious materials, Construction and Building Materials, Vol. 24, 2260–2266.
9. Rob Gaimster, Noel Dixon, 2003,Self Compacting Concrete, in: John Newman, Ban Seng Choo (Eds.), Advanced Concrete Technology, Process, Elsevier Butterworth Heinemann, Oxford, pp.9/1-9/23.
10. 2005, European Federation of National Associations Representing producers and applicators of specialist building products for Concrete (EFNARC), The European Guidelines for Self Compacting Concrete – Specification, Production and Use, pp. 1–63.
11. O. Gencel, C. Ozel , W. Brostow and G. Martı´nez-Barrera, 2011, Mechanical properties of self-compacting concrete reinforced with polypropylene fibres. Materials Research Innovations, 15(3):216-225.
12. Domone P.L., 2007, A review of the hardened mechanical properties of self-compacting concrete, Cement and Concrete Composites, Vol. 29, pp. 1–12
13. Domone P.L., 2006, Self-compacting concrete: An analysis of 11 years of case studies, Cement and Concrete Composites, Vol. 28, pp. 197–208.
14. Madandoust R. and Mousavi S.Y., 2012, Fresh and hardened properties of self-compacting concrete containing metakaolin, Construction and Building Materials, Vol. 35, pp. 752–760
15. Nehdi M., Pardhan M. and Koshowski S., 2004, Durability of selfconsolidating concrete incorporating high-volume replacement composite cements, Cement and Concrete Research, , Vol. 34, pp. 2103–2112.
16. Ho D., Sheinn A. and Ng C., 2002, The use of quarry dust for SCC applications, Cement and Concrete Research, Vol. 32, pp. 505–511.
17. Masahiro Ouchi, Sada-aki Nakamura, Thomas Osterberg, Sven-Erik Hallberg and Myint Lwin, Applications of Self-Compacting Concrete in Japan, Europe and the United States , Doc ID/URL: http://www. fhwa.dot.gov/bridge/scc.htm
18. Yahia A., Tanimura M. and Shimoyama Y.,2005, Rheological properties of highly flowable mortar containing limestone filler-effect of powder content and W/C ratio, Cement and Concrete Research, , Vol. 35, pp. 532–539.
19. Sánchez de Rojas Gómez MI, Frías Rojas M, 2013.Natural pozzolans in eco-efficient concrete.Eco-efficient concrete. Cambridge: Woodhead Publishing; p. 83-104.
20. Pourakbar S, Huat BK. 2017, A review of alternatives traditional cementitious binders for engineering improvement of soils. Int J Geotech Eng.11(2):206-16.
21. Seco A, Ramirez F, Miqueleiz L, Urmeneta P, García B, Prieto E, 2012, Types of waste for the production of pozzolanic materialsa review. In: Show KY, Guo X, editors.Industrial waste. London: IntechOpen, p. 141-50.
22. Aref M. 2018. Volcanic scoria as cement replacement. In: Aiello G, editor.Volcanoes-geological and geophysical setting, theoretical aspects and numerical modeling, applications to industry and their impact on the human health. London: IntechOpen; p. 211-38
23. Davraz M, Ceylan H, Topcu IB, Uygunoglu T. 2018, Pozzolanic effect of andesite waste powder on mechanical properties of high strength concrete. Constr Build Mater.165:494-503.
24. ASTM. ASTM C 618-19, 2019 Standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete. USA: ASTM;
25. O. M. A. Daoud, and O. S. Mahgoub, 2021, Effect of limestone powder on self-compacting concrete, FJES, 71-78.
26. Gołaszewski, J.; Gołaszewska, M.; Cygan, G, 2022, Performance of Ordinary and Self-Compacting Concrete with Limestone after Freeze–Thaw Cycles. Buildings 12. https://doi.org/10.3390/buildings12112003.

27. Taku J. K., Amartey Y. D., Ejeh S. P., Lawan A,2021. Durability evaluation of calcined clay and limestone powder blended ternary self-compacting concrete. Journal of Engineering Sciences, Vol. 8(1), pp. C1–C10, doi: 10.21272/jes.2021.8 (1).c1
28. Ifrah Mushtaq, Sandeep Nasier, 2018 Self Compacting Concrete Design And Performance Using Fly Ash, International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 4, April, pp. 436–445.
