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Effect Of Silica Fume On The Fresh And Hardened Concrete A Review

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ABSTRACT

The study you mentioned goes beyond measuring the workability, cubic compressive strength, and splitting-tensile strength of the modified concrete. It also focuses on the durability parameters of the concrete, specifically water absorption, permeability, sulphate attack, and chloride attack. The goal is to evaluate how the addition of silica fume impacts these important aspects of concrete performance. The paper provides a comprehensive review of the use of silica fume (also known as micro-silica or nano-silica) as a mineral admixture in concrete. It highlights the findings from various research studies, particularly emphasizing the fresh and hardened properties of concrete when silica fume is included in the mix. The results of the review demonstrate a significant improvement in the mechanical properties of concrete when it is blended with silica fume. This indicates that the addition of silica fume positively affects the strength of the concrete. The review also discusses the percentage replacement of silica fume in both normal-strength and high-strength concrete. One notable finding is that as the percentage replacement of silica fume increases, there is a decreasing trend in workability, as indicated by the slump value. This means that higher replacement levels result in a decrease in the concrete's ability to flow and be easily handled during placement . These findings suggest that a higher percentage of silica fume replacement may be beneficial for improving flexural strength compared to compressive strength. Overall, the review provides valuable insights into the effects of silica fume on the fresh and hardened properties of concrete. It highlights the potential benefits of incorporating silica fume as a mineral admixture and provides guidance on the optimal percentage replacement for different concrete properties.

Keywords: Silica Fume; workability; compressive strength; flexure strength.

1. INTRODUCTION

1.1 BACKGROUND

Silica fume, also known as microsilica, is a by-product obtained from the production of silicon and ferrosilicon alloys. It consists of very fine particles of amorphous silicon dioxide (SiO2) with a high surface area. Silica fume is often used as an admixture in concrete mixtures due to its unique properties. Its small particle size and large surface area allow it to fill the gaps between cement particles, improving the overall packing density of the concrete mixture. This results in a more homogeneous and dense concrete with reduced porosity. One of the main advantages of using silica fume in concrete is its high reactivity as a pozzolan . Silica fume reacts with calcium hydroxide to produce additional calcium silicate hydrate (C-S-H) gel, which is the main binder in concrete. This reaction leads to increased strength, durability, and reduced permeability in the hardened concrete..It is obtained as a by-product during the production of silicon and ferrosilicon alloys in the smelting process of high-purity quartz with coal or coke in electric arc furnaces. It is produced by reducing high-purity quartz to silicon at very high temperatures, typically up to 2,000ºC. During this process, SiO2 vapors are generated, which then oxidize and condense in the cooler areas of the furnace to form tiny particles of non-crystalline silica. Silica fume particles are extremely fine, with a particle size typically less than 1 micron and an average diameter of about 0.1 microns. These particles are about 100 times smaller than the average particles found in cement. Due to their small size, silica fume particles have unique properties and can fill the gaps between cement particles, leading to improved strength and durability of concrete when used as an additive. The discovery of silica fume occurred in Oslo, Norway, in 1947 when it was observed during the filtration of exhaust gases from furnaces. Since then, it has been recognized and utilized as a valuable supplementary cementitious material in concrete production, contributing to enhanced performance in terms of strength, permeability, and resistance to chemical attack. Silicon dioxide, also known as silica, is a compound composed of silicon and oxygen atoms. It is a naturally occurring mineral and one of the most abundant substances on Earth. High-quality material commonly used in the cement and concrete industry. Silica fume is a popular material used as a supplementary cementitious material (often referred to as an admixture) in concrete to enhance its strength and durability. It conforms to standards such as AASHTO M 307 or ASTM C 1240, which provide guidelines for its use in construction. According to the Florida Department of Transportation, the recommended range for replacing cement with silica fume is between 7% and 9% by mass of the cementitious materials in the concrete mixture. This range ensures a balance between achieving the desired benefits of silica fume and maintaining the overall performance of the concrete. In recent years, the demand for high-performance concrete has increased in the construction industry. Silica fume is often used as a replacement for cement in high-performance concrete to improve its strength and durability. However, the determination of the optimum dosage of silica fume replacement can vary among different researchers. Various researchers have conducted investigations to determine the optimal amount of silica fume replacement for achieving the desired mechanical properties, particularly compressive strength, in concrete. The optimum dosage may depend on factors such as the specific project requirements, concrete mix design, curing conditions, and testing methods employed. Consequently, different researchers may arrive at different optimum values based on their experimental setups and objectives. It is important to consider the specific requirements and consult relevant research studies or expert guidance when determining the optimum dosage of silica fume replacement for a particular concrete application.

