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FLEXURAL BEHAVIOR OF SELF-COMPACTING REINFORCED CONCRETE BEAMS INCORPORATING STEEL FIBERS AND NANO-GLASS POWDER

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Master's Thesis

Supervisor

Prof.Dr. Zeki HASGUR

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The thesis titled FLEXURAL BEHAVIOR OF SELF-COMPACTING REINFORCED CONCRETE BEAMS INCORPORATING STEEL FIBERS AND NANO-GLASS POWDER prepared by FIRAS MOHAMMED ABED and submitted on 00/00/2023 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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I hereby declare that this thesis meets all format and submission requirements for a Master's thesis.

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I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

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Signature

ABSTRACT

FLEXURAL BEHAVIOR OF SELF-COMPACTING REINFORCED CONCRETE BEAMS INCORPORATING STEEL FIBERS AND NANO-GLASS POWDER

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This study examined the impact of nano-glass powder and two SFRC distributions on self-compact concrete beams. it is found that adding 5% nano-glass powder has higher compressive strength than coarser materials due to its fineness. also, 7.5% replacement fracture strengths reached 3.51 MPa. This method reduces waste and maximizes concrete recycling, according to the results. in addition, the bending test includes tensile and compressive forces, flexural strength is usually higher than tensile strength. These two forces boost fiber flexural strength. At 26 kN, or 40% of the final failure load, the flexural zone fractured initially. Concrete lasts longer when steel fiber is added between 0 and 1%. Natural and manmade fibers reinforce concrete. A slight variation in load-deflection behavior, which was linear up to the yield point where it was measured. The load-deflection curve entered the plastic zone well after the reinforcement yielded, remaining practically horizontal until the ultimate/failure load.

Keywords: Nano-Glass Powder, Compressive Strength, Splitting Strength, Flexural Strength, SFRC.

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ABBREVIATIONS

RC	:	Reinforced Concrete
ACI	:	American Concrete Institute
ASTM	:	American Society for Testing and Materials
BS	:	British standards code
A	:	Area
d	:	Effective depth
δ	:	Displacement
δ_1	:	Displacement at the center
Py	:	Yield load
P_u	:	Ultimate load
P_{flex}	:	Flexural capacity
ρ	:	Reinforcement ratio

1. INTRODUCTION

The objective of material selection in civil engineering is to maximize the performance of the resulting construction by utilizing the material's specific properties. Nothing compares to the strength and durability of reinforced concrete for construction projects (RC). In contemporary structural engineering applications, the properties of a building material, such as its accessibility, structural strength, ductility, durability, and workability, are highly valued. Regardless of the fact that the RC is grossly underweight. One of the greatest benefits of reinforcement materials is their exceptional resistance to tensile strength, which appears to compensate for one of concrete's deficiencies: a lack of tensile weakness in tension-resistant stress. The tension stress resistance of the reinforcement significantly exceeds the concrete's compression stress resistance. Due to their cooperation, the two resources will work as a single entity to counteract any external influences. The star bond results from the intrinsic adhesion between reinforcements and concrete, the typical roughness of reinforcement bars, and the closely spaced rib-shaped deformations rolled onto the outside perimeter of the bars. This is a crucial point to keep in mind in regards to reinforcing steel bars. Corrosion on the reinforcements' exterior surfaces is prevented since the surrounding concrete shields them from external forces. Finally, a clever blend of concrete

1.1 REINFORCED CONCRETE BEAM

Reinforced concrete beams have been increasingly popular in recent years for use in the building of nonmilitary constructions all around the world. There are still issues to be resolved, despite the fact that concrete is widely used in building around the world. Concrete's weight and the fragility of concrete parts are two of the biggest obstacles. In engineering, the reinforced concrete beam is used frequently for several purposes. If these problems with concrete can be resolved, it might be used and performed much better. Beam specimens fail bending tests on a servo-controlled compression-cum-flexural testing system, as shown in figure 1.1.[3].

Figure 1.1: Experimental Setup[4].

The use of fibers also reduces the possibility of shrinkage cracking. The phrase "Fiber Reinforced Concrete" (FRC) indicates a brand-new category of building material in terms of mechanical strength, stiffness, and lifespan. In many different fields[5][6]. Flexural strength specifications have been produced in compliance with ASTM C78 Standards. Since steel fibers were properly strong and suitably connected to the material, the flexural strength of the SFRC increased with increased Vf of steel fibers (0.25% to 1%), from (13.95% to 34.88%). It's also a method of communication [7].

1.2 BEAM FLEXURAL BEHAVIOR

There are three distinct phases in the deformation behavior of a concrete beam under flexural load. The maximum tensile strength of the concrete has been reached. Eventually, the deflection will gain sufficient speed to exceed the load, and the linear behavior will cease. The reinforcement subsequently absorbs the tension forces applied to the beam. After a certain load is attained, the load-deformation curve begins to flatten and deformation accelerates rapidly. As seen in figure[8], as the internal lever arm diminishes, the cracks expand and the concrete on top of the beam is crushed.

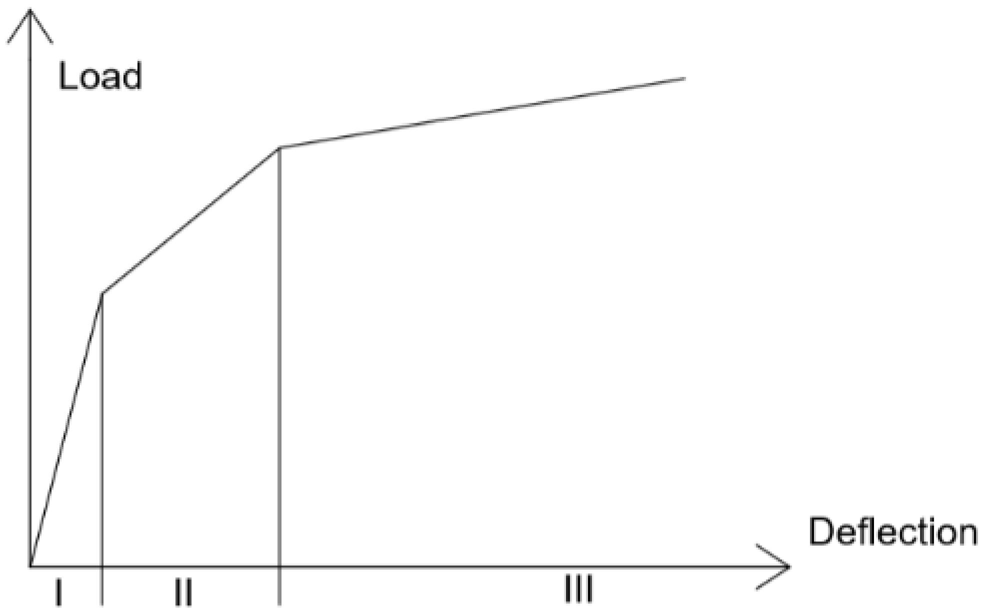

Figure 1.2: The Beam Flexural Behavior[8].

In the process of designing reinforced concrete, a number of presumptions are made. Two materials, each with its own set of characteristics, necessitate a design procedure unique from that used for homogeneous materials. The following are the presumptions made by the theory behind the flexural design of steel-reinforced rectangular cross sections:

a. Planar cross sections remain planar

b. The stress strain curves for concrete and steel are known

c. The tensile strength for concrete may be neglected

1.3 NANO-GLASS POWDER

Nanoscale materials have at least one significant dimension smaller than 100 nm and possess exceptional optical, magnetic, or electrical properties. As with ultrafine particulate pollution, nanoscale particles can be found nearly everywhere. Nanotechnology has functioned as both a theoretical foundation and a practical tool since its creation. It is a small representation of humanity's ceaseless pursuit of cosmological comprehension. We have previously proven that nanotechnology has far-reaching implications on the construction industry. With the same chemical composition, the qualities of nanoparticle-sized materials can be much superior to those of normal grain-sized materials. The unique physical and chemical features of nanomaterials may open the way for the creation of innovative, more effective materials[9]. Compared to larger particles, nanoparticles are capable of inconceivable feats. The discovery of nanoscale materials science has provided civil engineers with a new viewpoint on the characteristics, durability, cost savings, and energy efficiency of classic building materials such as cementitious materials and steel. Due to the size difference between nanoparticles and bulk materials, nanoparticles exhibit unique characteristics[10]. They reveal the relationship between atomic and macroscopic structures. When the atomic surface area of a substance grows at the nanoscale, unexpected and intriguing features arise. Nanoparticles (often SiO2, TiO2, etc.) function not only as filler but also as the crystal nucleus of the calcium silicate hydrate (C-S-H) gel, owing to the network of chemical connections they form with cement hydration products. Cement paste is compacted by compressing it between closely spaced cement grains. The entire system will transform into a dense network structure centered on nanoparticles, hence improving the microstructure of cement-based goods. Due to the high cost and complexity of producing these nanoparticles, their broad usage in cement-based composites is impractical. For the construction sector to advance in the future, alternatives to conventional nanomaterials that offer comparable or superior performance at a reasonable price and with a simple production method are required. In consequence, it reduces the cement content of concrete and is typically regarded as a more eco-friendly building material. Consequently, in the current thesis, this chemical will be utilized as a concrete additive to improve the properties of concrete[11][12].

1.4 SELF COMPACT CONCRETE

Self-compacting concrete (SCC) is a significant advancement for the concrete industry. Its introduction heralded a sea change in concrete engineering. Due to the fact that it contains highly attractive properties both when soft and when hard, it has achieved widespread distribution. This type of concrete is exceptionally user-friendly since it flows well through highly reinforced or geometrically complex structural features, fills voids without segregation or excessive bleeding, and dries rapidly. The widespread application of SCC in a range of industries is a result of its cutting-edge characteristics. Because of their "self-compaction," these cementitious compositions (concrete and mortars) can be employed with short steel fibers or scrap rubber particles. In addition, they ensure a strong connection to the embedded reinforcement, be it conventional steel bars and stirrups, fiber-reinforced polymers (FRP), or textile-reinforced mortars (TRM). SCC is the optimal material for mending concrete due to its exceptional workability, filling, and passing capacities. Recently, it has been utilized in jacketing applications, particularly for mending and/or reinforcing preexisting or broken RC elements. The majority of experimental research on the use of SCC jackets with steel reinforcement as a rehabilitation treatment was undertaken by the authors of this publication; nevertheless, this research is preliminary and exploratory in character. For self-compacting concrete beams without longitudinal reinforcing or stirrups, the cracking torque and ultimate torque are equivalent. In addition, when high strength self-compacting concrete is employed, the cracking and maximum torques of the tested beams are substantially magnified. Experiments determined that the ultimate torque of hollow self-compacting concrete beams with longitudinal reinforcement and stirrups was somewhat larger or less than that of solid self-compacting concrete beams with normal strength. Cracking and maximum torques are equal for solid and hollow normal strength self-compacting concrete beams in the absence of longitudinal reinforcing or stirrups [4].

1.5 STEEL FIBER REINFORCED CONCRETE

Concrete or mortar with an irregular dispersion of short fibers is what makes up fiber-reinforced concrete. When short fibers are added to textile-reinforced concrete, the resulting material is stronger and exhibits a more desirable crack pattern, with more many, smaller cracks rather than a single, bigger one. Steel and glass are two illustrative instances of the materials that can be employed in the fabrication of fibers. Fiber-reinforced concrete, despite its greater homogeneity compared to steel-reinforced concrete, consists of two separate components with distinct properties. Consequently, it is classified as a homogeneous composite material [8]. Fiber Reinforced Concrete (FRC) is produced by incorporating fiber reinforcements into the concrete mixture. The utilization of these components enhances the structural integrity of the building. Fiber reinforced concrete (FRC) is a composite material comprising discrete fibers that are randomly oriented and evenly dispersed within the matrix. The composition of steel fiber reinforced concrete (SFRC) involves the combination of hydraulic cement and steel fiber. The fine and coarse sediments are admixed with discernible steel fibers. The tensile strength of concrete is typically increased by using SFRC in building projects. Steel fiber is also used to prevent the micro holes and cracks that might come from using inferior materials. These additives, which are based on the transfer of tensile stresses through steel fibers, reduce the stress at the crack tips, slowing the spread of cracks and increasing the concrete's strength following the onset of cracks. Including fibers in concrete makes it last longer. Fibers, as shown in Figure 1.3, can be added to a concrete test specimen to give the material new and interesting properties.

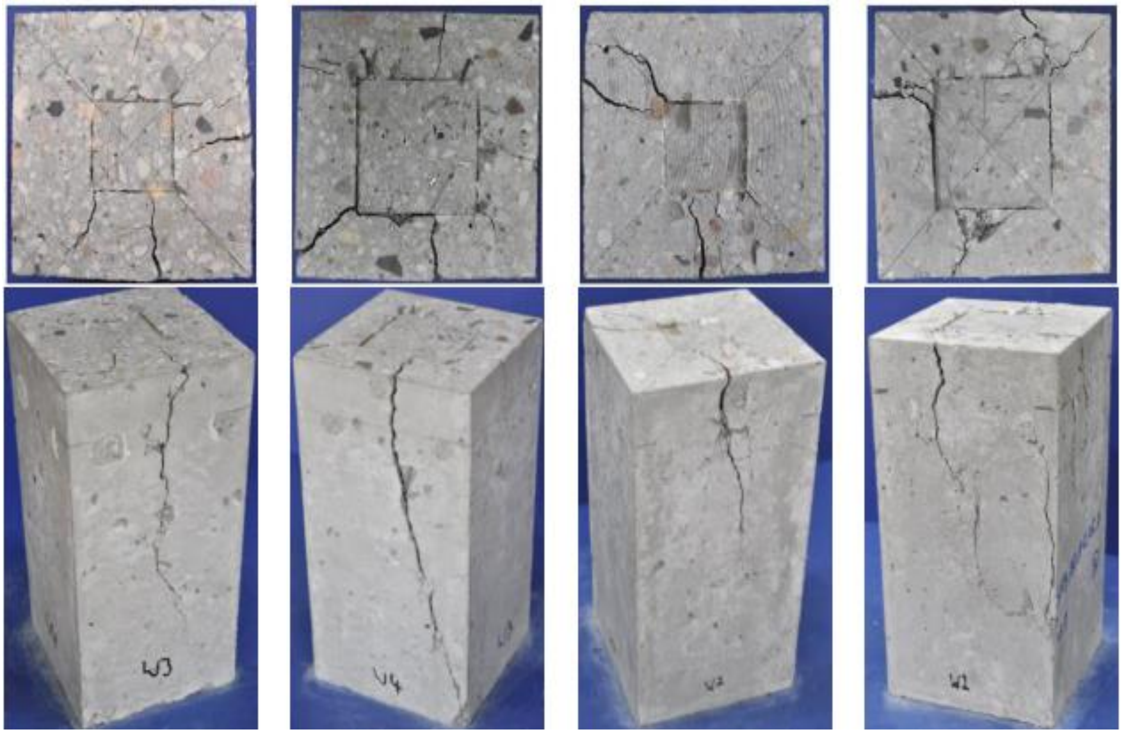

Figure 1.3: Test Sample with Different SFRC Percentage [2].

