A Review on Study of Silica Fume Nano Silica As Partial Replacement of Cement in Glass Fiber Concrete

Pradeep Kumar Chaturvedi[1], Kamlesh kumar chuodhary[2]
[1, 2] Dept of civil engineering
[1, 2] Saraswati Institute of Engineering & Technology, Jabalpur, India

Abstract- *In the recent past, there have been numerous attempts to enhance the strength and durability of concrete, particularly in hostile environments. Glass Fibe, It would seem that high performance concrete would be a better option for a sturdy and long-lasting building. Industries produce a lot of wastes and byproducts, such as fly ash, copper slag, silica fume, etc., which, when dumped or otherwise disposed of, can have negative effects on the environment and human health. Concrete's mechanical and durability properties are enhanced when silica fume and nano-silica are properly incorporated into the mix. This essay presents a review of the literature on using nano-silica and silica fume to replace cement, along with information on current and upcoming research directions.*

Keywords- Glass Fiber, Silica Fume, Nano-Silica Cements Sand and Crushed Stone

I. INTRODUCTION

Environmental problems may result from directly releasing waste materials into the environment. As a result, recycling industrial waste has received attention. Waste can be used to create new products or as an ingredient in other products to protect the environment from waste while maximising the use of natural resources. These industrial wastes are dumped nearby, spoiling the soil's natural fertility.

There are many ways to use fiber-reinforced concrete in structural components. Some fibres, such as those made of glass, carbon, polypropylene, and aramid, improve the abundance of qualities like hardness, durability, stiffness, toughness, and shrinkage. The goal of this study is to examine the characteristics of glass fibre reinforced high-performance concrete (GFRHC), which is used to prepare high-performance trail mixes that range in silica fume content from 0% to 25%. The best mixture is chosen, and nano-silica is used to replicate the constant cement content of 1.15%. Glass fibres are added to that optimised mixture at levels of 1%, 2%, 3%, and 4% by weight of cement along with nano-silica. Cube moulds measuring 100x100x100 mm, cylinder moulds measuring 100x200 mm, and beam moulds measuring 100x100x500 mm are made, cured for seven to twenty days, and then their hardened strength is assessed.

H.Mohammed et.al (2020) [2], A lower w/b resulted in better mechanical execution, according to an analysis of fourteen blends, UHPFRC's mechanical characteristics, and pliability. Additionally, the blends with 1.5 to 3 percent MGF showed the highest compressive strength, reaching up to 160 MPa. Additionally, it was evident from the data that any additional strength improvement above 1.5 percent MGF was impractical. Pei Ya et al., 2021 [3]. It was discovered that the characteristics of both freshly-poured and hardened UHPC-FM concrete were influenced by the type and quantity of additional fibres. Expanded fibre focus caused a slowdown in the development of new UHPC-FM blends, with glues containing PPF displaying the highest degree of smoothness.

Compressive strength (CS) was also improved with an increase of 0.5 percent, and it directly decreased with an increase of greater amounts. Compared to the control example, the flexural strength of tests containing 2.5 percent BF, PPF, and GF increased by 20.8 percent, 26.9 percent, and 27.9 percent, respectively (UHPC-A0) Flexural strength was increased by 25.8% for PPF samples and by 27.9% for composites with 25.8% glass fibres (GF). In comparison to the reference sample, there was an increase of 20.04 percent in BF, 24.92 percent in PPF, and 26.05 percent in GF (8429.5-kN). It was demonstrated that BF/PPF/and GF UHPC-FM samples were tougher than control specimens on average by 4,64, 4,75, and 4,86 times.

II. LITERATURE REVIEW

kumar, Pidugu Prasanna ; Chaitanya, Bypaneni Krishna (2022)

The purpose of this research is to investigate the properties of glass fiber reinforced high-performance concrete

(GFRHC) for arriving high-performance trail mixes are prepared with cement replacement with silica fume (SF) ranging from 0% to 25%. An optimum mix is chosen in that constant 1.15 % cement is replicate with nano-silica. For that optimized mix along with nano-silica, glass fibers are induced at 1%, 2%, 3%, and 4% by weight of cement. 100×100×100mm cube moulds, cylinder moulds of 100×200mm, and beam moulds of 100×100×500 mm are prepared and cured for 7, 28 days then hardened strength are evaluated. The result shows that at 10% replacement of cement with silica fume at constant w/b ratio 0.31 shown 59.06 Mpa for Mix-3 and at 2% addition of glass fibers shows the 69.4Mpa, 9.57 Mpa, and 7.91 Mpa of compressive strength, split tensile strength, and modulus of rupture for Mix-8. The quality of concrete of all the mixes are is excellent at 2% addition of glass fiber UPV value is 5281m/s.

Panel Sachin Patila , H Sudarsana Rao,Vaishali. G. Ghorpade (2022)

In this study, an additional cementitious material is made up of the mixture of MK and SF. The mechanical properties of Binary Fiber and Admixture based High-Performance Concrete (BFAHPC), which incorporates glass and polypropylene fibres as an inclusion, were intended to be studied. With an aggregate to binder content (A/B) of 1.75, water to binder ratios (W/B) ranging from 0.275 to 0.350 were used. The proportions of MK and SF that were replaced ranged from 0% to 15%. PPF was only used at 0.25 percent, and GF was added in volume proportions ranging from 0% to 1%. The overall effect of replacing cement with MK and SF at 5% each, with fibre dosages of GF = 1% and PPF = 0.25% for W/B of 0.275, was shown.