1.2 Production and form of silica fume

Silica fume, also known as microsilica or condensed silica fume, is indeed a by-product of the smelting process in the silicon and ferrosilicon industry. It is generated when high-purity quartz is reduced to silicon at temperatures reaching up to 2,000ºC. During this reduction process, silicon dioxide (SiO2) vapors are released. At the high temperatures involved, the SiO2 vapors oxidize and subsequently condense as fine particles in the lower temperature zone. These tiny particles consist of non-crystalline or amorphous silica. Silica fume particles are extremely small, with most falling within the range of 0.1 to 0.3 micrometers in diameter. This ultrafine nature gives silica fume unique properties and benefits when used in various applications. The production of silicon metal and ferrosilicon alloys can result in the generation of by-products that contain varying amounts of silica. Here's an overview of the two scenarios you mentioned:

1.Production of Silicon Metal and High-Silicon Ferrosilicon Alloys: By-products from the production of silicon metal and high-silicon ferrosilicon alloys (with silicon contents of 75% or more) typically contain 85-95% non-crystalline silica. Non-crystalline silica refers to amorphous or non-crystalline forms of silicon dioxide (SiO2).These by-products have a high silica content and are considered to be rich in amorphous silica.

2.Production of Ferrosilicon Alloy with 50% Silicon: The by-product generated from the production of ferrosilicon alloy with 50% silicon has a much lower silica content compared to the first scenario.The exact silica content may vary, but it is generally lower than the 85-95% range found in the high-silicon ferrosilicon alloy by-products. Additionally, the silica in this by-product is described as being less pozzolanic. Pozzolanic materials are substances that can react with calcium hydroxide in the presence of water to form cementitious compounds. Silica, particularly in an amorphous form, can exhibit pozzolanic properties, which means it can contribute to the strength and durability of concrete when properly processed.

The American Concrete Institute (ACI) defines silica fume as a very fine, noncrystalline silica material that is produced as a byproduct during the production of elemental silicon or alloys containing silicon. Silica fume is created in electric arc furnaces through a high-temperature process that vaporizes silicon and other impurities in the raw materials. These vapors then cool rapidly and condense into extremely fine particles, which are collected and processed into silica fume. It seems like you're describing a type of powder that is typically gray in color, resembling substances such as Portland cement or fly ash. It can exhibit both pozzolanic and cementitious properties.the schematic diagram of silica fume production.

1.3 Physical properties of silica fume

It is primarily composed of fine particles of amorphous silica, with particle sizes approximately 100 times smaller than those of Portland cement. The properties of silica fume can vary depending on the type of production and the specific manufacturing process employed. Silica fume is commonly available in three forms: powder, condensed, and slurry. The powder form consists of finely divided particles and is the most commonly used form. Condensed silica fume refers to the agglomeration of the powder particles into larger aggregates. Slurry silica fume is a suspension of the powder in water and is typically used for specific applications. The color of silica fume can range from light to dark grey or white. This color variation is attributed to the different manufacturing processes and can be influenced by several parameters. For example, the composition of the raw materials used, such as wood chips in the case of some production methods, can affect the color of the silica fume. The type of furnace used during production can also impact the color of the final product.