The mechanism of failure of concrete is governed by a number of elements, including the concrete's size, the loading speed (which causes rebar to slide out of the concrete or steel to break when it reaches its maximum strength), and the concrete's strength. It is possible to increase the strength of concrete by reinforcing it with fibers. [13]

SFRC, as a structural material, exhibits notable attributes such as elevated residual tensile strength within the post-cracking region and enhanced capacity for strain energy absorption. These properties arise from the presence of fibers that engage in bridging activities at the surface of cracks. SFRC, also known as Steel Fiber Reinforced Concrete, is commonly employed in various construction applications, including but not limited to flooring, housing, precast structures, bridges, tunneling, heavy-duty pavement, and mining. This material is favored due to its exceptional durability, enhanced strength, increased tensile strength, and improved resistance to stress. A plethora of studies pertaining to the mechanical properties of steel fiber reinforced concrete (SFRC) have been published in recent years. Previous studies[14] demonstrates that SFRC has much superior characteristics to conventional concrete. Incorporating SFRC into composite steel-concrete beams that will be subjected to a negative bending moment may therefore be an efficient method for enhancing the mechanical performance of the beams. Small enough to be evenly distributed throughout the uncured concrete after mixing, reinforcing steel fiber has an aspect ratio (ratio of length to diameter) between 20 and 100 and a variety of cross sections. Due to their resilience and lifespan, steel concrete fibers are well-suited for usage in demanding industrial settings, where they may enhance the control of concrete cracking. They were developed to improve the quality of hardened concrete and shotcrete. Regularly, industrial concrete beam systems must bear point loads from rack legs and dynamic loads from automobile traffic as instances of severe stresses. By equally scattering steel fibers throughout the concrete, the material is changed into a more ductile composite, hence boosting the beam's durability, strength, and ability to absorb energy over time. The use of metal as a reinforcing material[15]. Three-paddle mixer with diagonal rotation. The components had to be blended in order to get a uniform mixture, so they did just that. First, softly poured water is followed by the fibers. The incorporation of fibers makes the material more specific

Figure 1.4: Steel Fiber.

1.6 PROBLEM STATEMENT

Self-compacting concrete (SCC) has many advantages over traditional concrete in production and installation, such as not requiring external or internal vibration for compaction, being easier to work with, pumping more efficiently, and better bonding with densely packed reinforcing. In addition, fewer people are needed to get an SCC system up and running. SCC may significantly surpass conventional concrete in terms of surface quality, mechanical performance, and longevity. Strict quality control procedures must be in place during the production and installation of SCC. Because SCC is far more fluid than conventional concrete, pumping is the most efficient application method. Examining the effect of integrating nano-glass powder with various steel fibers on the performance of self-compacting concrete (SCC) beams is deemed crucial given the relevance of this concert improvement in structures. This study focuses mostly on beams because they are the structural element that carries the majority of a building's horizontal and vertical loads. Due to the paucity of data on concrete beams, increasing the tensile softening behavior associated with shear failure that accompanies the flexure effect remains a serious concern. The difficulties of this field has encouraged researchers to investigate it, but no solid principles or standards have yet been produced for use in concerted bam design.

1.7 OBJECTIVES AND SCOPES

The impact on the performance of self-compacting concrete (SCC) and its application in concrete beam was deemed a vital goal for this study. In order to attain this purpose, several reinforcements are studied while flowing:

a. investigate the mechanical properties of self-compacting concrete (SCC) with the addition of SFRC.

b. investigate the mechanical properties of self-compacting concrete (SCC) with the addition of Nano-Glass Powder material.

c. combine SFRC and Nano-Glass Powder material to achieve the SCC beam specification.

1.8 AIM AND IMPORTANCE OF STUDY

The fundamental goal of this research is to examine the two-point stress effects of nano-glass powder and different kinds of steel fiber in self-compacting concrete (SCC). The primary purpose of this study was to gain insight into the mechanical and structural characteristics of fiber-reinforced concrete. The focus here was on providing a description of fiber-reinforced concrete's structural properties that would hold up well in a broad range of Nano-glass environments.

1.9 THESIS ORGANIZATION

This thesis has five chapters. Chapter one includes an introduction to the SCC concrete specifications, beam characteristics and the specification of additives including Nano-glass and SFRC. This observed the problem statement, objectives and the aim of study

chapter two presents a general view of fibers' effects ad Nano-glass on concrete behavior in different studies collected from various researches.

The experimental program, including the studied parameters, the work methodology, and the testing of SFRC concrete specimens and Nano-glass concrete specimens are presented in Chapter three.

Chapter four discusses the result and the calculation of the work. Chapter five is the conclusion

2. LITERATURE REVIEW

2.1 GENERAL

The current chapter provides a synopsis of the study's overarching goals. In addition, it provides an evaluation of the work done thus far and a discussion of future directions. This also incorporates the properties of steel fiber and nano glass powder, both of which are critical to today's ecologically conscious construction methods. Due to the increasing dangers posed by global warming and climatic fluctuations that have an adverse effect on natural resources, "green building" has become a hot topic of discussion among architects and urban planners in recent years. It is for these reasons that we find green architecture to be such a prevalent topic of discussion as we peruse the relevant literature.

Japan was also responsible for the invention of self-compacting concrete (SCC) in the 1980s. This new concrete doesn't require any more energy to compact completely. There are monetary, social, and ecological gains to be made by using SCC instead of regular concrete. High concentrations of superplasticizer admixtures and, on occasion, a viscosity modifying admixture are added to standard concrete ingredients to create SCC, which is then characterized by its exceptional workability. Compared to more conventional concretes, SCC places a greater emphasis on the ratio of fine to coarse aggregates and the cement (powder) content. Fly ash, silica fume, slag, metakaolin, and marble powder are just some examples of fine fillers that can be used alongside cement to up the paste percentage. In contrast, the actual application that is relevant to the present investigation is nano glass powder's additional replacement of cement content. The results of this study can help fortify the existing framework. This is an international issue, as studies with striking similarities have been conducted in both developed and less developed countries. Despite this, conducting study with extra construction materials is crucial for the future endeavors of that country, but it hasn't been given much thought so far. This article discusses a wide range of subjects, including the nature of "self-compacting concrete," the eco-friendly materials that can be used in "green building," and the ways in which the concepts of reinforced concrete can be strengthened by the insertion of fibers. This article covers every one of those points and more.

2.2 BACKGROUND

The majority of a building's framework will likely be made of concrete. Aggregates, cement, chemical components, and water are combined to create this composite substance. In the realm of building, it is second only to glass powder as a reinforcement material in terms of frequency of use. As a superfine powder with siliceous qualities, glass powder can be used in conjunction with concrete. It's possible that glass is somewhat of a standard building material. You can't let it live forever. When something has served its purpose, it either gets recycled or sent to the junkyard. For the time being, let's assume that glass won't break down over time. Landfilling is therefore not a green practice. Self-compacting concrete, likewise, is put to use in situations where it can settle under its own weight. With the advent of Fibers, it was decided to utilize a superplasticizer (Tec-Mix 550) in the hopes of boosting the material's potential applications. As the concrete settles under its own weight, the utilization of this chemical admixture is beneficial for colliding the fibre within the concrete, necessitating more important power. It is common knowledge that adding fibers to concrete can alter its properties. There are many types of fiber used in concrete, however steel fiber is quite prevalent. For large, heavy constructions like skyscrapers, the use of lightweight concrete is crucial for lowering the structure's own weight. It allows for the reduction of extra loads in the case of repairing or reinforcing already-existing buildings. Self-compaction also negates the need for vibrations in preexisting concrete when compacting new materials. In order to better understand the effects of modifying the micro steel fiber concentration in high strength steel fiber reinforced self-compacting concrete, this study will examine such effects. Due to the financial, energy, and environmental advantages alternative materials (waste from various industrial operations) are gaining popularity as the present ecological trend works toward reducing the usage of natural raw materials in the field of construction materials.

The aim of the current study to compare the fresh and hardened properties of SCCs with and without steel fibers, and to determine the impact that SCM additions as cement replacements have on these properties. Steel fiber reinforced concrete, more frequently referred to as SFRC, has been considered highly sought after and widely used in structural engineering throughout the course of the last several decades due to the fact that it possesses outstanding hardened performance. The largest advantages are the prevention of macrocrack creation, the late effect of microcrack propagation to a scopic conscience level proper enhancement of ductility following the formation of propagation of cracks. All three of these benefits come after the production of microcracks. In addition to this, the concrete mixture is considerably more robust and has significant strengths when residual impacts are considered after the onset of the initial crack. In this study, we examine how different configurations of steel fibers interact with steel bar reinforcement. This article summarizes the results of an experimental study program that looked at how adding steel fibers to reinforced self-consolidating concrete beams affected their flexural tensile strength, fracture behavior, and workability.

The amount of glass that is dumped annually is quantified in tons. Due to the fact that glass does not biodegrade, it is often discarded in landfills, which is not a sustainable practice. Glass is mostly composed of silica. It would be a big step forward for sustainable infrastructure if milled (ground) waste glass was used as a supplementary substitute in concrete. (systems that are environmentally benign, energy efficient, and cost effective). Calcium silicate hydrate (C-S-H) is predicted to occur when micro-sized fragments of discarded glass encounter pozzolanic interactions with cement hydrates. The goal of this study was to compare and contrast the chemical composition of clear and coloured glass. Chemical analysis of cement and glass samples (XRF) technology was selected for X-ray fluorescence evaluation. These results demonstrated the slight structural differences considering glasses with coloring and non-colored one. Flow and compressive strength tests were conducted with mortar and concrete that had anywhere from 0% to 25% ground glass added to the mix. All of the way up to the replacement levels, w/b position (cement + glass) remained same. Increasing the glass component improved mortar flow marginally, while having minimal impact on the workability of the concrete. Experimental results showed that the compressive strength of mortars with admixture increased when the same mix parameters were used in conjunction with a 1% super plasticizing admixture use (weight by cement with other components). Research was conducted to learn how packing and pozzolanic procedures affected the mixture. The nano glass powder shown in Figure 1 has been cleaned and may be used as a cementitious additive.

Figure 2.1: Nano Glass Powder.

The shear behavior of the hardened mixture material is going to be investigated through the utilization of this experimental effort by adding steel fibers to a high strength concrete mix while taking into consideration differences in volume fractions in order to accomplish this objective. This will be done in achieving this particular objective. It was accomplished by analyzing the internal properties of the innovative concrete material that have an impact on its shear resistance, as well as by conducting an evaluation, both qualitatively and quantitatively, of the roles which fibers as steel one play in shaping the characteristics of the material in a structural manner. A sustainable development requires that the built environment function better than it does now, and the current endeavor will result in suggestions that attempt considering improvement in the behavior of the RC elements towards shear. [Citation needed] Sustainable development requires that the built environment function better than it does now. In particular, there would be a much-reduced risk of cracking that was abnormally wide, which, over the course of time, might lead to concerns with durability or even premature collapses. According to the research that has been done [1-3], self-compacting concrete has a low level of shear resistance. Considering the fact about compressive the cracks in high strength concrete tend to be trans-granular and smooth in general. In addition, the particles that make up the aggregate are not bound together, which leads one to believe that the aggregates have a lesser impact on the strength shear of the material. The substantial development of fractures in the SSC assumes the appearance of a linear fracture that gradually extends as it advances. This occurs when there is insufficient interlocking of the aggregate particles. It is necessary to add steel fibers to the concrete mixture in the same way that aggregates are added in order to get the desired improvement in shear behavior. This must be done in the same way that aggregates are added. Because of this, patching will be able to be done more quickly. Figure 2 is a representation of the manufacturing process for self-compacting concrete.

Figure 2.2: Self-Compacting Concrete Production.

The construction industry has relied heavily on concrete for the larger part of the last few decades because of the material's amazing mechanical strength, exceptional transport qualities, and significant economic advantages. However, concrete's narrow range of applications for tension-dominated and slim structures is a result of its high brittleness, poor strength-to-weight ratio, and strength at the lower tensile position. Due to these concerns, concrete was not a possibility. Corrosion of internal steel reinforcing bars can further reduce the longevity of concrete structures, which are already susceptible to damage due to concrete's low tensile strength and high brittleness. This may occur if water is left to pool on the concrete for an extended period of time.

Because of the massive amount of trash produced by the construction industry, there is a significant opportunity for improving the utilization and recycling of raw materials [4]. This industry also provides potential for industrial symbiosis, which can be accomplished by transforming other industries' waste products into raw materials that can be used in the building industry [5]. The manufacturing of concrete in particular makes it possible to incorporate a variety of waste products from other industries and agricultural practices, either as partial substitutes for the aggregates or for the cement. Because cementitious materials play such an important part in the construction industry, it is of the utmost significance to work toward increasing their resistance to wear and tear as well as their mechanical properties [6-10]. Costs can be reduced by decreasing the cement concentration in concrete, as cement is the most costly ingredient [11]. The primary focus of research on potential alternatives to cement up until this point has been on partially substituting other materials for cement. The hunt for locally sourced materials that could be used in place of cement has received a lot of attention and effort from researchers. Because of the significant amount of work that has been put into ensuring that these materials are renewable, sustainable, economically viable, and favorable to the environment, approved is the use of scraps as a stand-in for the original. As a result of their demonstrated ability to fulfill most of the demands for long-lasting concrete and blended cement, supplementary cementitious materials are currently used in many parts of the world [12, 13]. The International Energy Agency (IEA) and the World Business Council for Sustainable Development (WBCSD) identified the substitution of cement with other materials with cementitious properties that contained lower levels of carbon as one of the four levers that could be used to bring about a reduction in carbon emissions (2009). Pozzolans are a class of siliceous minerals used as cement substitutes. Pozzolans are insoluble in water and do not have cementitious qualities on their own, but when processed and finely divided, they react with lime $Ca(OH)_2$ in the presence of water to produce extra C-S-H (calcium-silicate-hydrate). Contrary to popular belief, pozzolans do not contribute to a cementitious environment when used alone [14]. The ash from these pozzolans is often utilized. This is especially true for the wastes. Banana leaf ash, silica fume, ground granulated blast furnace slag, limestone powder, mixed cements, fly ash, and fly ash are all examples of materials that fit this description. The self-compacting banana leaf ash concrete is a type of SCC that has ash from banana leaves partially replacing the cement in the mixture. This not only makes it possible for there to be less degradation of land for natural resources as a result of the replacement with waste banana leaf, but it also makes it possible for there to be less of a problem with waste management.