Osama Zaid, Jawad Ahmad, Muhammad Shahid Siddique, Fahid Aslam, Hisham Alabduljabbar & Khaled Mohamed Khedher (2021)

The current study aims to determine the effects of adding glass fibre to sustainably produced concrete that uses silica fume as a partial replacement for cement and coconut shell added in a variety of ratios to replace coarse aggregate on mechanical and durability aspects. Different mixtures were created using coconut shell in place of coarse aggregates in varying ratios. In all concrete blends, Portland cement was replaced with silica fume at levels of 5%, 10%, 15%, and 20% by cement weight. Glass fibre volume ratios used in this study were 0.5%, 1.0%, 1.5%, and 2.0%. Glass fibres partially increase concrete density before slightly decreasing the density of coconut shell concrete. Compressive and flexural strength both increase as the percentage of glass fibres

Sachin Patil, Dr.H.M. Somasekharaiah, Dr. H. Sudarsana Rao, Dr.Vaishali G.Ghorpade (2021)

It was suggested to look into the mechanical properties of Composite-Fiber Reinforced High-Performance Concrete (CFRHPC), which is made with the addition of glass and polypropylene fibres. With an aggregate to binder ratio (A/B) of 1.75, the water to binder ratios (W/B) of 0.275, 0.300, 0.325, and 0.350 were chosen. GF was added in volume percentages ranging from 0% to 1%, FA and SF were replaced in the range of 0% to 15% each, and PPF was maintained at 0.25%. For maximum strength properties for CFRHPC, it was discovered that the combined effect of FA and SF at 5% each as replacement for cement and composite fibre dosage of GF=1% and PPF=0.25% for W/B of 0.275 was the best option.

Sachin Patil, Somasekharaiah h m ,Sudarsana Rao H & Vaishali G.Ghorpade (2021)

Glass fibers (GF) and Polypropylene fibers (PPF) are used as an addition to produce Composite-Fiber Reinforced High-Performance Concrete (CFRHPC), and it was proposed to investigate its mechanical properties. The water to binder ratios (W/B) of 0.275, 0.300, 0.325, and 0.350, with an aggregate to binder ratio (A/B) of 1.75, were adopted. FA and SF were replaced in the range from 0% to 15% each, GF were added in volume percentages from 0% to 1%, and PPF were kept constant at 0.25%. The combined effect of FA and SF at 5% each as replacement of cement and composite fiber dosage of GF=1% and PPF=0.25% for W/B of 0.275 was found to be an optimum combination to obtain maximum strength properties for CFRHPC. A relationship in the form of mathematical models between cube compressive strength with cylindrical compressive strength, split tensile strength, and flexural strength of FA and SF based CFRHPC was also derived from this investigation's experimental results.

C M Kansal, S Single and R Garg (2020)

This study presents strength behaviour of concrete based composites including three different ternary binders namely Nano-Silica (NS), Silica Fume (SF) & Steel Slag (SS). NS as fragmental substitution of cement, SF as the fragmental substitution for the fine aggregates and SS as fragmental substitution of coarse aggregates has been used. The study has been conducted at an optimized content of NS (2%) and by varying the content of SF (10-15%) and SS (10-30%). Cement concrete having M60 grade strength at fixed W/C (0.35) has been explored for the strength behaviour. The studies have revealed that the optimized content of NS, SF and SS can be used as a partial substitute of cement, fine aggregates and coarse aggregates respectively to obtain increased strength.

Mayank Mishra, K.G.Kirar & Chetan Sharma (2018)

This experimental investigation is carried out to study the different strength characteristics of concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) and addition of steel fiber. In this investigation M30 grade of concrete is replaced with ground granulated blast furnace slag (15%, 25%, 35%, and 45%) by weight and addition of steel fiber having dimensions (0.45 x 25mm) in different percentage (1%, 1.5%, 2%, and 2.5%).Strength of concrete was determined by performing compressive strength test on (150mmx150mmx150mm) size cubes and split tensile strength test on (300mmx150mm) size cylinder. Finally, the strength performance of slag blended fiber reinforced concrete is compared with the performance of conventional concrete.