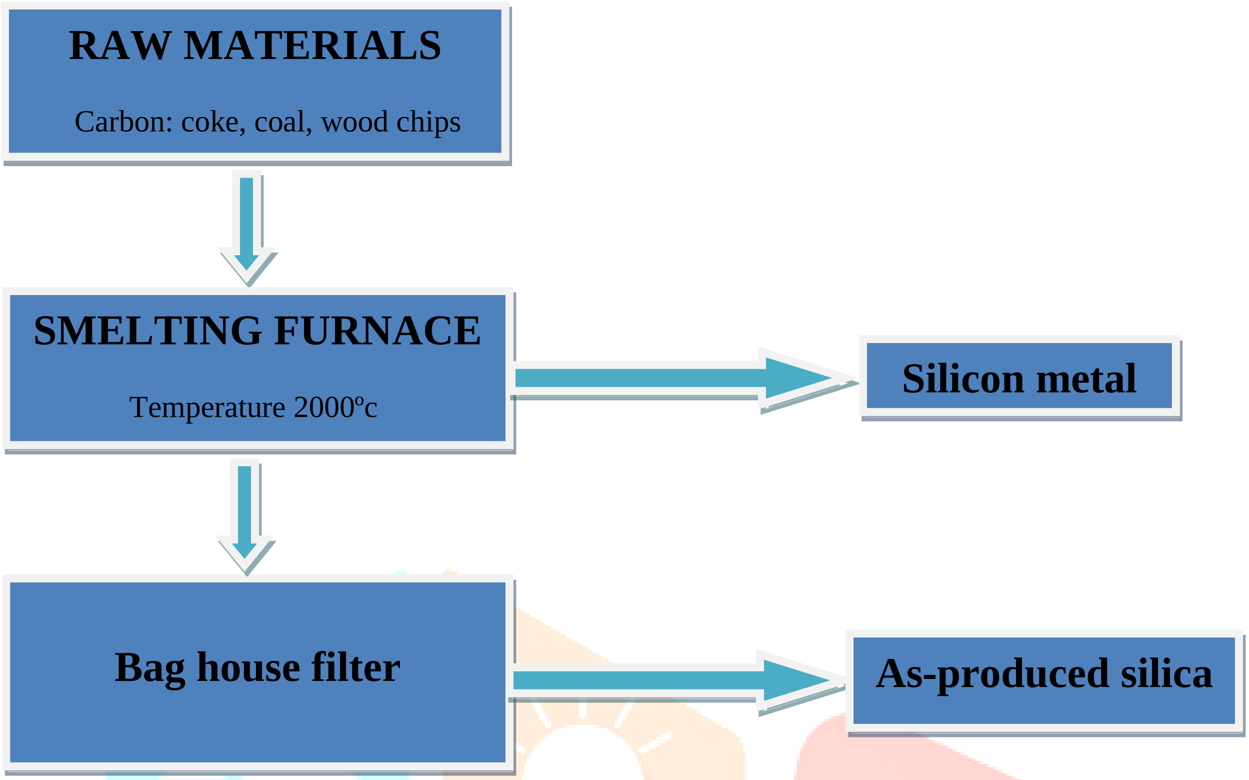

Fig. 1 Schematic diagram of silica fume production (khan and siddique 2011)

1.4 Effect of silica fume on fresh and hardened concrete properties

Fresh properties

- Water demand increases in proportion silica fume.
- Addition of silica fume will lead to lower slump but more cohesive mix.
- There is large reduction in bleeding and concrete with silica fume could be handled and transportation without segregation.
- Concrete containing silica fume can have plastic shrinkage cracking and therefore, sheet or mat curing should be consider .

Hardened properties

- Increase ultimate strength gain.
- Lower permeability of concrete.
- Increase durability of concrete.
- Reduces alkali aggregates resection.
- Reduces steel corrosion.
- Reduce sulphate attack.
- Resistances against frost damage (freeze –thaw cycle).