For the presence of microscopic cracks, concrete exhibits a non-linear departure from the yield requirement. Previous studies [15-17] have shed considerable light on this phenomenon. The presence of fibers inside the cementitious matrix usually assists to stop the spread of cracks, leading to a more ductile reaction. Fibers added to the mix to make the concrete less brittle may cause the final concrete to have a different size impact than conventional concrete because the brittleness of the concrete is a major factor in the size effect. However, there are now only a few amount of research [18-20] available that examine the size effect of fiber-reinforced concrete. No studies on the size effect of amorphous metallic fiber reinforced concrete SFRC have been previously published, to the author's knowledge. That's why it's critical that we learn more about the size effect in SFRC. The major purpose of this study was to compare the flexural performance of SCC constructed with different percentages of fiber volume fractions and different ratios of water to cementitious material, depending on the size of the specimens tested.

2.3 PREVIOUS STUDIES

For considering its low cost and high versatility, concrete has become the go-to building element worldwide. However, a large amount of carbon dioxide and other greenhouse gases are released into the atmosphere through the burning of fossil fuels and decarbonization of limestone during the cement manufacturing process. The energy consumption of ordinary Portland cement (OPC) is third highest, behind that of aluminum and steel [21, 22]. Consequently, the cement industry and humanity's future are both threatened by the harmful effects of CO_2 on the environment and the large amounts of energy required. Concrete should be phased out in favor of more environmentally friendly structural materials [23, 24]. The sustainable substitute for conventional, OPC-based concrete in recent years has been geopolymer concrete [25, 26]. The substantial reduction in both CO2 release and the requirement of natural resources has attracted a lot of attention to geopolymer concretes. The raw ingredients don't need to go through a calcining process like OPC does, which means less energy is used in the production process. CO_2 emissions from geopolymer concrete are reported to be 5-6 times lower than those from OPC concrete [27, 28]. Also, the consideration of the concrete incorporating geopolymer both reduces carbon footprints significantly but also recycles the byproduct rubbishes containing the alumino-silicate made up composition into cutting-edge building supplies [29, 30].

Self-compacting concrete (SCC) is widely used in civil engineering for the construction of pre-cast factories, high-rise buildings, and other structures needing strong reinforcement. Characteristics of SCC include its fluidity, its ability to fill and traverse gaps, and its lack of phase separation and bleeding. Masonry has been revolutionized by the development of self-compacting geopolymer concrete. It's a modern material that enhances the best features of geopolymer and SCC [31-33]. Studies on self-compacting geopolymer concrete are scarce (SCGC). Like regular SCC, SCGC needs more research to see how well it performs in both its fresh and hardened states before it can be put to any practical use.

There are a number of benefits to using mineral fillers and supplemental cementitious materials (SCM) in concrete, including improved durability, workability, and hardened state qualities [25, 34, 35]. Because of their beneficial effects on the concrete's mechanical performance, the environment, and the economy, SCMs like fly ash and GGBFS have seen widespread application in the scholarly literature [25, 36].

Due of its poor tensile strength and flexibility, SCC is often reinforced with steel fibers [37]. Adding steel fibers to concrete raises its resistance to cracking after it has already occurred, as well as its toughness and ductility [37, 38]. In addition, the cost-effectiveness of steel fiber reinforced SCC exceeds that of regular SCC [39]. The fiber properties and fiber content determine the optimization method and design procedure needed to meet SCC standards [31-33]. For most buildings, using steel fibers at a concentration of 1 percent by volume of concrete is thought to be optimal [40]. This is primarily a cost-related decision.

Steel fibers (SFs) are a viable option for preserving reinforced concrete's tensile strength, among other ways to do so. The fibers in concrete create a bridging mechanism that allows tensile stress to be transferred over cracked areas, giving the material its residual strength [41-44]. Furthermore, fiber stitching activity is crucial in efficiently limiting crack growth and propagation [45, 46]. Evidence showed that boosting the SF content of concrete not only increased its impact strength but also improved its toughness and stiffness [47-49]. Combinations of nano glass powder (NGP) and silica fumes are allowing for the development of new types of reinforced concrete (RC) characterized by strong flowability, passing ability, and self-compactability when freshly mixed. These features result from the hardened state's inclusion of SFs and NGP. However, enhancing the fresh properties of RC while concurrently mixing NGP and SFs presents a significant challenge. Research shows that adding NGP to RC increases inter-particle friction, which reduces the mix's flowability and its ability to pass through a sieve [50-52]. Due to its low density, rubber particles are also more prone to rise to the surface of the concrete during mixing. This causes the mixture to become less stable due to segregation. Addition of SFs decreases concrete's flowability and passing ability due to increased interference and obstruction in mixtures [53, 54]. When coarse aggregate is mixed with NPG and SFs, the problem becomes much worse. Reviewing the literature in this area reveals how little research has been done on the phenomenon under consideration. There have been no small- or large-scale tests of concrete incorporating SFs, and no research has been done on the together influence of NGP and fibers with steel properties on the flexural behavior of full-scale beams, especially when SCC is used. Therefore, this study was conducted to investigate flexural properties of massive beams fabricated from RC, VRC, SFRC, and SFVRC. This research looked at the cracking properties, flexural capacity, initial cracking moment, and beam response to deflection under load. The results are compared to experimental data to see how well the code design equations approximate the cracking moment and the flexural capacity. This type of concrete is so uncommon that there are no relevant examples in the published literature. The primary objective of this study is to increase the number of applications of NGP, with or without SFs, that use concrete. To achieve our goals, we will use a hybrid strategy that incorporates elements of both. Beams were produced with varying amounts of NGP (from 0% to 35%), SF volumes (from 0% to 0.35% and 1%), and SF lengths (from 0% to 1%). Beams had anywhere from zero percent to thirty-five percent NGP utilised in their making. (Two different ones, 35mm and 60mm). The percentages can be changed depending on a number of factors, and it also is affected by the curing procedures.

To learn how self-compacting concrete can be used, it is necessary to examine the experimental database that has been created from past experiments and the appropriate literature. By doing so, one can learn how to best utilize the capabilities. Data from the literature was used to create a database based on SFRC and SCM because so little study has been done on FRSCRC. Because SFRC has been examined more, this is the case. This was executed because there is a dearth of previous studies focusing on FRSCRC. This databank focuses on the structural behavior of the concrete, and it also provides some context and the methods used in the experiments for the study. As part of the research, the experiments were conducted. Figure 3 takes into account the loading tests of the reinforced beam and describes the fracture distribution and failure manner in detail.

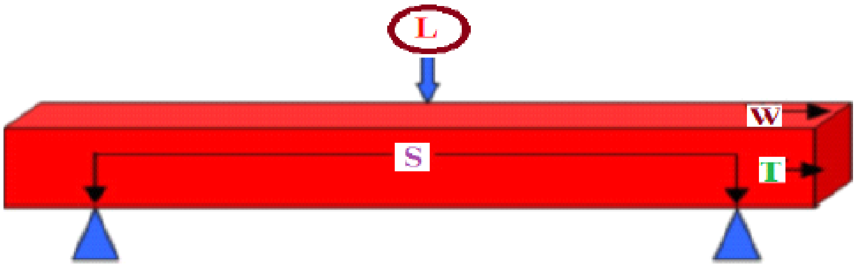

Figure 2.3: Strength in Bending, Represented Graphically (L: beam or load, S: spam, T: thickness, W: width).

Unlike traditional concrete, self-compacting concrete (SCC) does not require any mechanical consolidation in order to fill the formwork and enclose the reinforcement once it has been placed. It can be compacted without the use of vibration and can move freely through tight passages without clumping or excessive bleeding. SCC mix is made up of the same components as NVC: aggregate, cement, water, admixtures, and sometimes minerals. SCC, in contrast to NVC, has fillers and superplasticizers added to increase its flowability, such as silica fume, limestone powder, blast furnace slag fly ash, etc. SCC saves time and money in the concreting process since it can flow under its own weight with no or minimal vibration. Considering the report of ACI committee [55], Lightweight concrete with high strength capabilities is defined as lightweight concrete following the structural consideration with a 28-day compressive strength of 40 MPa or more, while structural lightweight aggregate concrete is defined as concrete made of 1120-1920 kg/m3 of lightweight aggregates and having a 28-day compressive strength of at least 17 MPa. Adding fibers to high strength concrete improves its mechanical qualities, as stated by Shah and Ribakov, making it a more appealing building material. In order to keep the fibers manageable and to ensure fair dispersion, they are kept short [56]. Without the primary reinforcement bars, concrete with high strength steel fibers added has more pliability and load-carrying capacity than concrete reinforced with steel fibers of average strength [57]. Using the optimal steel fiber weight ratio in high strength concrete allows for the creation of high performance bending components with elastic-plastic behavior comparable to that of regular strength concrete members [58]. Adding fibers to lightweight concrete is equivalent to adding fibers to conventional weight concrete in terms of load bearing capability and crack control [59]. The concrete's tensile strength is increased, and its resistance to deformation is enhanced, and the width of cracks is decreased. However, adding fibers to concrete has a significant detrimental effect on its workability [53]. Steel fiber reinforced SCC was studied by Akcay and Tasdemir, who compared the effectiveness of employing standard steel fiber (6 mm) and high strength steel fiber (30 mm) in the material. Steel fibers were found to have a minor impact on the workability of concrete, however this change was found to be more related to the geometry of long fibers than the strength of fibers themselves [60]. It has been claimed that using a volume percentage of 2% or more of steel fibers in SCC, which is 20 mm in length, makes it difficult to deal with and pass through rebars [49]. Adding glass fibers to ceramic concrete slows its flow [61]. Using a slump flow of 600 mm, 35-65 MPa compressive strength, and 3.5-6.5 MPa tensile strength, Liao et al. developed self-compacting high-performance fiber reinforced concrete [62] using long steel fibers measured 30 mm with proper ends with hooked styles.

There has been a lack of consensus on how the addition of fibers to concrete would affect its compressive strength. Concrete with steel fibers has a higher compressive strength up to a volume percentage of 1.5%, but subsequently decreases to 12.9% at 2%, as reported in the literature. Compressive strengths of different concretes were found to be increased by 19-42% when short steel fibers (13 mm in length) with an aspect ratio of 65 were added, according to study published by Ma et al. in 2013 [63]. In contrast, Atis and Karahan argue that steel fiber reinforcement in concrete does not significantly increase the material's compressive strength [64]. Compressive strength is unaltered by the inclusion of steel fibers, according to a study using fibers ranging in length from 22 to 44 mm, but when subjected to compression, the failure mode changes from brittle to ductile, and the specimens remain intact until the end of the test [47]. Recent research has also shown that including steel fibers in concrete can reduce the material's compressive strength. In 2014, Khaloo et al. [49] The compressive strength of both medium and high strength concretes dropped by 18.6% and 7.5%, respectively, when steel fibers were introduced at a 2% volume percentage. Studies using ultra-high strength concrete reinforced with polyvinyl alcohol micro fibers and alkali-resistant propylene fibers found substantial reductions in both the concrete's compressive strength and its modulus of elasticity [65].

Flexural strength was improved by 8.7-10.7% when 0.3% polypropylene fibers were added to concrete, according to another study [66]. By increasing the fibers content in concrete, Pajak and Ponikiewski (2013) discovered that SCC acted similarly to NVC, with an increase in flexural strength. Integrating long steel fibers into concrete increases its durability [67]. It outperforms conventional steel-fiber concrete in strength and adaptability. To improve the flexural strength of RC beams, Mortinalo et al. use high performance fiber reinforced concrete. Micro steel fibers with a 0.18 mm diameter and 12.5 mm length were used. When compared to a standard beam, their max load increased by a factor of 2.15 [68]. Increasing the steel fiber content of SCC increases the concrete's toughness. Adding fibers to concrete increases flexural strength because the ultimate load is increased. Because fibers considerably contribute to the resistance against the development and spread of cracks, the findings of these experiments show that adding fibers to lightweight concrete significantly boosts its toughness [48]. When polypropylene and nylon fibers are introduced to oil palm shell concrete, the flexural strength increases by 46%-86% [69]. Chidambaram and Agarwal, who investigated the effect of steel fiber reinforcement and geo grid confinement on the flexural and shear behavior of RC beams, found that the addition of steel fibers to the concrete mix improved both properties. It has been shown that decreasing the distance between beams in reinforced concrete made using geo grids and steel fibers increases the material's flexural strength and shear strength. In their paper, Holschemacher and Klug [70] discovered that the bond of fibers in SCC was superior when comparing SCC to NVC. It's possible to get the most out of fiber's additional benefits in SCC. As compared to standard strength fibers, high strength fibers exhibit more ductility and can support heavier loads after cracking [71]. Lightweight concrete's low specific gravity makes it a good choice for reinforcing and repairing aging buildings, and the combination of lightweight concrete's advantages and those of high-strength steel fibers in SCC results in a material with exceptional flexibility.

This study handles the glass powder used in self-compacting concrete by A Rajathi [72], experimenting with different mix proportions to learn how the powder behaves in self-compacting concrete, among other things. When discussing one of the most exciting advances in the field of development at the moment, SSC is a must-use acronym. Self-fusing cement, also known as "Superior cement" and "Self-merging cement," is now one of the most significant developments in the construction industry.

The Mayur B [73] SCC is a solid that collapses under its own mass. Simply called "the solid" by most people. That can be placed and compacted into either side of a formwork; this eliminates the requirement for vibrators or any other external source of energy to compact the material. Binu P [74] when it comes to engineered materials, SCC is among the most cutting-edge. produced by dedicated researchers. When compared to regular vibrated achievements, SCC's boosted results are clearly superior.

Among the many benefits of concrete are a lowered risk of injury due to human error, new possibilities in building design, increased durability, a safer workplace, lower costs and easier upkeep. In this work, we test the efficacy of SCC created from different combinations of fly ash, sand, and glass powder, and we compare the results to those obtained with regular cement. Receipt requirements in clean state behavior, such as droop stream, V Funnel, and L box, are verified. The solidified state parameters, such as compressive quality, are also determined after 7 and 28 days.