Pidugu Prasanna kumar, Bypaneni Krishna Chaitanya (2018)

Fiber-reinforced concrete has various applications in structural components. Some of the fibers like glass, carbon, polypropylene, and aramid fibers give an improvement in generous properties like hardened, durability, stiffness, toughness, shrinkage. The purpose of this research is to investigate the properties of glass fiber reinforced highperformance concrete (GFRHC) for arriving high-performance trail mixes are prepared with cement replacement with silica fume (SF) ranging from 0% to 25%. An optimum mix is chosen in that constant 1.15 % cement is replicate with nano-silica. For that optimized mix along with nano-silica, glass fibers are induced at 1%, 2%, 3%, and 4% by weight of cement. 100x100x100mm cube moulds, cylinder moulds of 100x200mm, and beam moulds of 100x100x500 mm are prepared and cured for 7, 28 days then hardened strength are evaluated. The result shows that at 10% replacement of cement with silica fume at constant w/b ratio 0.31 shown 59.06 Mpa for Mix-3 and at 2% addition of glass fibers shows the 69.4Mpa, 9.57 Mpa, and 7.91 Mpa of compressive strength, split tensile strength, and modulus of rupture for Mix-8. The quality of concrete of all the mixes are is excellent at 2% addition of glass fiber UPV value is 5281m/s.

Cyril Cyriac (2016)

Self curing and internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture cement products. Addition of steel fiber has a significant role in increasing the tensile and compressive strength of concrete.

III. MATERIALS

Glass Fibers

Glass fiber is commercially available in different grade, made from silica sand. The different types of glass fibers are electrical (E-glass), high- strength (S-glass), and alkali-resistance (AR-glass). E-glass has high electrical protecting properties, low vulnerability to dampness or moisture, and high mechanical properties. S-glass has higher tensile strength and modulus, in any case, its higher cost make it less best than E-glass. AR-glass is exceedingly impervious resistant to alkali attack in cement- based matrices, however at the development, estimating perfect with thermoses resin that are normally used to cultured FRP bars are not accessible. Composites produced using glass fiber show great electrical and thermal insulation properties.

Fig no.1 Glass Fiber

Silica Fume

It has also been called silica fume, micro silica, amorphous silica and other similar names. These metals are used in many industrial applications to include aluminum and steel production, computer chip fabrication, and production of silicones which are widely used in lubricants and sealants. While these are very valuable material , the by-product silica fume is of more importance to the concrete industry.

In general they have SiO_2 contents ranging from 85-96%. Silica fume is an ultrafine airborne Silica fume has specific surface area about 20,000 m/kg as against 230 to 300 m/kg. Its unit weight usually varies 130 to 430 kg/m. In order to measure the specific area of silica fume a specialized test called the “BET METHOD” .Silica fume has become one of the necessary ingredients for making high strength and high performance concrete. In India, silica fume has been used very rarely. Nuclear power corporation was one of the first to use silica fume concrete in their KAIGA,KOTA nuclear power projects.

Fig no. 2 Silica fume

Table no 1—Chemical composition and color of cementitious materials

Chemicals	Cement	Silica fume
SiO_2	21.0%	92.9%
Al_2O_3	5.2%	0.69%
Fe_2O_3	2.3%	1.25%
MgO	3.9%	1.73%
CaO	63.9%	0.4%
Na_2O	0.5%*	0.43%
K_2O		1.19%
SO_3	2.4%	—
LOI	—	1.18%
Color	Gray	Dark gray

Nano-Silica

Nano-Silica, also called quartz dust or silica dust, is a material that, like SF, is characterized by its high SiO2 percentage, over 99%. The use of nano-silica (crystalline SiO2) reduces the volume of cement and completes the grading curve of the aggregate mix in the zone of the smallest sizes. Its purpose is to produce a filler effect, that is, to fill in gaps and, consequently, increase the compactness of the concrete. For this reason, when nano-silica is used in the manufacturing of UHPC, there is a higher demand for water or SPs and a delay in the setting process. Research into the differences between nano-silica and SF when added to the cement paste shows that the pozzolanic activity of nano-silica is higher than that of SF, which makes the cement paste thicker and accelerates the hydration process .In addition, greater bond strength between the cement paste and the aggregates is achieved. However, like cement and SF, nano-silica has a high cost and significant carbon footprint. It can also cause serious health problems such as silicosis.

Fig no.3 Nano-Silica

IV. PROPOSED METHODOLOGY

Mixing Procedure

Mixing of ingredients is done in pan mixer of capacity 41 liters. The cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform colour and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by slump cone test. There are 3 types of mixing methods

a) Normal mixing method
b) Double mixing method
c) Triple mixing method

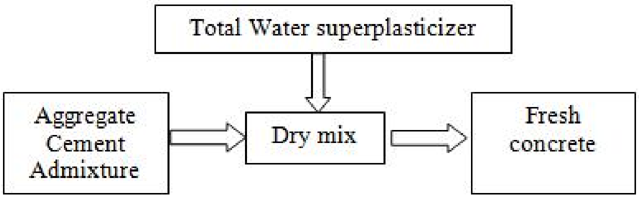

Figure 4: Mixing Methods

V. CONCLUSIONS

The following conclusions are made from the study:

1. Using recycled aggregates and fly ash, the target mean strength of M30 grade concrete can be achieved without lowering the water-cement ratio.
2. The strength of concrete decreases as the percentage of recycled aggregate increases. This may be due to the loose mortar surrounding the recycled aggregate, which prevents the cement paste and aggregate from properly bonding.
3. 30 MPa is typically used for a variety of structural applications At 28 days,

4. The target mean strength for M30 grade concrete was attained when silica fume and nano silica with Glass fibers were substituted for natural aggregate.

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