2. LITERATURE REVIEW

- **Seong Y. Oh, Gwon Lim, Sungmo Nam, Byung- Seon Choi, Taek Soo Kim, Hyunmin Park (2023).** The study you mentioned aimed to examine the impact of silica fume mixed in concrete blocks on laser-induced explosion behavior. The experimental findings suggest that the removal rate of the concrete surface containing silica fume was significantly higher in laser-scabbled SF20 specimens. Moreover, the surface removal degree of specimen SF20 was observed to be deeper and wider compared to other specimens. This suggests that the laser-scabbling process resulted in a more extensive removal of the concrete surface in the SF20 specimen. The deeper and wider removal indicates a more thorough and aggressive removal of the material, potentially leading to a greater overall surface roughness.
- **Alice Lorenzatia, Stefano Fantuccib, Alfonso Capozzolib, Marco Perinob (2016).** Experimental tests, measurements were conducted on two fresh VIPs (Vacuum Insulation Panels) with different thicknesses: 10 mm and 30 mm. The objective was to analyze the thermal performance of these panels under different average temperature conditions. In this stage, three different values of average temperature, denoted as θavg, were considered. The average temperature is the mean temperature between the cold and hot plates of the VIP. It should be noted that the temperature difference between the plates was fixed at 20°C throughout the experiments.
- **Osama zaid, jawad ahmad (2021).** A recent study discovered that incorporating 45% coconut shell aggregate, along with 1.5% glass fiber and 15% silica fume, enhances the compressive strength of concrete by approximately 20% after 28 days of curing. At 45% substitution of coconut shell aggregate with crushed aggregate and 1.5% addition of glass fiber and 15% silica fume, the concrete split tensile strength increases 22% at 28 days. The density of coconut shell concrete enhanced up to the optimum level and also shows from the co-relation between compressive strength and density that CS concrete is a doable option.
- **Ales Frýbort , Jana Stulirova , Miroslava Gregreova , Giri Grosek (2023):** This paper showcases the unexpected alteration of the chemical makeup of silica fume micropellets within a concrete composite system containing pozzolan additives. Over a span of 18 years, the concrete underwent modifications solely through exposure to drinking water in controlled laboratory settings.The study on the microchemistry of two visually distinct silica fume micropellet variants reveals insights into their untapped potential. By examining the raw materials' input potential, characterized by varying levels of Na_2O, K_2O, and SiO_2, valuable information about their performance in concrete can be gleaned. The more porous silica fume type, featuring lower alkali and SiO_2 content, exhibits enhanced capability to sequester calcium hydroxide (CH) and expand the scope of the

pozzolan reaction. Over time, the chemical composition of its internal and external alteration areas gradually merges with the surrounding calcium silicate hydrate (CSH) gel, offering promising possibilities for optimizing concrete performance.