According to A. Baskar [75], the study's goal is to investigate the effect of varying cement-to-glass powder and cement-to-egg shell powder ratios on the final product's strength, hardness, and other qualities, using a mix design optimized for M20 cement. When making concrete, a great deal of carbon dioxide is released into the atmosphere, which has a variety of effects. As part of this initiative, concrete was put to use to lessen the amount of material thrown away by commonplace uses. Here, they sub in materials like glass powder and egg shell powder in place of cement due to the latter's weaker properties but higher weight-quality after seven, fourteen, and twenty-eight days. Self-compacting concrete, developed by Deepa Balakrishnan [76], is considered the most significant engineered materials created by structural engineers. When compared to conventionally vibrated concrete, SCC's advanced achievements include reduced human-caused risk, opportunities in building and development, increased solidity and workplace security, cost-effectiveness, ease of maintenance, and so on. In this work, we test the efficacy of SCC created from different combinations of fly ash, sand, and glass powder, and we compare the results to those obtained with regular cement. Receipt requirements in clean state behavior, such as droop stream, V Funnel, and L box, are verified.

Today, Jayeshkumar Pitroda [77] says the globe is seeing the creation of extremely complex and difficult civil engineering structures. Glass fiber (or glass fiber) is a material made up of millions of microscopic glass strands woven together. Concrete, as the most essential and widely used material, is frequently expected to have extreme durability and adequate malleability. To that end, researchers in the field of concrete technology are working to create new types of concrete with desirable properties.

Gavirneni Priyanka and T. Sujatha [78] Self-compacting concrete (SCC) is concrete that can compact itself without the need of external force. Self-compacting concrete combined with glass fibers creates glass-reinforced self-compacting concrete (GFRC), a versatile hybrid material. This dissertation analyzes the mechanical properties of Self-compacting Concrete with varying amounts of glass fibers (0%, 0.1%, 0.15%, and 0.2%). The mechanical characteristics of fresh and cured Self-compacting concrete are investigated via a series of experiments. The M30 and M40 grades, which include varying percentages of glass fibers, are examined and contrasted with respect to their compressive strength, split tensile strength, flexural strength, durability, and load versus deflection parameters.

Self-compacting concrete, pioneered by Shahana Sheril P.T. [79], is a relatively new innovation in the concrete industry, and the incorporation of fibers into it has been shown to increase its strength. Self-compacting concrete with fiber addition has been the subject of a number of research efforts. In this research, we aimed to examine the differences between M20 and M30 self compacting concrete (SCC) and glass fiber reinforced SCC in terms of their fresh and hardened state qualities (GFRSCC)

A. B. K. Abhishek This study [80] examines the research of how long steel-reinforced self-compacting concrete lasts. To a certain extent, the use of steel fiber may boost compressive strength and help avoid fractures. Within the brittle mass, steel strands have begun to form. When safety and longevity are primary design priorities, fiber reinforced concrete is a must.

S.A. Bhalchandra [81] argues that the use of trained personnel for laying and compacting concrete is significant for the construction of long-lasting concrete structures. Self-Compacting Concrete is able to do this because of its exceptional characteristics when in its fresh form. When it's in its plastic condition, it fills a mold or mold cavity uniformly and flows around clogged reinforcement. When fully cured, its strength and durability rival or even surpass those of ordinary concrete. Since the performance of plain self-compacting concrete has been researched extensively, but the performance of fiber reinforced self-compacting concrete has not, the objectives of this work is to rectify that.

According to B. Sandhya Rani and N. Priyanka [82], implementing SCC significantly alters concrete's performance, hardened characteristics, and surface quality, strength, and durability. In this study, we replace cement with FLYASH and calculate the maximum amount of polypropylene fibers that can be utilized in SCC. It has been found that up to 40% of the SCC mix can be replaced with fly ash without compromising the concrete's toughened or mechanical qualities.

Mrs. Najilah Farouk and I. Padmanaban considered to make concrete buildings last longer, Japanese researchers in 1988 created the first self-compacting concrete (SCC). Thin sections and areas of congested reinforcing sometimes cause difficulties in consolidating conventional concrete, leading to a high concentration of air spaces that reduce the material's strength and durability. The difficulty can be avoided altogether with the use of self-compacting concrete (SCC), which is engineered to compact down under its own weight.

Jacob Anu and Anumod A. S. Anu [83], SCC is a new kind of concrete that doesn't need vibration to lay or compress. Reinforcement may still flow under its own weight to completely fill the formwork and achieve full compaction, even if the flow path is blocked. Some of the numerous advantages of SCC include its high fluidity, superior segregation resistance, and exceptional self-compatibility. The standard blend, discovered after trial and error. The effects of Polypropylene fiber and Metakaolin additions to self-compacting concrete are studied, both immediately after mixing and after curing.

This research compares and contrasts two types of self-compacting concrete, Nominal Mix Self Compacting Concrete (NMSCC) and Fiber Reinforced Self Compacting Concrete (FRSCC), both in their fresh and hardened states. Our M20 SCC blend meets the requirements of both BIS 10262:2009 and ACI 211.1-91. Super Plasticizer (SP) CONPLAST SP430SRV, a chemical admixture, and mineral admixture (10% fly ash by weight of cement) are both necessary for NMSCC. The w/c ratios of 0.25, 0.30, and 0.35 are used for cement. To produce FRSCC, NMSCC is combined with either 0.9, 1.35, or 1.8 kg/m3 of concrete volume of Polypropylene (PP) fibers of varying lengths, by Yogesh S. Kanade and Shailesh S. Angalekar [84].

Shagufta Javed, Jincy. J, Dinesh. A, Harini. S, Jasmine Jeba. P, and Shagufta Javed [85] Concrete is a building material made from a combination of cement, sand, gravel, and water that dries hard and sturdy. For concrete to flow into complex molds or molds with numerous reinforcing bars, vibration is essential. Self-compacting concrete, in which fly ash and silica fume are used as partial cement replacements, is the subject of this study. Fly-ash (at 5%, 10%, 15%, 20%, and 25%) and silica fume (at 2.5%, 5%, 7.5%, 10%, and 12.5%) are used in place of OPC in this recipe. The experimental studies show that the fresh qualities (workability) and the mechanical characteristics (split-tensile strength and compressive strength) are improved by the addition of silica fume.

R. N. Gaywala D.B. Raijiwala declaed [86] Self-compacting concrete (SCC) is an alternative to traditional cement that doesn't need vibration during placement or compacting. Even if the flow channel is blocked, the reinforcement may still fill the formwork and be compacted to its full volume by gravity alone. This paper provides an overview of the current state of knowledge regarding the various harden properties of self-compacting concrete made with Ordinary Portland Cement "Ultratek" made and low-calcium fly ash from Birala Glass, Kosamba, Gujarat as binder materials in the concrete mixes, as well as other readily available ingredients from Gujarat. The experimental studies compare the material to M25 grade concrete in terms of compressive strength, split tensile strength, flexural strength, and impact strength.

This research takes a close look at the Self Compacting Concrete (SCC) with many Mineral Admixtures and Fibers created by Arulsivanantham P. and Gokulan R. The term "self-compacting concrete" refers to a kind of concrete that does not need vibration in order to be compacted. Self-compacting high-performance concrete is another name for self-consolidating concrete. It is not essential to consolidate this concrete mixture. This article reviews the research on how fibers and other mineral admixtures affect self-compacting concrete's properties in depth [87].

Using agro-industrial waste materials in concrete is a typical option for waste disposal and economic purposes, as noted by Batham Geeta, Bhadauria S. S., and Akhtar Saleem [88]. This study looks into the newest developments in self-compacting concrete, which utilize agro-industrial byproducts. This research also discussed the most recent admixture applications and how well they worked to improve the quality of SCC. They could be added to the SCC as filler to improve its mechanical and physical qualities. The purpose of this paper is to collect the most recent advances in SCC, investigate their impact on SCC properties, and set an international standard against which future research can be measured.

Ashutosh Sangamnerkar [89] studied the pozzolanic properties of fine glass powder in concrete and compared its results to those of other pozzolanic materials, such as silica fume and fly ash. Cement was substituted with 5%, 10%, and 15% glass powder in a series of compressive strength and durability tests. Glass powder with particle sizes ranging from 600 to 100 micrometers was utilized to investigate the impact of this variable. The results indicated that the concrete's strength could be greatly improved by using 10% glass powder.

When used together as a partial cement replacement, glass powder and fly ash can affect the microstructure of the concrete. When compared to untreated concrete, the modified mix reduced the rapid chloride permeability coefficient [90]. Fly ash's alumina content makes it more suitable for this purpose. After reviewing the relevant literature, we find that opinions on glass powder's effect on concrete's final qualities remain divided. However, the chemical makeup, particle size, and any impurities or other chemicals added to the glass to give it color all play a role in how concrete containing glass powder behaves. However, there are many who believe the glass powder's small particles are to blame for both phenomena, despite universal agreement that glass's high SiO_2 content is to blame for its pozzolanic behavior and that glass's high Na_2O concentration is to blame for its ASR response. There are two primary routes to create nanomaterials, either from the bottom up or the top down [91]. Top-down approaches involve reducing the size of the starting material to the nanoscale by grinding or other means. This is done so that the top-down approach can be utilized. This can be done with no change to the original content's qualities. Using an assembly or self-assembly technique, new nanomaterials are engineered in the bottom-up or molecular technology manner. This method is sometimes referred to as "molecular technology." On rare occasions, the term "molecular technology approach" has been used to describe this strategy as well [92]. A glass nanoparticle with a size ranging from 0.1 to 10 nanometers has been developed specifically for usage in concrete and other engineering-related applications.

As was mentioned in prior studies, incorporating nano glass particles into concrete improves the material's durability, ductility, and impact resistance; however, doing so reduces the material's compressive strength, modulus of elasticity, splitting tensile strength, and flexural strength. This is due to the fact that nano glass particle in concrete mixtures reduces the amount of flexural strength that can be achieved. One option to assist reduce the effects of these limitations is to locate a material that has the potential of boosting the mechanical qualities of concrete. Steel fibers are one of these components that, when added to concrete, can improve the concrete's mechanical qualities. According to Zamei [93], strengthening the material in both compression and bending, steel fibers in concrete are a popular additive. Steel fibers of three geometrical forms (corrugated, straight, and hooked end) were also tested for their performance. This is why the researchers utilized steel cords with hooks at one end in their experiment. The effect of steel fiber volume fraction on concrete's mechanical characteristics has been the subject of several investigations [64, 94, 95]. The findings of these studies showed that the optimal fiber content for concrete is between 0.75 and 1.5 percent by volume. As a result, for the purposes of this investigation, the volume fraction of steel fibers was set at 1%. The research conducted by Sukontasukkul [96] investigated whether or not rubberized concrete has the potential to enhance the reaction to gunfire of a bulletproof panel made of steel fiber reinforced concrete. The results indicate that rubber boosts the bullet's ability to absorb impact energy, leading to reduced damage. According to Medina [97], adding even a tiny proportion of rubber to concrete can significantly improve both its resistance to fire spalling and its tensile strength. In addition, an increase in the percentage of rubber results in a decrease in the strength of the concrete; however, this effect can be counteracted by the inclusion of fibers, latex, or fillers.

It has not been determined how the addition of glass powder and steel fibers to concrete will influence the mechanical properties of the material, and this aspect of the mix still requires additional research. As a result, in this body of research, nano glass powder was blended with steel fibers in order to investigate the effects that these two components have on the performance of reinforced concrete beams. Materials with remarkable optical, magnetic, or electrical capabilities with at least one critical size below 100 nm are considered to be nanoscale materials. These materials are employed as supplemental cementitious material to manufacture self-compacting concrete (SSC). In addition, the production of SFRC included the utilization of steel fibers with hooked ends at a volume fraction of one percent throughout.

2.4 SELF-COMPACTING CONCRETE

As the name suggests, self-compacting concrete is a variety of the building material that can compact and level itself alone by the force of gravity. Unlike other types of concrete, this one doesn't require any further mechanical consolidation to spread, fill the reinforced formworks, and keep its uniform consistency [98, 99]. The use of Self-Compacting Concrete (SCC) is a recent development in the building trade. Self-compacting concrete is also known as self-leveling concrete, high performance concrete, super-workable concrete, highly-flowable concrete, and non-vibrating concrete, among many other names [100]. This innovative concrete type may now be used to completely fill the formwork without causing any vibrations.

By definition, "SCC is the concrete that is able to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, boxouts, etc., while retaining homogeneity," as stated in the British Standard BS EN 206-9 (2010).

ACI Committee 237R-07 (2007) defines SCC as freshly mixed concrete that may flow around reinforcement and consolidate within formwork under its own weight without vibration.

By their definition, SCC is "concrete that may flow inside the formwork, filling it naturally and working its way around the reinforcing bars and other obstacles, compacting as it goes under the force of gravity" [101].

SCC is characterized virtually identically by other studies [102, 103] as a highly flow-able concrete that should meet the following criteria.

a. Flowability means that SCC can move on its own weight to fill all areas of the formwork without the need for additional vibration or assistance.

b. Ability to pass through: SCC must be able to go past thick steel bars used for reinforcement.

c. It is important for SCC to resist segregation, meaning that its major components do not migrate or get separated (aggregates or fibers).

Self-compacting concrete (SCC) was created in Japan in 1988 to increase the uniformity and reliability of concrete by eliminating the need for consolidation operations on-site or concrete ready-mix factories [103]. For reasons including improving the overall durability of concrete and addressing issues with the homogeneity and compaction of cast-in-place concrete within complex (i.e., highly reinforced) structural parts, this concrete was developed (Jost & Campion, 2000). Self-compacting concrete (SCC) has revolutionized the building sector since its introduction in the late 1980s [104]. Increased productivity, greater construction quality, and a far more pleasant working environment on site are just some of the many advantages of SCC, in the concrete industry, which has been called a "quiet revolution". Self-compacting concrete (SCC) has improved both concrete technology and working safety and health conditions by eliminating the need for mechanical compaction on building sites [105, 106]. The use of self-compacting concrete (SCC) has skyrocketed in recent years. Leemann, Loser, Münch, & Composites, Already, it is gaining popularity in the construction business and is seen by some as a possible substitute for the majority of the conventional concrete used today [107]. During the previous three decades, SCC has been hailed as "the most innovative advance in concrete". Numerous benefits accrue from the use of this novel concrete, including expedited building times, decreased dependence on highly trained construction personnel, reduced background noise at job sites, increased worker safety, decreased environmental impact, simplified construction procedures, higher quality finishes, and longer service life [108].

Unit SCC differs from traditional concrete in three key respects: it flows under its own weight without the aid of vibration; it may move through formwork sections that are narrow or congested with reinforcement; and it becomes homogeneous, with excellent resistance to segregation or bleeding. It is exceedingly difficult to compact concrete in concrete members where vibrating devices cannot be used, such as thin beams or when the spacing of the rebars is low. This means that self-compacting concrete (SCC) is frequently employed because to its ability to flow between dense bars and in intricate molds. The concrete flows through the inside of the construction sections, filling the voids and moving past the dense reinforcing bars and other barriers under the force of gravity. Further, SCC is advantageous since it resists segregation during the casting process. This quality allows concrete to be poured and transported in a uniform fashion. Improper compaction can have unfavorable results, including diminished mechanical and durability performance.