29. E G Velichko,2020,Self-compacting concrete with TPP fly ash, Materials Science and Engineering 896, IOP Publishing doi:10.1088/1757-899X/896/1/012091.
30. Abdul Bari J , Kuldeep Singh A,2023, Experimental Analysis of Self-Compacting Concrete Behavior by Replacing Cement with Fly ash, Web of Conferences 399, 03011, https://doi.org/10.1051/e3sconf/202339903011.
31. Vemula Aravind , A. Nagaraju , K. Chaitanya , 2022,Experimental study on effect of fly ash content on selfcompacting concrete, Advancements in Sustainable Materials and Infrastructure, IOP Conf. Series: Earth and Environmental Science 1086 (2022) 012045.
32. Arie Wardhono, 2020, Flowability and strength properties of high volume of fly ash material on self-compacting concrete, Journal of Physics: Conference Series 1747 (2021) 012033, IOP Publishing doi:10.1088/1742-6596/1747/1/012033.
33. Ahmed M. Tahwia , Ahmed H. Abdelraheem , Taha E. Taha ,2019, Durability performance of silica fume Self-Compacting Concrete, /Engineering Research Journal 164 ,December,C15-C34.
34. Ade Lisantono1 and Y P B Pratama,2020,Effect of silica fume on the compressive strength and modulus elasticity of self-compacting high strength concrete, IOP Conf. Series: Earth and Environmental Science 426 (2020) 012057 , doi:10.1088/1755-1315/426/1/012057
35. V. Sre Adethya, D. Sri ruban , R. Anuradha3 , S. Vinoth, 2021, Effect Of Silica Fume On Rheology And Mechanical Property Of Self Compacting Concrete, Journal of Civil Engineering and Technology (JCIET) Volume 07, Issue 1, January-December ,pp. 1-10.
36. Salem Alsanusi,2013, Influence of Silica Fume on the Properties of Self Compacting Concrete, World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering Vol:7, No:5.
37. Eltahir Elshaikh , Salma Mahmoud,2022, Experimental Study on the Properties of SCC using Meta-Kaolin from Sudan, SSRG International Journal of Civil Engineering Volume 9 Issue 7, 44-49, July.
38. Nazrin Fathima Fazil M. & Chithra C.J,2023, Experimental investigation on fly ash based self-compacting concrete with metakaolin, Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 11(X), http://dx.doi.org/10.7770/safer-V12N1-art2783.
39. Peerzada Danish, Mohan Ganesh G,2020, Behaviour Of Self-Compacting Concrete Using Different Mineral Powders Additions In Ternary Blends, Romanian Journal of Materials 2020, 50(2), 232 – 239.
40. Alice T. Bakera , Mark G. Alexander,2019, Use of metakaolin as a supplementary cementitious material in concrete, with a focus on durability properties, RILEM Technical Letters (2019) 4: 89-102 DOI: http://dx.doi.org/10.21809/rilemtechlett.2019.94.
41. A Vittalaiah , Rathod Ravinder , C Vivek Kumar,2020, Study on effect of strength and durability parameters and performance of Self Compacting Concrete replacement with GGBS at different dosages, E3S Web of Conferences 184, 01106 (2020) https://doi.org/10.1051/e3sconf/202018401106.
42. J.Vengadesh Marshall Raman, V.Murali Krishnan,2017, Partial Replacement of Cement with GGBS in Self Compacting Concrete for Sustainable Construction, SSRG International Journal of Civil Engineering (SSRG – IJCE) ,Volume 4 Issue 3 , March 2017.
43. Peng Zhang, Dongsheng Shi, Ping Han & Zheng Ma ,2024, Study on the mechanical properties and pore structure of granulated blast furnace slag self-compacting concrete based on grey correlation theory, Journal of Asian Architecture and Building Engineering, 23:2, 634-648, DOI: 10.1080/13467581.2023.2244559.