- **Tao Lou, Cheng Hua, Fang Liu, Qiang Sun, Yu YI, Xiaofeng Pan (2022):** A study investigated the preparation of modified concrete with reduced carbon footprint by replacing varying percentages of cement paste with two types of solid waste silica fume. The workability, cubic compressive strength, and splitting-tensile strength of the 28-day cured concrete were measured. The increasing substitution of cement paste with Supplementary Cementitious Materials (SCMs) such as Silica Fume (SF) and High Strength Fly Ash (HSF) led to a consistent decrease in both the slump and air content of fresh concrete. As the replacement percentage of SF and HSF rose from 0% to 10%, the slump of the concrete mixture decreased by 27.0% and 33.6% respectively, indicating reduced workability. Similarly, the air content decreased by 13.7% and 25.5% respectively, implying a decrease in the concrete's ability to entrain air. These findings demonstrate that higher proportions of SF and HSF in concrete mixtures result in reduced slump and air content, which can impact the concrete's overall performance and handling properties. Increasing the substitution amount of SF (Silica Fume) from 0% to 10% resulted in a 26.7% increase in cubic compressive strength and a 40.7% increase in splitting-tensile strength. Increasing the replacement amount of HSF (High-Strength Fly Ash) from 0% to 10% led to a 44.7% increase in cubic compressive strength and a 57.4% increase in splitting-tensile strength.
- **Abdalla M. Saba, Afzal Husain khan, Mohammad Nadeem Akhtar (2021):** The study focused on analyzing the strength and flexural behavior of self-compacting concrete (SCC) incorporating steel fiber and silica fume. It aimed to understand the impact of these additions on the rheology and mechanical properties of SCC. The findings revealed that the inclusion of 20% silica fume as a cement replacement had minimal effects on concrete properties and compressive strength, while ensuring structural durability and environmental friendliness in construction. The results indicated that utilizing silica fume as a cement substitute, along with incorporating steel fiber, resulted in a more economically viable and long-lasting SCC. Overall, this research emphasized the potential benefits of these additives in enhancing the performance and sustainability of SCC, making it a favorable choice for construction projects.
- **Cheng Ding, Kaixi Xue, Hongzhi Cui, Ziqing Xu, Haibin Yang, Xiaohua Bao , Guangsheng Yi (2023) :** This study focuses on the research conducted on the fire resistance of silica fume insulation mortar. A novel type of fireproof insulation mortar, consisting of silica-ash, was developed and analyzed. Through experimental tests, the addition of silica fume was found to enhance the microstructure of the mortar by filling gaps and facilitating a secondary hydration reaction. This resulted in a significant increase in bond strength and compressive strength of the mortar. The thermal conductivity and dry density exhibited an initial increase followed by a decrease as the amount of silica fume was increased up to 10%. Consequently, the optimal dosage of silica fume was determined to be 10%. After incorporating silica fume, the recommended proportioning scheme for the mortar involved the following ratio of materials: cement: aggregate: water: dispersible latex powder: fly ash: diabaserock powder: AOS foaming agent : gelatin: silicafume = 1:1.67:2:0.045:0.15:0.225:0.035:0.02:0.138.These proportions were formulated after the improvement of silica fume.
- **Reni Suryanita, Harnedi Maizir, Rizki Zulapriansyah, Yon Subagiono, Mohd Fadzil Arshad (2022):** The study investigated the impact of incorporating silica fume into foam concrete mortar mixtures to enhance strength. Results indicated that the CLC (Cellular Lightweight Concrete) block specimens without silica fume had a compressive strength of 0.64 MPa. However, when silica fume was substituted at 10% of the cement weight, the strength improved. On the other hand, using silica fume above 20% of the cement weight resulted in a decline in the strength of CLC foam concrete. Consequently, it is strongly recommended to utilize silica fume within the range of 0.5%–0.15% by weight of cement for the production of CLC foam concrete.