2.5 ELEMENTS OF SSC

2.5.1 Cement

According to the specifications outlined in ASTM C150 / C150M-20, Portland cement is classified as a hydraulic cement. This type of cement possesses the ability to both harden through a chemical reaction with water and produce a product that is resistant to water. The manufacturing process involves the pulverization of clinkers, which are primarily composed of hydraulic calcium silicates. Additionally, the inclusion of one or more forms of calcium sulfate as an inter-ground addition is a common practice in the production of Portland cement (ASTM, 2020).

Cement can be thought of as "any of a range of materials that are capable of binding aggregate particles together," as stated by ACI Committee 237 in 2007. It is a chemically reactive binding material that can set and harden in the presence of water.

According to BS EN 197-1 (2011), "Portland cement clinker is a hydraulic substance which shall consist of at least two-thirds by mass of calcium silicates ($3CaOSiO_2$ and $2CaOSiO_2$)." The remaining one-third is made up of aluminum and iron containing clinker phases and other compounds. CaO-SiO_2 must be at least 2.0 or higher. Magnesium oxide (MgO) content cannot be higher than 5.0% (mass).

2.5.2 Coarse Aggregate

Prior research took into consideration both the target compressive strength and the maximum size of coarse aggregate used in generating this value. A good coarse aggregate may be used to create coarse aggregate with a gradation of no more than 2-12 millimeters and a compressive strength of up to 70 MPa. When creating concrete with a high strength, it's necessary to consider both the aggregate's inherent strength and the bond or adhesion that the paste has with the aggregate. These two elements are essential for making sure the concrete has a high strength. Crushed stone aggregates provide a superior compressive strength in concrete than gravel aggregate, according to experiments carried out with the same size aggregates and cementing ingredients concentration. The same aggregate sizes were used for these testing. High-strength concrete requires large, coarse particles that are free of potentially harmful dust and clay coatings. They must also be clear of clay and dust, according to this. The best coarse aggregate particles are made of crushed rock or natural gravel, especially if it comes from a glacial source. From a rheological and structural perspective, the coarse aggregate particles should be roughly the same size. The importance of avoiding flat or elongated particles cannot be emphasized enough.

2.5.3 Sand

When the particles of the granular material used to make concrete or mortar are so small that they pass through a 4.75mm screen, the aggregate is referred to as fine aggregate. "(1) aggregate passing the 9.5 mm (3/8 in.) sieve, almost totally passing the 4.75 mm (No. 4) sieve, and largely retained on the 75 mm (No. 200) sieve," is how the American Concrete Institute (ACI) characterizes fine aggregate. The bulk of the space in concrete-making recipes is taken up by the structural filler known as fine aggregates. The fine aggregate must not include any organic contaminants in harmful concentrations, as required by ASTM C33/C33M-18 (2018). The fine aggregate's chemical make-up, shape, size, and other characteristics may have a significant impact on how well concrete functions. Any fine aggregate used in mortar or concrete that will be exposed to water, humidity, or moist ground for an extended period of time must not include any components that are deleteriously reactive with the alkalis in the cement.

2.5.4 Mineral Admixture

To complete the cementitious system, mineral admixtures are also mixed in. Depending on their qualities and the effect on concrete intended, they may be used in addition to or as a partial replacement for Portland cement. Concrete's workability, strength, and compactability can all be enhanced with the help of mineral admixtures. Since these materials react differently with various cements, testing is necessary to identify (1) whether the material is actually enhancing the property, and (2) the correct dosage rate, as either too much or too little can be detrimental or fail to accomplish the desired effect [109]. Additionally, the silica, alkali, and carbon contents of the source should be determined. There are a variety of distinct formats in which silica fume can be purchased. It is difficult to handle in bulk form because of the high unit weight that it has in bulk form (118 to 147.5 pcf, which is between 200 and 250 kg/m^3. It is now possible to purchase silica fume in a densified form. The bulk densities of this form are approximately 800 to 1,200 kg/m^3, which is almost twice as high as those of the bulk form. The price of densified silica fume is higher than the price of bulk silica fume.

2.5.5 Water

The aggregate in concrete is held together by a paste made from water and cement. The quantity of water employed is proportional to the robustness of the end result. Water quality issues reduce cement's setting time and weaken the concrete's strength and durability. It is possible that the chemical components of water play an active part in the chemical reactions, modulating the concrete's setting, hardening, and strength development. Batch water, ice, water provided by the truck operator, free moisture on the aggregates, and water introduced as admixtures are all acceptable sources of mixing water according to the ASTM C1602/C1602M-18 (2018) standard. Concrete can be made with either potable water or with water that isn't safe to drink. For water to be considered compatible with this code, the standards and testing frequencies for individual or combined water sources are laid out in detail. Non-potable water or water from a concrete production operation can be used in a ready-mix concrete plant if it complies with the qualifying limitations stated in the ASTM C94/C94M-21B (2021) standard. You should only utilize water from a reputable source in your mixing. It is possible to use the water collected during the washing process at a ready-mix concrete plant as mixing water, provided that it is stored in a way that prevents the introduction of contaminants until it is removed from the storage outlet. Low-pH water, or water with a pH value below 6, is another property having practical applications. A decrease in the alkalinity of the pore fluid, which leads to the removal of the cementitious material, is attributed by Mehta and Monteiro (2014) to the presence of fluids with a pH value below 12.5. There are as much as 35,000 parts per million of salt in the water. Water with dissolved salts of 28 ppm is suitable for use as mixing water for regular concrete.

2.5.6 Superplasticizer

Admixtures are substances added to a mixture to modify its characteristics. Common admixtures include water reducers, retarders, high-range water reducers, and superplasticizers. They help get the ideal water-to-cementing component ratio and make the most of the vast volumes of cementitious material found in high-strength concrete. The use of a superplasticizer allows for the production of high-strength concrete. These substances are also known as high-range water reducers. Plasticizers are chemical additions that enable concrete's final water content to be reduced by 15%. Adding it to concrete or mortar allows the amount of water to cement to be reduced without compromising the workability of the resulting product. Self-compacting and high-performance concrete may also be made using this method. Their contribution to the fresh paste's efficacy is substantial. Reduce the amount of water used in conjunction with the cement to boost the concrete's strength. These admixtures are often used in the manufacturing of high-strength concrete (greater than 50 MPa) because they allow for the creation of workable mixes with water-cement ratios much below 0.40.

In most cases, the adsorption of superplasticizers on the hydrating cement particles comes first in the sequence of events leading up to the interaction of cement and superplasticizers. It has been hypothesized that the adsorption features of superplasticizers and other organic additions, as well as their effects, can be explained by a charge controlled-reaction mechanism 18 model that involves Ca^{2+} ions as a result of early hydration. When water comes into contact with cement, calcium ions that have been liberated during the hydration process instantly form a bilayer. This is then followed by the adsorption of superplasticizer anions on the Ca2+ ion side of the bilayer.

2.6 EFFECTIVE DISCUSSION ON MATERIALS

In recent years, self-compacting concrete (SCC) has been a popular choice for high performance applications. Self-compacting concrete (SCC) is a kind of concrete that doesn't need the use of vibrational force during the placement and compacting processes. It flows easily and uniformly, filling all cracks and crevices, even in heavily reinforced concrete elements. SCC not only makes the surrounding area more peaceful by decreasing the amount of background noise caused by vibrations, but it also enhances the quality of the concrete produced with less labor. In recent years, this concrete's popularity has grown around the globe for a wide range of applications. Despite the technical benefits of using SCC, the supply cost might be two to three times that of traditional concrete, depending on the combinations used and the quality control of the concrete that is produced. As a result, efforts are made to reduce the price of producing SCC by switching out more expensive components, particularly those derived from waste. In addition, the building industry in many nations is expanding rapidly, leading to an increase in the demand for natural resources. A scarcity of readily available natural resources threatens this expansion. The world's natural resources are dwindling, and industrial waste is on the rise. The use of non-traditional and new materials, as well as recycling of waste materials, is an integral part of sustainable development for building. This is done to make up for a shortage of natural resources and to discover alternative strategies of protecting the environment.

Using a super-plasticizer is typically required to achieve great mobility in SCC. Eliminating segregation can be accomplished by adding a substantial amount of powdered material. To accomplish these goals while reducing the price of SCC, powder components Concrete can incorporate a wide variety of fillers and admixtures, including fly ash, silica fume, lime stone powder, glass filler, quartzite filler, and powdered granulated blast furnace slag. By substituting fly ash for cement, an industrial byproduct from thermal power plants or a fine organic component with pozzolanic capabilities, concrete's mechanical qualities and durability may be enhanced. This has led to the widespread acceptance of using alternative cementing elements, such as discarded or recycled materials, while making Portland cement concrete. One material that must be recycled is glass, which comes in a wide variety of shapes. Glass can be found in many different shapes and sizes, including that of containers, flat sheets, bulbs, and cathode ray tubes. Because of this, it is essential that glass be recycled so that it can be used again. Recycling glass has several potential uses in building and construction. Asphalt concrete, regular concrete tiles, masonry blocks, paving blocks, and other decorative purposes are good places to start when thinking about using waste glass, but the use of waste glass in structural concrete, especially SCC, is still in its infancy in terms of practical applications. By reducing water absorption and dry shrinkage, glass can be used as an additive in concrete. The use of high-content glass particles in concrete has been linked to the induction of the alkali silica reaction (ASR), which may reduce the material's strength and durability. Problems arise when employing waste glass as aggregate replacement due to the alkali-silica interaction between the waste glass and the alkalis generated by the cement during hydration. Because of this, cracks appear in the concrete. Meyer et al. suggest a variety of measures to prevent ASR, including grinding glassware to a particle size of less than 300 m, using mineral admixtures, using alkali-resistant glass, sealing concrete to keep it dry, and using low-alkali cement. The ASR findings also showed that dangerous growth and cracking could occur if the glass content was more than 45%. Liu claims that the harmful effects of ASR can be reduced with the help of low-alkali cement and ASR suppressants like silica fume, metakaolin, fly ash, and GGBS. Fly ash can be employed as a binder to greatly restrict the ASR growth of all the SCC specimens, and we've settled on a limit of 50% recycled glass.

The use of recycled glass as fine aggregate in the production of SCC has been the subject of increasing study in recent years. In general, they found that replacing the shattered glass with sand improved the mixture's flowability and softened its harsh properties. Examining the potential for making SCC using flat waste glass as the fine aggregate is the focus of this study. Glass like this is often used in building projects.

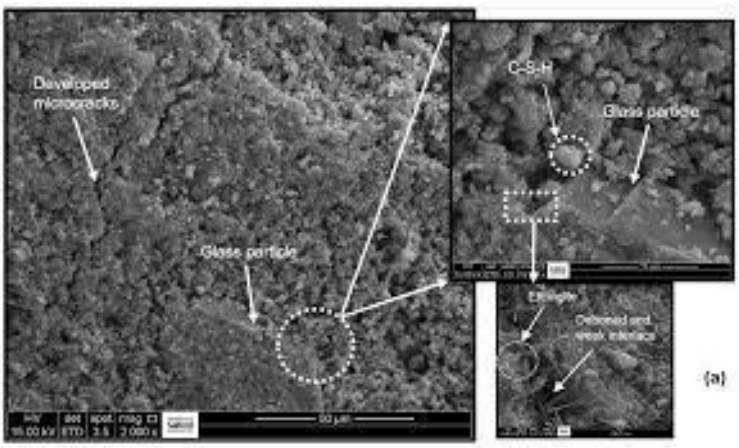

Figure 2.4: Scanning Electron Microscopy with Nano Glass Powder.

Steel fiber must be in the position of quality. The bundles of sisal fiber, also called SIF, arrived in lengths of about one meter. They were first cleaned and then chopped into pieces ranging in size from 16 to 20 mm before being added to the mixtures. These fibers came from several Mosul, Iraqian, markets. For the purpose of comparing the epoxy adhesive's performance to that of the other RPC blends, it was used in this investigation. It was supplied by KOSTER Construction Chemicals of Kocaeli, Turkey. In the business world, this product is commonly referred to as KOSTER1 KB-Fix. The substance's properties must be verified at each and every stage of the investigation.

2.7 SUMMARY

Self-compacting concrete, or SSC, is a novel concrete technology that has significantly benefited the construction industry by eliminating many of the issues commonly associated with traditional concrete. Nano glass powder (NGP) is a viable alternative to cement in concrete production due to the presence of cementitious elements it contains. Nano glass powder, often known as NGP, can be produced either from recycled or newly manufactured glass. Since existing natural resources have been quickly depleted due to rapid population growth, urbanization, and industrialisation, more skyscrapers have had to be built to house the expanding human population. High-strength concrete is required to address not just the structural issue, but also the issue that is intrinsic to concrete. Carbon emissions can also be mitigated to some degree by cutting back on cement production or consumption. Sustainable building may be achieved, for example, through the recycling of old glasses into nano glass powder and the subsequent use of this powder in place of cement during construction. In that case, it's helpful to be able to withstand the onslaught of sulfates while simultaneously maintaining a green environment. Numerous studies [110-113] have examined the potential benefits of NGP in the production of high strength concrete and self-compacting concrete. However, there has been little effort made in the past to assess the mechanical and rheological properties of SSC that contains both NGP and steel fiber. There's no way around it; this must be completed. By doing this study as a single experiment, we were able to ascertain the synergistic effect of the NGP and the steel fiber. A small number of factors (such as the percentage of NGP that was replaced and the weight-to-capacity impact) were included in the field of sustainability assessment when relative investigations were conducted, as shown in the aforementioned literature study. Within the bounds of this investigation, we attempted to account for a spectrum of NGP percentages, from 5% to 25% with a 5% interval. Substituting this material can still yield acceptable strength if environmental impact is taken into account in the right way. Each test is carried out and an empirical relationship is created between the various parameters to determine the efficiency of NGP in structures using non-destructive testing. In addition, this work provides a comparison of the flexural behavior of DT with that of NDT regarding the NGP effect. The compressive strength test, the flexural strength test, and the fracture distribution analysis are all types of DT. Various correlations were compared with the results of the previous research by the established standards or codes in order to validate the predicted equations in the field of SSC or SFRC by using NGP and steel fiber, which had not before been recognized. This was done to ensure the reliability of the connections drawn.

3. RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this study, we carried out an experimental investigation on the strength of concrete beams using an SFRC model and nano-glass particles. High reinforcement ratio structural beams are more prone to shear and bending failure due to the stress placed on the connection between the beams. It is not always possible to solve practical problems using typical analytical techniques because concrete structures are complex due to the many materials used in their production. Complicating elements include the loading conditions, the existence of a recognized stress-strain relationship, and an accurate depiction of the boundary condition. For a fuller knowledge of phenomena like concrete fracture, yield strength in longitudinal and transverse reinforcement, displacement and strain conditions, and typical shear stresses, experimental methods are strongly advised. RC structures have a wide range of uses in the engineering sector. Such structures are typically developed or investigated using conventional experimental procedures, which necessitate the analysis of experimental data gathered in a lab environment.

3.2 MATERIAL PROPERTIES

The physical, molecular, and mechanical features of a product that define its usability and capabilities for mass manufacturing are known as its material properties. In this case, a product's capabilities would be precisely defined by its material characteristics. In the creation of concrete and bituminous, as well as as fill, base, and top layers in the construction of highways, sand and gravel are utilized as coarse and fine aggregates, respectively. In the mining sector, they are utilized for backfilling alongside cement and mill waste. River sand is frequently utilized for tasks involving concrete. Additionally, they can be utilized to build different block compositions. The particle texture and grain size distribution of this sand are more uniform. The river and dunes just need a small amount of water.

3.2.1 Fine Aggregate

Medium size sand from Euphrates river with a modulus of fineness = 2.20; normal grading with the silt content 0.8%, Specific gravity 2.677.

3.2.2 Coarse Aggregate

Crush gravel with a size of 5-20 mm and normal continuous grading was used. The crushing index d"6% and the specific gravity 2.738.

3.2.3 The Used Water

Concrete's compressive strengths, permeability, durability, weather resistance, drying shrinkage, and susceptibility to cracking are all affected by the amount of water used in its composition.

3.2.4 Superplasticizer

The addition of water to concrete admixture strengthens the material. The construction industry makes extensive use of this mixture. The pervasive use of this cement mixture in the delayed hydration process in a variety of construction domains raises the risk of additional degradation. In addition, this combination is particularly effective in humid climates. Superplasticizer admixtures are high-performance, long-lasting superplasticizers for concrete that enable the production of pumpable and flatwork-ready reinforced concrete with differing degrees of strength. The main additives used in the present work are:

a. Sikament R-7 N

Sikament is a water-reduction and set-delaying admixture for concrete.It's a plasticizer and retarder for concrete made from modified lignosulfonates. For tasks that need more time for concrete to cure and better workability, it is employed:

i. Large pours, to prevent formation of cold joints;

ii. Long travel times from the concrete plant to the site;

iii. On site mixing;

iv. High ambient temperature

Only set retarding, does not delay the hardening process; Allow cement reduction compared to plain concrete; Increase in ultimate strength; Good control of slump loss even at elevated ambient temperature; Reduced shrinkage and creep; Chloride free, does not attack reinforcement steel.

b. Stabilizer Aquagel

Aquagel, a biopolymer-based anti-washout additive, is a ready-to-use, powdered admixture designed specifically for submerged concrete. There is little loss of particles, including cement from newly mixed concrete, when the concrete is treated with Sika® Stabilizer Aquagel. water with these properties has exceptional rheological features:

i. Maintains cohesiveness

ii. Prevents segregation and washout

iii. Permits large placements without cold joints

iv. Maintains compressive strength

is recommended for use at 0.03 % to 0.25 % of cementitious materials (cement, fly ash, silica fume and slag).

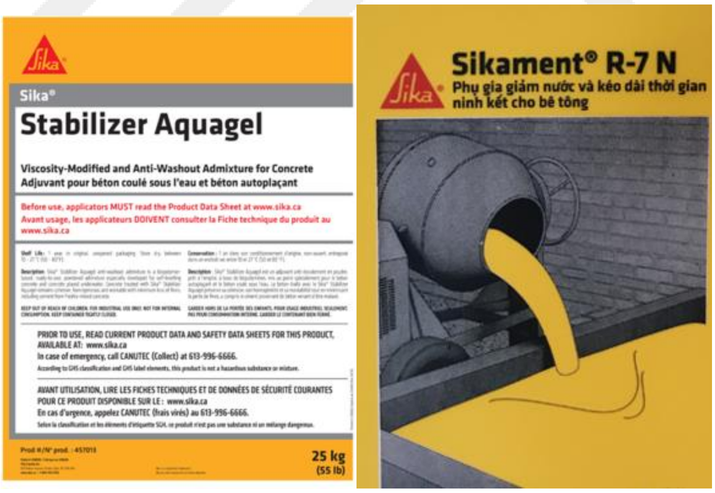

Figure 3.1: The Used Additives in The Present Work.

3.3 PROPERTIES OF CONCRETER MIXTURE

The self-compacting concrete differs from conventional concrete in the following three characteristic features, namely,

a. appropriate flowability,

b. non-segregation,

c. no blocking tendency. An increase in the flowability of concrete is known to increase the risk of segregation. Therefore, it is essential to have a proper mix design.

The elements listed in Table 3.1 were supposed to be combined.

Table 3.1: Mixing Design.

	material	Mix (1:1.8:2)
1	Cement (kg)	425
2	River sand (kg)	770
3	gravel (kg)	868
4	Super plasticizer 0.5%	2.13
5	Water in liters (W/C: 0/55%)	234

After numerous iterations, the ratio of conventional concrete to green concrete to waste was found to be 1:1:3. Both combinations had the same water-to-cement ratio of 0.55% by weight, which was determined by the properties of the individual components. Because testing and research have revealed that fibers are more active when mixed with fine aggregate, a water-reducing admixture was applied at a constant dose of 250 m1/50 kg to boost the workability of the cement. To achieve the requisite malleability, various kinds of superplasticizer were utilized. The type of project will determine the cement to choose. Prior to moving forward, it is crucial to assess the expected cement performance in the design mix. For this experiment, Kubaisa cement from western Iraq was used. The superplasticizer used is of the Type A variety and complies with ASTM C 494. It is thought that cement content has no effect on strength over a specific cement-to-aggregate ratio. In order to make concrete sufficiently strong when the cement concentration is too low, additional cement must be added to raise it to the minimum (American Society of Concrete Contractors, 2005). These investigations show a link between cement content and strength, defying the Abrams principle. The Cement to Water Ratio (W/C) and the degree of hydration of the cementitious materials, both of which affect the porosity of the cement paste and the interfacial transition zone between the coarse aggregate and the cement paste, determine the strength at a certain age. It is better to reduce the water content as the wet bulb's temperature rises because doing otherwise increases capillary porosity and lowers strength. This will also reduce the water-to-cement ratio.

3.4 TYPES OF ADDED MATERIALS

Fiber bridging activities at the fracture surface provide SFRC superior strain energy absorption and a high residual tensile strength in the postcracking zone. Flooring, housing, precast, bridges, tunneling, heavy duty pavement, and mining are just some of the many applications for SFRC's durability, increased strength, tensile strength, and stress resistance. They were created to raise the caliber of shotcrete and cementitious concrete. Industrial concrete beam systems commonly experience different kinds of high stress in addition to point loads from rack legs and dynamic loads from automotive traffic.The mechanical characteristics of SFRC have been the focus of in-depth study in recent years. Current research shows that SFRC offers many benefits over traditional concrete. Therefore, using SFRC might be a way to improve the mechanical performance of composite steel-concrete columns that are being bent negatively. Metallic reinforcement is used Short, discrete lengths of steel fiber with an aspect ratio (ratio of length to diameter) between 20 and 100, with varied cross sections, and tiny enough to be disseminated randomly in a mixture of unhardened concrete using conventional mixing processes make up steel fiber used for reinforcing concrete. Durability and improved concrete crack control in demanding industrial applications are the main goals in the development of steel concrete fibers. The material is transformed into a more ductile composite, enhancing the beam's longevity, strength, and capacity to absorb energy over time. This is accomplished by equally distributing steel fibers throughout the concrete. The fiber's specific density was 7.8 g/cm3. Initially, a Diagonal rotations mixer with three paddles was used to thoroughly combine the dry materials (sand, gravel, cement, and silica fume). The components needed to be combined in order to create a uniform mixture, and that is exactly what was done. The water is gradually introduced in this process, then the fibers. The material can be molded once the filaments have been added.

Figure 3.2: SFRC Fiber Type 1.

Figure 3.3: SFRC Fiber Type 2.

Nano glass is used in this situation as a supplement. If you want to expedite the laying and solidifying of concrete, add some glass granules to the plastic concrete. Cement, grit (fine particles), and coarse aggregate are the three main ingredients in concrete. Compressive strength can be engineered by varying the ratios of cement, grit, and aggregate in the concrete mixture. The cost-effectiveness and output of concrete building are enhanced by the thoughtful composition of the concrete grade mix. The price of concrete construction can be decreased with careful concrete mix design. Concrete gains strength, freeze-thaw resistance, and sulfate resistance when glass particles are added. Nanomaterials offer a huge potential for increasing the qualities of concrete (features including water permeability, abrasion resistance, and pore structure; mechanical properties like compressive strength, split tensile strength, and flexural strength) because of their tiny fragment size and increased surface area. The nano glass used for this experiment is shown in Figure 3.4.

Figure 3.4: Nano-Glass Powder.

Table 3.3 : The Nano-Glass Characteristics

component	content %
Sodium oxide (Na2O)	10.46
Aluminum oxide (Al203)	3.52
Calcium oxide (CaO)	10.59
Iron oxide (Fe2O3)	1.77
Potassium oxide (IC20)	0.89
Magnesium oxide (MgO)	1.56
Sulfur trioxide (SO3)	0.03
Loss on ignition (L01)	0.6
Silicon dioxide (SiO2)	71.09

3.5 PRODUCTION SAMPLES

When Portland cement and aggregate are combined with water, a fluid slurry is produced that can be readily poured and shaped. Using a process known as concrete hydration, which involves a reaction with the cement to solidify it, concrete binds its constituents into a stone-like substance over the course of several hours. During this period, not only can concrete be poured into molds, but also a variety of prefabricated instruments and processes can be manufactured. Before pouring concrete, reinforcing components (such as steel rebar) are embedded to enhance the material's tensile strength, resulting in reinforced concrete.To evaluate a broad range of fracture velocities in a single experiment, it was necessary to develop a specimen shape that would facilitate the interaction of reflected stress waves with the crack point during its rapid propagation. The selected model specimens have the dimensions depicted in figure 3.2: 15 cm * 15 cm * 15 cm cubes, 200 cm * 100 cm cylinders, and 100 cm * 100 cm * 500 cm blocks.

Figure 3.5: Project Mold Samples.

3.6 PROCESS

In the first stage, dried components such as sand, gravel, cement, and additives are thoroughly mixed by rotating them in a mixer. Everything was combined until it formed a solid mass. Slowly and cautiously adding water to the mixture, followed by the fibers, produces a casting slurry. The mold was generously lubricated so that the concrete sample could be removed without adhering to the mold.

Figure 3.6: Oiling The Molds.

A specific quantity of sand is evenly distributed. The required amount of cement is applied to the sand and then distributed out. Next, the sand and cement are worked with a spade until the color is uniform and there are no visible streaks, until the mixture has a uniform color and no visible streaks.For freshly poured concrete of high quality, it is essential that its constituents are thoroughly mixed. During mixing, the aggregate particles are coated with cement material. Concrete must be correctly mixed for optimal workability and performance in both the fresh and hardened states. Segregation and bleeding are prevalent problems in concrete that has been improperly mixed. Determine how much of each ingredient will go into the final product before combining the ingredients to create a homogenous aggregate. There has been a great deal of research into the effects of various types and quantities of materials on performance, but much less into the effects of mixing on its qualities. To make the panel, a vibrating machine was used to force the ready mixture into the mold. Using a steel fiber cylinder as a standard mold, three layers of normal concrete were cast, with accurate rod leveling between each layer. The specimen was vibrated until the air bubble broke through the outer layer. Three samples of the material should be cast in each of the three different cases in order to acquire reliable readings of the material's compressive strength, modulus of elasticity, and tensile strength. The timbers are vibrated from the outside with a vibrator while the mold is filled with concrete.

Figure 3.8: Casting Process.

The moisture content of soil (also known as soil moisture), rock, pottery, and wood can be estimated by weighing two separate samples at various times. Numerous scientific and technical fields make use of the water content ratio, which varies from 0 (totally dry) to the material's porosity at saturation.

3.7 TESTS FOR CONCRETE PROPERTIES

3.7.1 Compressive Strength Test

Since the strength of concrete is directly connected to the composition of the hydrated cement mortar, a compressive strength test may be used as a proxy for evaluating the quality of concrete. Samples of concrete might be tested using a compression test to monitor their strength development over time. Cube specimens' compressive strength was evaluated at 7 and 28 days (BS 1881: Part 103: 1983). The compressive strength of concrete cylinders may be properly determined using these methods. A compressive axial force is given to the sample till failure after it has been prepared and placed in the machine's center.

Figure 3.9: Compressive Test Machine

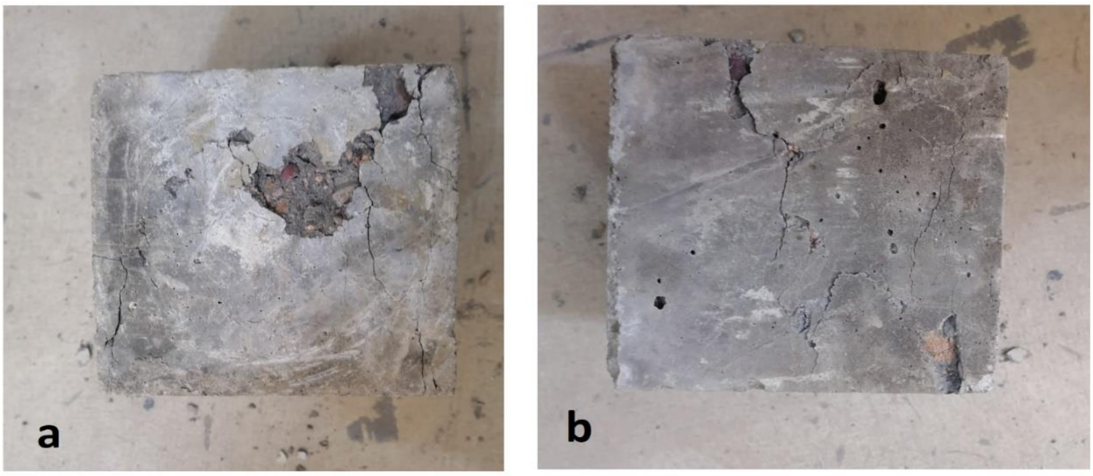

Figure 3.10: Results of Cubes Compression test, a) Plain Concrete, b) Concrete with SFRC.