44. S.P.Kanniyappan ,B.Tamilarasan , M.Sivakumar,2022, A Study On Durability Properties Of Self-Compacting Concrete Using Ggbs,ijmter.
45. Eskinder Desta Shumuye and Zhao Jun,2018, A Review on Ground Granulated Blast Slag (GGBS) in Concrete, Proc. of the Eighth International Conference On Advances in Civil and Structural Engineering - CSE 2018 Copyright © Institute of Research Engineers and Doctors. All rights reserved. ISBN: 978-1-63248-145-0 doi: 10.15224/ 978-1-63248-145-0-14.
46. Liu, SH, Wang, I, 2019 Influence of Limestone Powder on hydration properties of complex Binders. Mater. Res . Innov. Vol. 18, pp 186 – 190,Doi: 10.1179/1432891714Z.000000000624.
47. Prokospkir G, Manchu, K,, Huts, V,2020, The effect of using granite Dust as a component of concrete Mixtures. J Case studies in construction Mater, 13 e00349, 1 - 7 2214 - :5095.
48. Apeh JA, Ameh JE,2020, Properties of Steel Fiber Self - compacting concrete incorporating. Quarry Dust Powder. Challenge Journal of concrete Rese rch Letters. 11 , doc.org/10.20528/cjcrls.2020.01..001
49. Arivamangal A, Felixkala T,2014, Strength and availability properties of granite concrete. J. Civ-Eng, Res.4, 1- 6. Doi .org /10.5923//cjcrl 20140.101
50. Koura BO, Hossenpour A, Yahia EK, Kadiri A.2019,a New Proportioning approach of Low and normal Self- consolidating concrete based on the characteristics of Fine Mortar and granular skeleton, Constr. Build .Mater. Vol. 239 pp 117892, 2020, doi 10.1016/J. con Built Mat.717892,
51. Alyamac, KE. Ghafari, E. & Ince, R,.2018, development of eco Ef icient Self- compacting concrete with MarblePowder using the re-polish surface method. Journal of cleaner production,. 133 – 192-202,doi 10.31118/jbms.v812.1080
52. Ghafoor, N. Sharbgf, M. & Batilov, I,2019,.National pozzolan containing Self-compacting concrete.FourthInternational conference on sustainable construction Materials and Technologies.Las Vegas, U.S.A
53. Ashish, D. K.2018a."Concrete Made with Marble Powder andSupplementary Cementitious Material for Sustainable Development."Journal of Cleaner Production.doi:10.1016/j.jclepro.2018.11.245
54. Toubal Seghir, N., M. Mellas,Ł. Sadowski, and A.Żak. 2018."Effects ofMarble Powder on the Properties of the Air-cured Blended CementPaste."Journal of Cleaner Production183: 858–868. doi:10.1016/j.jclepro.2018.01.267
55. Li, L. G., Z. H. Huang, Y. P. Tan, A. K. H. Kwan, and F. Liu.2018."Use ofMarble Dust as Paste Replacement for Recycling Waste and ImprovingDurability and Dimensional Stability of Mortar."Construction andBuildingMaterials166:423–432.doi:10.1016/j.conbuildmat.2018.01.154.
56. Ahmad, J., Kontoleon, K. J., Al-Mulali, M. Z., Shaik, S., Ouni, M. H. E., & ElShorbagy, M. A. (2022a). Partial substitution of binding material by bentonite clay (BC) in concrete: a review. Buildings, 12(5), 634.
57. ASTM. (2017).ASTM D6868 standard specifcation for biodegradable plastics used as coatings on paper and other compostable substrates.ASTM International, West Conshohocken PA3.Retrieved from http://www.astm. org/DATABASE.CART/HISTORICAL/D6868-03.htm
58. Choudhary, R.,Gupta, R., Alomayri, T., Jain, A., & Nagar, R. (2021). Permeation, corrosion, and drying shrinkage assessment of self-compacting high strength concrete comprising waste marble slurry and fy ash, with silica fume. Elsevier
59. Ashish, D. K., & Verma, S. K. (2021).Robustness of self-compacting concrete containing waste foundry sand and metakaolin: a sustainable approach. Journal of Hazardous Materials, 401, 123329.