- **Gaurav Chand, Abhishek Kumar, Shobha Ram (2022):** This study investigated the compressive and split tensile strength of TRASF (Treated Recycled Aggregate Self-Compacting Concrete) specimens compared to untreated RAC (Recycled Aggregate Concrete) and CM (Control Mix) at 28 days. The compressive strength of TRASF specimens was found to be 50.75% higher than untreated RAC and 10.86% higher than CM. Similarly, the split tensile strength of TRASF specimens was 42.85% higher than untreated RAC and 6.91% higher than CM. TRASF also demonstrated superior resistance to acidic environments, indicating its acid resistance property. The filling of cracks and pores in RAC reduced water absorption and promoted the formation of strength-imparting compounds C-S-H (Calcium Silicate Hydrate). However, the study concluded that the use of metakaolin and pumice powder at the given percentage of cement replacement did not result in significant changes in the final results, limiting their practical application.
- **Shamsad Ahmad, Omar S. Baghabra Al-Amoudi, Saad M.S. Khan, Mohammed Malehuddin (2022):** This study investigated the impact of partially replacing ordinary Portland cement (OPC) with natural pozzolan (NP) and silica fume (SF) on the mechanical properties, shrinkage, and durability of concrete. The concrete mixture with 20% OPC replaced by NP exhibited a lower compressive strength compared to the OPC-only mixture. However, when 5% SF was added to the OPC-NP blend, the compressive strength of the OPC-NP-SF concrete matched that of the plain OPC concrete for up to 28 days of curing. Beyond 28 days, the OPC-NP-SF concrete demonstrated higher compressive strength compared to OPC concrete. Additionally, both OPC-NP and OPC-NP-SF mixtures displayed reduced drying shrinkage compared to OPC concrete, indicating the beneficial effects of NP and SF in controlling shrinkage.
- **Xiaodong Ma, Tingshu He, Yongdong Su, Renhe Yang, Yuhao Sun (2022):** This study explores the impact of adding silica fume to the cement fly ash system. The inclusion of silica fume enhances both the fluidity and strength of the system. As the silica fume (SF) content increases, the mortar's fluidity increases while the water requirement decreases. By incorporating 2.0% silica fume, water consumption can be reduced by 4.5%. Although a small amount of silica fume has minimal effect on early strength, it improves later strength significantly. Among the experimental groups, the specimens with 2.0% silica fume doping exhibit the best performance, with a 15.56% improvement after 28 days. Silica fume decreases water absorption and enhances resistance to external ions entering the interior through aqueous solutions. Based on comprehensive cost calculations and experimental results, replacing a small amount of cement with silica fume can reduce costs by approximately 0.2 RMB/kg, decrease the amount of cement used, lower energy consumption, and enhance fluidity. If the same workability is maintained, water consumption or superplasticizer usage can be reduced.
- **Zhenmin Wan, Tingshu He, Ning chang, Renhe Yang, Heping Qiu (2022):** This study explores the effects of Silica fume (SF) in combination with alkali liquid accelerators and alkali-free liquid accelerators on the rebound rate of shotcrete in construction. The addition of SF has a positive synergistic effect, resulting in a reduced rebound rate. Furthermore, the inclusion of SF (specifically FS) enhances the mechanical properties of shotcrete. However, it should be noted that the addition of FS also leads to a significant increase in both autogenous shrinkage and drying shrinkage of cement mortar. At 180 days of age, the autogenous shrinkage of 9FSAR-4 increased by 29.1% compared to the control group, while the drying shrinkage increased by 33.5%. Similarly, the autogenous shrinkage of 9FSAS-7 increased by 23.1% and the drying shrinkage increased by 33.8% compared to the control group.
- **Ewa Kapeluszna, Lukasz Kotwica, Wieslawa Nocun-Wczelik (2021):** This study aimed to compare the impact of various highly reactive pozzolans on the speed of cement hydration and the physical and chemical properties of pastes and mortars. The analysis demonstrated that the interaction between C3A (tricalcium aluminate) and the pozzolans played a crucial role in the hydration process. Particularly, the surface area of the pozzolans was found to be vital, as it influenced the hydration of aluminates. Surprisingly, even though the silicon fume (SF) contained a minimal amount of alumina (0.6%) compared to the white electrofused