3.7.2 Splitting Test

The split tensile test is a complex method for evaluating the tensile strength of concrete. In this test, a cylindrical specimen is inverted and subjected to a radial force on its surface in order to induce a vertical fracture throughout its whole diameter.The tensile strength of the concrete used to construct a building has a considerable impact on the likelihood of cracking. Because of its fragility, concrete is also very susceptible to strain. Therefore, it is quite unlikely to withstand the stress. Tensile stresses in concrete that exceed its tensile strength cause the material to crack. To determine the strain at which concrete members could break, their tensile strength must be determined. The tensile strength of concrete may also be measured by seeing how much force it takes to crack a concrete cylinder during a tensile strength test.IS 5816 1999, like with other similar norms, takes its cues from ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen). In the following sections, we'll discuss in detail how to conduct a split cylinder test on a concrete specimen.

Figure 3.11: Splitting Test Machine.

Figure 3.12: Splitting Test Result.

3.7.3 Flexural Test Machine

Applying an increasing longitudinal compressive force on concrete cylinders during the measurement yields the results of the flexural test. The ability to specify longitudinal stresses using a bonded or unbonded sensor makes it easier to determine the average deformation between two sites that are diametrically opposite. After developing flexural cracks, all of the tested beams ultimately collapsed in flexure, crushing concrete in the compression zone. The largest bending moment was concentrated in the space between the two point loads, where the first visible fractures appeared. Concrete specimens strengthened by copper slag replacement may withstand greater pressures, as seen by the load deflection curve. The flexure failure energy absorption of these beams was calculated by finding the area under the load vs. deflection curves. Based on the measured values, it was found that the copper slag-replaced beams had higher energy absorption values. The fact that the beams are ductile may be to blame for the increase in beam energy absorption.

Figure 3.13: Flexural Test Machine.

Figure 3.14: Flexural Test Result.

Figure 3.15: Results of Flexural Samples Test.

The machine was stopped and the crane pulled away after the maximum weight was applied so that further data could be collected on the final fractures and failure patterns. As can be seen in Figure 3.14, after the radius of failure has been determined, the sample is photographed, and a new sample is placed to the testing device.

4. RESULTS AND DISCUSSION

Flexural strength is the capacity of a material to withstand bending forces that are perpendicular to its longitudinal axis. The flexural strength of restorations that will be subjected to significant pressure or tension must be exceptional. Consequently, flexural strength also determines the applications of a given material: The greater the potency of a material, the more units that can be restored. Field samples of beams must be accurately prepared. Flexural assays are extremely sensitive to sample preparation, curing, and handling. Due to their weight and fragility, transporting beams from the construction site to the facility may be hazardous. Allowing a beam to dry out causes it to weaken. Beams are required to undergo standard curing and damp testing. Self-compacting or self-leveling concrete is a form of concrete that compacts and levels itself using only gravity. After it has been distributed and poured into the reinforced forms, this concrete does not require mechanical consolidation. Recent innovation in the construction industry is self-compacting concrete. It is also known as self-compacting concrete, self-leveling concrete, high performance concrete, super-workable concrete, highly-flowable concrete, and non-vibrating concrete. The revolutionary concrete permits the complete filling of formwork without the typical concomitant vibrations.

In addition, as stated in Chapter 3, a super-plasticizer is frequently required to achieve substantial mobility in self-compacting concrete. Adding a substantial amount of powdered substance is a surefire method to eliminate segregation. Self-compacting concrete's powder components enable it to achieve these objectives while keeping costs low. Numerous fillers and admixtures, including SFRC and Nano-glass powder, silica fume, lime stone powder, glass filler, quartzite filler, and pulverized granulated blast furnace slag, can be utilized in concrete. The mechanical properties and durability of concrete can be improved by substituting additives for cement. Additives is either a byproduct of thermal power facilities or a fine organic material with pozzolanic properties. Glass is available in numerous forms, including bottles, sheets, lamps, and cathode ray tubes. Therefore, recycling glass is necessary so that it can be reused. Nano-glass has a multitude of applications in the construction industry.

4.1 RESULTS OF THE MECHANICAL PROPERTIES TESTS

The use of SFRC and nanoparticles enhances the cementitious materials' mechanical attributes, hastening the emergence of early strength in concrete. Improved flexural, fracture, and compressive capabilities are revealed in the initial testing at a very early stage. The strengthening process of nanomaterials was encouraged by the pozzolanic infill effect, nucleation effect, and bridging development, according to this review. The Cube Test is carried out using three separate samples of each type of concrete.

Table 4.1: Results of Self-Compacting Concrete's Samples.

test number	concrete mixing properties	compressive strength Mpa	splitting strength Mpa	flexural strength Mpa	description
1	reference	35.65	3.53	6.63	Plain concrete
2	sfrc1 30	36.37	3.57	6.76	Concrete with 30kg/m3 SFRC 1st type
3	sfrc1 40	37.82	3.58	7.03	Concrete with 40kg/m3 SFRC 1st type
4	sfrc1 60	39.22	3.62	7.29	Concrete with 60kg/m3 SFRC 1st type
5	sfrc2 30	35.98	3.54	6.69	Concrete with 30kg/m3 SFRC 2nd type
6	sfrc2 40	36.43	3.54	6.78	Concrete with 40kg/m3 SFRC 2nd type
7	sfrc2 60	38.69	3.59	7.20	Concrete with 60kg/m3 SFRC 2nd type
8	nano-glass 2.5	34.69	3.45	6.45	Concrete with nano glass 2.5%
9	nano-glass 5	36.77	3.48	6.84	Concrete with nano glass 5%
10	nano-glass 7.5	33.94	3.51	6.31	Concrete with nano glass 7.5%

The ingredients and proportions used in each set of tests are the same because they are needed in equal amounts to create concrete with the desired consistency and strength. At room temperature, all elements of concrete can be mixed. According to the mixing design described in chapter three, weight and volume calculations must be used to estimate the appropriate amounts of cement, aggregates, and water for each mix. Each batch of concrete produced approximately 10% additional concrete after being utilized to create the necessary number of test specimens. The cubes have been kept for the past 24 hours, give or take a half hour, in a room with a relative humidity of at least 90% and a temperature of 27 degrees Celsius, plus or minus 2 degrees Celsius. They were held at a temperature of 2 degrees Celsius (27 degrees Celsius) in clean, fresh water.

4.2 FLEXURAL DEFLECTION RESULTS

4.2.1 Nano-Glass Deflection Effect

The laboratory data for compressive strength are displayed in Table 4.1 and 4.2. Figure 4.1 depicts the consequences of using nano glass powder in cement after 28 days. The chemical composition of the glass particle reaction may be to blame for this result. The success rate increases to 5% after 28 days. The cumulative percentage increase and compressive strength both increase at 5% cement replacement. The increased compressive strength that results from using recycled nano glass powder in lieu of or in addition to conventional materials is due to the powder's fineness. The consequences are a better pozzolanic silica reaction and better filling between cement paste and aggregate. The maximum fracture strengths observed for the 7.5% replacement are 3.51 MPa. Based on the findings, this strategy is advantageous for recycling and waste reduction during the concrete construction process. The former yields superior results and is an efficient strategy for reducing cement consumption, which in turn reduces the environmental impact of cement production.

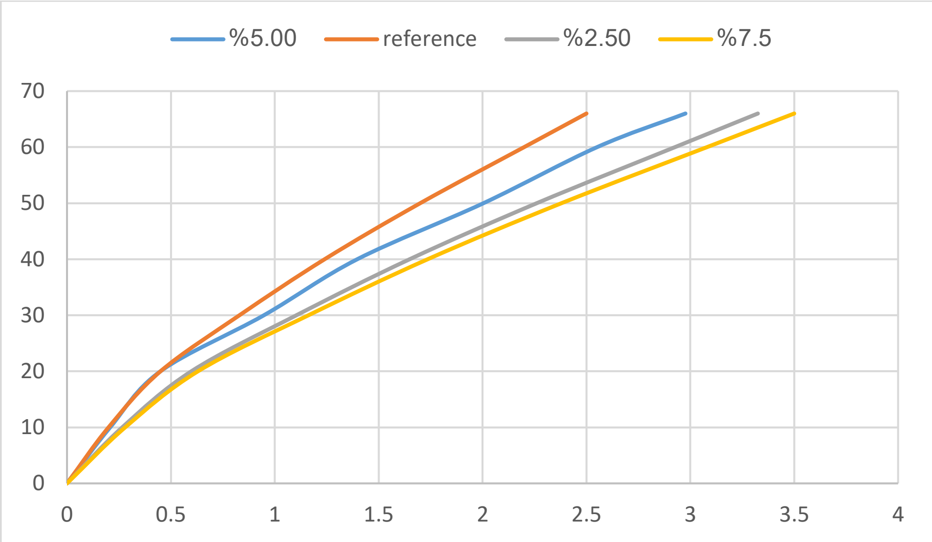

Figure 4.1: Results of Nano-Glass Effect.

Table 4.2: Numerical Results of Nano-Glass Effect.

load kN	plain concrete	2.5% nano-glass	75% nano-glass	7.5% nano-glass
10	0.20	0.27	0.21	0.28
20	0.45	0.60	0.45	0.63
30	0.83	1.10	0.95	1.16
40	1.24	1.65	1.40	1.74
50	1.70	2.26	2.00	2.38
60	2.20	2.93	2.55	3.08
70	2.50	3.33	2.98	3.50

The present strength information about the concrete members can be used to understand their fracture and deflection behavior. The fracture and flexural tensile strengths of the concrete must be carefully taken into account during design since they affect the flexural and shear members. For the sake of these evaluations, homogeneity substitutes for stability or resistance to segregation. The mixture is made using high-range water-reduction admixtures. Additionally, the addition of a chemical effect or the incorporation of particles into the concrete both guarantee segregation resistance. The increase in price of self-compacting concrete is mostly due to these admixtures that vary viscosity.

4.2.2 SFRC type 1 Deflection Results

Calculating the flexural strength by analyzing the compressive and tensile tensions present in the bending failure zone. In contrast, the compression load, which induces pure tensile stress along the diameter of the specimen, determines the failure point for dividing tensile strength. If the same material were only subjected to tensile forces, each fiber would be subjected to the same amount of tension, and the material would fail as soon as the weakest fiber reached its tensile limit. Consequently, it is not uncommon for the flexural strength of a material to exceed its tensile strength. The bending test involves both tensile and compressive forces, so the flexural strength is typically greater than the tensile strength. When these two forces cooperate, the contribution of the fibers to the flexural strength increases. Observations in a mixture follow a similar pattern; at a stress of 26 kN, or approximately 40 percent of the ultimate failure load, the first fracture was detected within the flexural zone. The bridging effect of discontinuous fibers allows for increased strength in fiber-reinforced concrete (FRC). Thus, SF improves concrete's durability, brittleness resistance, and compressive strength. To maximize durability, steel fiber should be added to concrete at a rate of between 0 and 1 percent. For better mechanical qualities and fracture resistance, concrete is reinforced with natural and synthetic fibers.

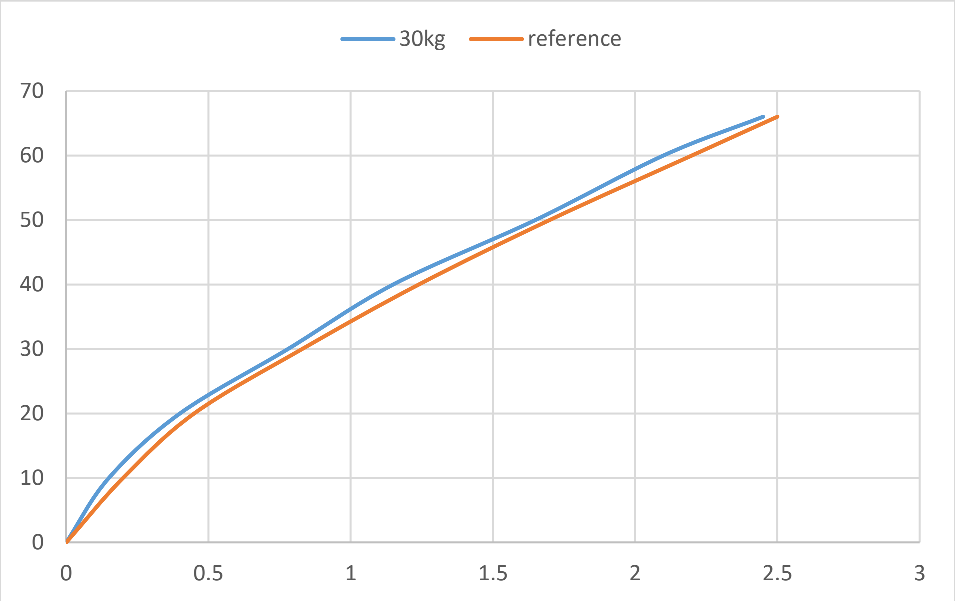

Figure 4.2: Compression Results of Plain Concrete and Concrete with 30 kg/m3 SFRC-1.

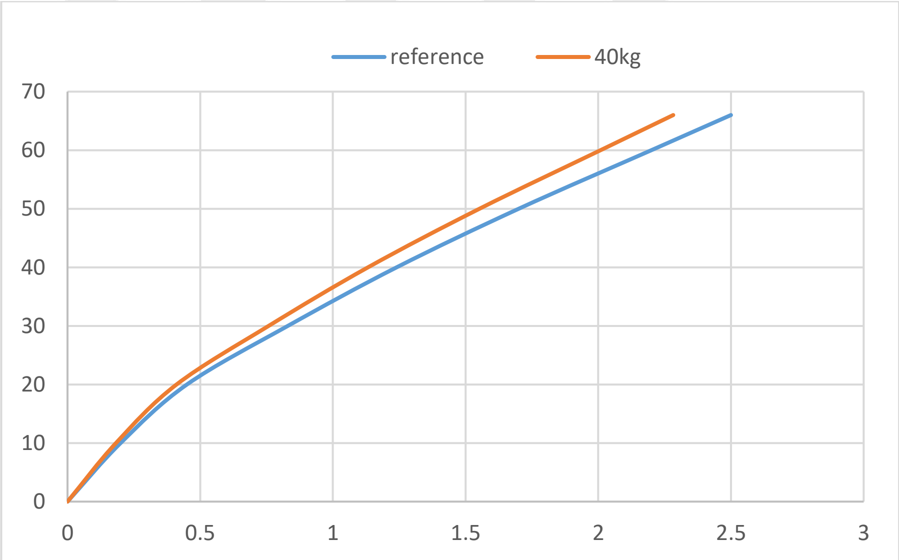

Figure 4.3: Compression Results of Plain Concrete and Concrete with 40 kg/m3 SFRC-1.