corundum powder (WEP) (12.5%), it had a significant impact on the hydration of aluminates. This indicates that the alumina content in the supplementary cementitious material (SCM) plays a secondary role in the early stages of cement hydration. Highly reactive pozzolans also influenced the rate of heat generation and the position of the aluminate peak, depending on the C3A content in the cement.

- **Zhijie Yang, Dong Kang, De Zhang, Changwang Yan, Ju Zhang (2021):** This paper presents the results of dynamic hydrothermal synthesis experiments conducted to produce calcium silicate minerals. The synthesis involved the use of calcium silicate slag and silica fume at various C/S molar ratios. The synthesized materials were analyzed using techniques such as XRD, SEM, EDS, specific surface area, and pore size distribution to determine the phase species, micromorphology, and micro-pores. Additionally, the authors investigated the reaction mechanism behind the hydrothermal synthesis of calcium silicate slag and silica fume. Overall, the paper provides valuable insights into the synthesis process and the properties of the resulting calcium silicate minerals.
- **Rabee Shamass, Ottavia Rispoli, Vireen Limbachiya, Robert Kovacs (2023):** The purpose of this study was to evaluate the effects of incorporating a ternary cementitious mix and recycled concrete aggregates (RCA) on the mechanical properties of concrete and the structural performance of reinforced beams. Additionally, a life cycle assessment (LCA) was conducted to assess the environmental impact, particularly the global warming potential (GWP). The results indicate that the use of RCA did not significantly affect the compressive strength, tensile strength, and modulus of rupture of the concrete. This can be attributed to the RCA's increased angularity and surface roughness, which facilitate better interlocking between aggregates and enhance the interfacial bond with the cement paste. The thorough LCA provided insights into the overall environmental impact of the incorporation of the ternary cementitious mix and RCA.
- **Farshad farmani, Parissa Khadiv-Parsi, Ali Akbar Ramezanianour, Babak Bonakdarpour, Fatemeh Yazdian (2022):** This study employed two environmentally friendly techniques to improve microbially-induced carbonate precipitation in cement mortar. The first technique involved replacing 20% of cement with silica fume, while the second technique focused on immobilizing bacterial spores within porous scoria aggregates. When the cells were immobilized in scoria of different sizes, they were able to degrade over 50% of urea within 72 hours, which was reasonably close to the degradation achieved by free cells (around 60%). Thermogravimetric analysis (TGA) revealed that approximately 23% of the sediments formed in scoria were composed of calcium carbonate. This finding was further confirmed by X-ray diffraction (XRD) tests, which detected the presence of calcite and vaterite formations.
- **Musa Adamu, Mohammad Louay Marouf, Yasser E. Ibrahim, Omae Shabbir Ahmad, Hani Alanazi, Abdulrahman louay Marouf (2022):** Based on the experimental results and analysis, the addition of DPF (Derived Plastic Fiber) and silica fume in concrete reduced its densities in both fresh and hardened states. This is because the density of silica fume (630 kg/m3) is lower than that of the cement (1440 kg/m3) it replaced. This makes DPF advantageous for lightweight concrete production. However, DPF had a negative impact on compressive and splitting tensile strength, while it improved the flexural strengths of the concrete. Adding 1% DPF slightly enhanced the split tensile strength, and up to 3% DPF significantly improved the flexural strength of the concrete.
- **Bo Wang, Kailon Lu, Chao Han, Qing Wu (2022):** This study investigated the micromorphology and phase composition of two types of coatings: MKPC coating and silicon fume modified MKPC coating. The analysis was conducted using SEM-EDS and XRD tests to examine their properties, as well as to understand the anti-corrosion mechanism. The results indicated that the inclusion of silica fume significantly improved the anti-corrosion ability of the MKPC coating. This finding holds importance for future research on MKPC coating. However, it is necessary to verify these findings through real-world engineering applications. Additionally, it is recommended to conduct detailed studies on the strength of silica fume modified MKPC coating and the adhesion between the steel substrate and coating, both before and after immersion.

- **Huan-Sheng Huang, Hai-Yan Zhang, Yan-Mei Lv, Yao-Jia Chen (2023):** This study presents an optimization design procedure for developing high-strength lightweight geopolymer cold-bonded aggregate (GCBA) through powder agglomeration. The ternary precursor materials used were metakaolin (MK), fly ash (FA), and silica fume (SF), and the procedure was experimentally validated. The research found that the SF content, specifically the Si/Al ratio, was a crucial factor influencing the strength of GCBA. Through experiments, the mechanism of SF's effect on GCBA strength was revealed. When considering the MK-FA binary blend or the MK-FA-SF ternary blend systems of GCBA, the study observed that varying the contents of MK and FA within the range of 25 wt% to 75 wt% did not have a significant impact on GCBA strength, while keeping the SF content constant.
- **Xinyan Wu, Yanghai Shen, Liang Hu (2022):** This study investigated the properties of geopolymer concrete activated by sodium silicate and silica fume activator. It was found that geopolymer concrete excited by silica fume exhibited superior early strength. The compressive strength reached 43.36 MPa at 7 days of curing in a curing box at 200°C, with humidity above 95%. This type of concrete can be suitable for various applications, including road engineering and emergency repair projects. When comparing the sodium silica alkaline activator to the silica fume activator, geopolymer concrete showed similar compressive strength but had fewer surface cracks and inner pores. Overall, these findings suggest the potential benefits of using silica fume as an activator for geopolymer concrete.
- **Promise D. Nukah, Samuel J. Abbey, Colin A. Booth, Ghassan Nounu (2023):** This study introduces a new type of concrete called Lytag-silica fume concrete (LSFC), which has various applications in structural and construction projects. The research aimed to evaluate the development of compressive strength and stress-strain relationships in LSFC lightweight concrete to determine its strength progression and establish a beam design equation. The study involved testing four different mix compositions, ranging from concrete grades 20 to 50, with varying cement dosages. The results indicated that a rectangular parabolic stress block could be derived using representative stress-strain curves. The LSFC achieved an ultimate compressive strain of 2.18‰ after 28 days, while normal weight concrete exhibited 3.5‰. Furthermore, 94.15% of the compressive strength of LSFC was attained within 7 days.
- **Yuanfeng Lou, Kaffayatullah Khan, Mohammad Nasir Amin, Waqas Ahmad, Ahmed Farouk Deifalla, Ayaz Ahmad (2022):** This study aimed to investigate the utilization of silica fume, the most prevalent industrial byproduct, as a supplementary cementitious material (SCM). In addition to a conventional literature review, the study employed a scientometric review technique to statistically analyze different aspects of the existing literature. Scientometric analysis involves processing large amounts of literature data using appropriate software tools. The study objectives encompassed conducting a scientometric analysis of the literature on silica fume in concrete research, evaluating various aspects, and providing a comprehensive review of research on cementitious composites incorporating silica fume.
- **Yanbin Yao, Bojain Wu, Wenziao Zhang, Ying Fu, Xiangqing Kong (2023):** This study investigates the growing issue of solid waste generation due to the ongoing development of the economy and society. The study focuses on three major components of solid waste, namely construction and demolition waste (CDW), used tires, and silica fume. The research specifically examines the combined effects of silica fume and recycled steel fibers (RSF) on the mechanical properties, impact resistance, and microstructure of recycled aggregate concrete (RAC). The goal is to understand the synergistic effects of these materials, potentially leading to improved performance and sustainability of RAC.

3. CONCLUSION

Silica Fume, as a mineral admixture, has demonstrated promising results in enhancing the quality of concrete. Several conclusions can be drawn regarding the properties of both fresh and hardened concrete when Silica Fume is used. These main conclusion are presented as follows:

I. Silica Fume is highly reactive and possesses pozzolanic properties. Due to its high fineness modulus, it contributes to increased cohesiveness in concrete. However, this high fineness modulus also results in a higher water requirement to maintain the desired workability of the concrete. To offset this increased water demand, plasticizers can be added.

II. The workability of concrete incorporating Silica Fume is influenced by various factors, including particle size, specific surface area, particle shape, and replacement level. In general, smaller particle sizes and higher specific surface areas of the mineral admixture lead to an increased demand for water in the concrete mix. As the percentage of Silica Fume increases, the workability of fresh concrete tends to decrease.

III. The compressive strength of concrete improves with an increase in the replacement level of Silica Fume up to a certain range, typically between 8% and 12%. Beyond this range, no significant change in compressive strength can be expected, and instead, a decreasing trend may be observed. Additionally, the compressive strength of the concrete decreases with higher water-to-cement (w/c) ratios and increasing levels of Silica Fume replacement.

IV. The split tensile strength of concrete generally increases up to a certain replacement level of Silica Fume, typically between 10% and 15%. However, similar to compressive strength, the split tensile strength decreases with higher w/c ratios and increasing levels of Silica Fume replacement. A similar trend is observed in the flexural strength of concrete within the replacement range of 10% to 15%.

V. Concrete blended with Silica Fume exhibits improved durability parameters compared to normal Ordinary Portland Cement (OPC) concrete. Durability aspects such as water absorption, permeability, resistance to sulphate attack, and chloride penetration resistance are typically higher in Silica Fume blended concrete. These properties contribute to enhanced durability and long-term performance of the concrete.

In summary, the use of Silica Fume as a mineral admixture in concrete offers several benefits, including increased cohesiveness, improved compressive and split tensile strength (up to a certain replacement level), and enhanced durability. However, it is important to consider factors such as water demand, w/c ratio, and the percentage of Silica Fume replacement to ensure optimal results and maintain the desired properties of the concrete.

4. ACKNOWLEDGMENT

I would like to express my heartfelt gratitude to the individuals who have played a significant role in the success of my work, without mentioning their names. Their continual direction and support have been instrumental in crowning my endeavor with success, filling me with happiness and exhilaration upon its completion. First and foremost, I am immensely grateful to my dissertation advisor, who is a Professor in the Department of Civil Engineering at Integral University in Lucknow. Their guidance and invaluable advice throughout the entire process, as well as at key points, have been indispensable. Their expertise and support have shaped my work and contributed to its achievement.

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