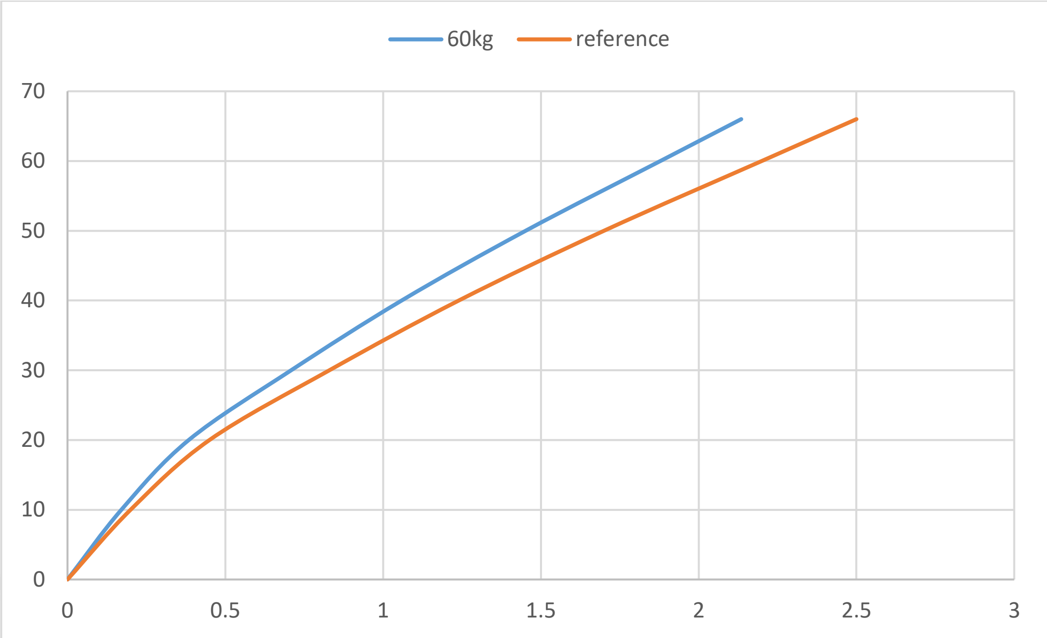

Figure 4.4: Compression Results of Plain Concrete and Concrete with 60 kg/m3 SFRC-1.

Table 4.3: Numerical Results of SFRC Type 1 Effect.

load kN	plain concrete	concrete with 30kg SFRC	concrete with 40kg SFRC	concrete with 60kg SFRC
10	0.20	0.15	0.18	0.17
20	0.45	0.40	0.41	0.38
30	0.83	0.78	0.76	0.71
40	1.24	1.15	1.13	1.06
50	1.70	1.65	1.55	1.45
60	2.20	2.10	2.01	1.88
66	2.50	2.45	2.28	2.14

A fracture happened in the 28 kN to 66 kN stress range. These cracks started in the flexural zone of the beam and advanced toward the compression zone when the load was gradually increased. Under modest stresses, the fractures, which are widely separated and appear, occur; however, they do not result in the formation of new cracks. Early-stage cracks are brought on by moderate flexural stresses brought on by the applied loads and the beam's own weight, as well as internal expansion and contraction of concrete components. The tensile strains that formed at the bottom fibers when the weight was gradually placed exceeded the concrete's flexural tensile stress**.**

4.2.3 SFRC Type 2 Deflection Results

When testing splitting tensile strength, the compression force that generates pure tensile stress along the specimen's diameter determines the precise location at which the specimen breaks. The material would break as soon as the weakest fiber reached its tensile limit if the identical material was simply extended; each fiber would be stretched by the same amount. As a result, it is common for a material's bending strength to be greater than its pulling strength. Since both tensile and compressive pressures are used during the bending test, the flexural strength is typically greater than the tensile strength. The fibers' contribution to the flexural strength increases when these two stresses combine. A combination shows a similar pattern of observations. At a stress of 22 kN, or around 43% of the final failure load, the first crack was discovered in the flexural zone. By employing fibers that are not connected to one another, fiber-reinforced concrete (FRC) can be made stronger. This is due to the fibers' ability to fill in gaps. Concrete becomes stronger, more brittle-resistant, and able to support more weight when SF is added to it. The ideal range for steel fiber addition to concrete is 0%–1%. The concrete will survive longer as a result. To make concrete tougher and less prone to cracking, it is fortified with synthetic and natural fibers.

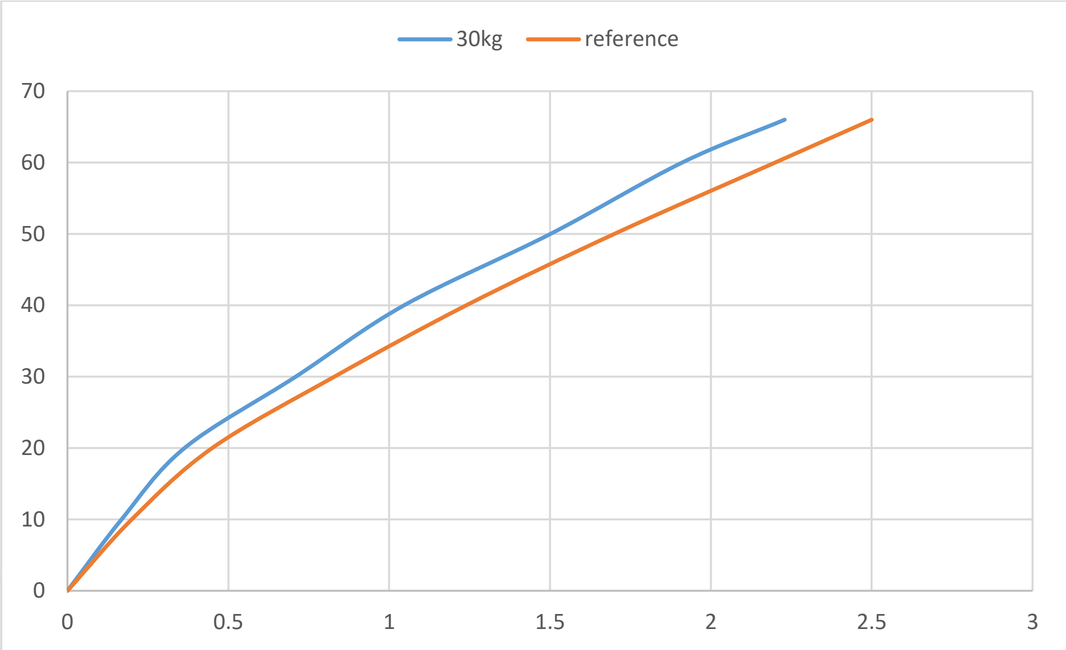

Figure 4.5: Compression Results of Plain Concrete and Concrete with 30 kg/m3 SFRC-2.

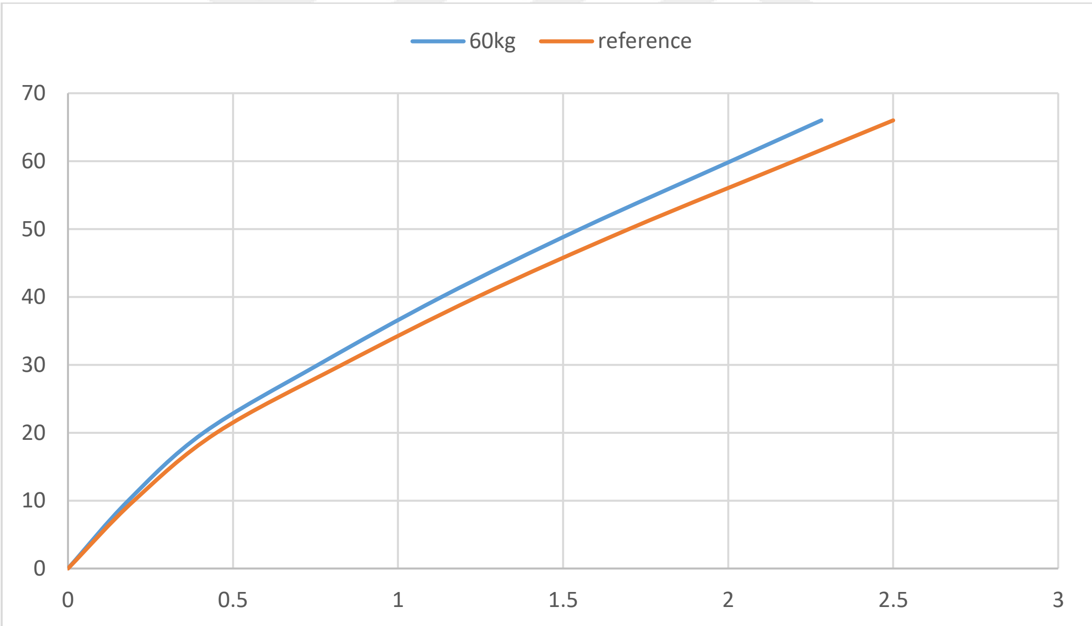

Figure 4.6: Compression Results of Plain Concrete and Concrete with 60 kg/m3 SFRC-2.

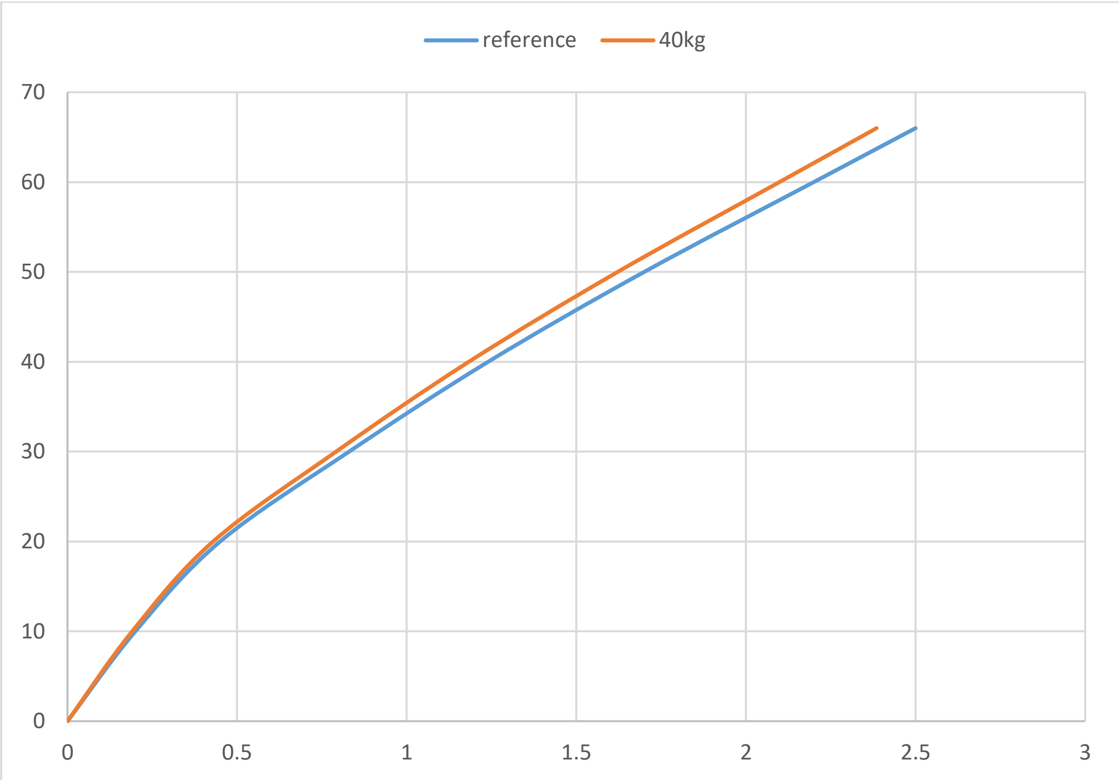

Figure 4.7: Compression Results of Plain Concrete and Concrete with 40 kg/m3 SFRC-2.

Table 4.4: Numerical Results of SFRC Type 2 Effect.

load kN	plain concrete	concrete with 30kg SFRC	concrete with 40kg SFRC	concrete with 60kg SFRC
10	0.20	0.17	0.19	0.18
20	0.45	0.36	0.43	0.41
30	0.83	0.71	0.79	0.76
40	1.24	1.05	1.18	1.13
50	1.70	1.50	1.62	1.55
60	2.20	1.91	2.10	2.01
66	2.50	2.23	2.39	2.28

A fracture took place when the stress levels were anything from 23 kN to 66 kN. These cracks started in the flexural zone of the beam and progressed toward the compression zone as the load was gradually raised. The beam had two zones: the flexural zone and the compression zone. The fractures are widely spaced apart and manifest themselves under modest stresses; nonetheless, they do not cause more cracks to occur as a result of their presence. In the early phases of cracking, they are induced by the moderate flexural stresses that are a result of the beam's own weight and the applied loads, as well as the internal expansion and contraction of the concrete elements themselves. The flexural tensile stress of the concrete was eventually exceeded by the tensile stresses created at the bottom fibers as the weight was progressively increased.

5. CONCLUSION AND RECOMMENDATION

The effects of nano-glass powder and two types of SFRC distributions when used in producing concrete beams, the mechanical behavior of concrete with cement levels were investigated in this work. The following observations are made in light of the results:

a. adding 5% of the nano-glass powder with the other materials raises both the cumulative percentage gain and the compressive strength. The fineness of recycled nano glass powder contributes to the material's higher compressive strength when used in place of or in addition to coarser materials. As a result, the reaction between the pozzolanic silica and the cement paste improves, as does the filling between the aggregate and the paste. The highest fracture strengths measured were 3.51 MPa for the 7.5% replacement. The results indicate that this approach is useful for minimizing waste and maximizing recycling in the production of concrete. The former is more effective in lowering cement use and, by extension, the environmental impact of cement manufacture, and it produces superior outcomes.

b. The flexural strength is often higher than the tensile strength since the bending test incorporates both tensile and compressive forces. The contribution of the fibers to the flexural strength is enhanced when these two forces work together. Similarly, the initial fracture within the flexural zone was observed at a stress of 26 kN, or around 40% of the final failure load. Due to their bridging effect, discontinuous fibers can be used to boost the strength of fiber-reinforced concrete (FRC). Thus, SF improves concrete's durability, brittleness resistance, and compressive strength. Incorporating steel fiber into concrete at the optimal level (between 0 and 1 percent) increases its longevity. Natural and synthetic fibers are used to strengthen concrete, increasing its strength and durability.

c. a minor shift in load-deflection behavior, which had been linear up to the yield point where the deflection was measured. The load-deflection curve entered the plastic zone well beyond the point when the reinforcement yielded, remaining almost horizontal all the way up to the ultimate/failure load.

5.1 RECOMMENDATION

The researcher recommend to investigate the effect of high temperature on the present research's

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