



REPUBLIC OF TÜRKİYE

ALTINBAŞ UNIVERSITY

Institute of Graduate Studies

Civil Engineering

**STRUCTURAL BEHAVIOR OF REINFORCED
CONCRETE BEAMS INCORPORATING STEEL
FIBERS AND NANO-GLASS POWDER**

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Master's Thesis

Supervisor

Prof.Dr. Zeki HASGUR

Istanbul, 2023

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The thesis titled STRUCTURAL BEHAVIOR OF REINFORCED CONCRETE BEAMS INCORPORATING STEEL FIBERS AND NANO-GLASS POWDER prepared by ENAS FAEK HAMADI and submitted on 00/00/2023 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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ABSTRACT

STRUCTURAL BEHAVIOR OF REINFORCED CONCRETE BEAMS INCORPORATING STEEL FIBERS AND NANO-GLASS POWDER

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Date: August/2023

Pages:86

Structural concrete performance has a different characteristic from those of regular concrete at the different levels of structural elements and their effects on capacity. This is done by evaluating the structural acts that steel fibers and nano glass particles in molding the behavior of concrete material and affect the shear resistance. This thesis investigates the impact on concrete of varying the concrete percentage, water-to-cement ratio, nano-glass powder content, and SFRC impacts based on 331 kg and 486 kg of cement. The results show that increasing the nano glass powder decreased the cement beam reliability properties while SFRC percentages were shown to increase beam reliability. The splitting results were reduced by the nano glass powder, and the flexural results improved as the SFRC was raised.

Keywords: SFRC, Nano-Glass Powder, W/C Ratio, Flexural Strength. Compressive Strength, Splitting Strength.

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ABBREVIATIONS

SFRC : Steel Fiber Reinforced Concrete

SF : Silica Fume

C-S-H : Calcium Silicate Hydrate

PP : Polypropylene

PE : Polyethylene

PA : Polyamides

PIA : Polyvinyl Acetate

PES : Polyester

1. INTRODUCTION

1.1 OVERVIEW

the structural design involves the structural beams to provide additional stability. The structural beam, which can be composed of steel, concrete, or wood, is used to span an open region and support a very heavy object. Commonly, steel I-beams are encased in concrete to produce concrete structural beams for use in the construction of bridges, buildings, and other concrete structures. In a structural system, the principal function of a beam is to resist loads that are perpendicular to the beam's axis[1]. The primary mode of deflection exhibited by the subject in question is bending. The magnitudes of the reaction forces exerted at the supports of a beam exhibit a linear relationship with the magnitudes of the loads applied to the beam. The accumulation of all forces acting on a beam results in the generation of internal stresses, strains, and deflections. These internal effects are exhibited within the beam in the form of bending moments and shear forces. The defining attributes of a beam encompass its mode of sustenance, the configuration of its cross-sectional area, the state of balance, its extent, and its composition. Power series methods are utilized to investigate finite beam problems. This involves generating a power series distribution that is dependent on the beam's deflection, contact stress, and external loading. The aforementioned methodologies represent a subset of the numerous techniques that have been devised for the assessment of beams situated upon a cohesive elastic substrate [2]. The boundary value problems of multilayered elastic materials have been addressed by several techniques over the past few decades, such as the transfer matrix approach, the stiffness matrix method, the finite layer method and the analytical layer-element technique. These techniques have made it possible to examine concrete beams for the first time. Current methods fall short of defining beam characteristics precisely. In the Code for design of concrete structures, the concrete equivalent coefficient values for various concrete grades are supplied[3]. Only near the edge of the concrete compression zone, when the compressive strain is at its greatest intensity, does this analogy hold true. The conversion factor prescribed by the code cannot be used to perform a section load analysis on a reinforced concrete beam that has not yet achieved its maximum condition. There have been many studies done up to this point on the stress and deformation of reinforced concrete beams. Researchers have looked at how secondary loading affects a beam's overall bearing capacity. The impact of the initial strain

on the eventual bearing capacity of the beam, as well as the factors that influence, as well as the effects of, the lagging strain, are all discussed in a variety of references. Comparable research includes a range of mixing and additive design strategies, as well as the forced examination of a number of states under a number of distinct circumstances. This is why we need more research funding and real data[4].

1.2 NANO-GLASS POWDER

Nanoscale materials are those with exceptional optical, magnetic, or electrical properties and at least one crucial size below 100 nm. Nanoscale particles, such as ultrafine particulate matter, are virtually ubiquitous. Nanotechnology has acted as both a theoretical framework and a practical tool since its creation. It is a small representation of humanity's endless pursuit of cosmic comprehension. As stated previously, nanotechnology has a significant impact on the construction industry. Materials with nanoscale particle size can have vastly superior properties compared to those with conventional grain size and the same chemical composition. Due to their unique physical and chemical properties, nanomaterials have the potential to facilitate the creation of cutting-edge, more efficient materials[5]. Nanoparticles are capable of doing tasks that would be challenging for larger particles. In addition, the introduction of nanoscale materials science has given civil engineers a fresh viewpoint on the characteristics, durability, cost savings, and energy efficiency of conventional building materials such as cementitious materials and steel. Due to the fact that nanoparticles are smaller than bulk materials, their characteristics may vary[6]. They show the relationship between macroscopic and subatomic structures. As the number of atoms on a substance's nanoscale surface increases, the substance gains unexpected and intriguing features. In addition to their filler function, nanoparticles (often SiO₂, TiO₂, etc.) produce a network of chemical contacts with the cement hydration products and, in certain instances, serve as the crystal nucleus of the calcium silicate hydrate (C-S-H) gel. By filling the spaces between the cement grains, the cement paste is compressed. To improve the microstructure of cement-based materials, the entire system will transform into a dense network structure centered on nanoparticles. These nanoparticles cannot be widely incorporated into cement-based composites due to the difficulty and expense of their production. For the future development of the building industry, novel nanoparticles as an alternative to conventional nanomaterials with high performance at a fair cost and a straightforward production procedure are required.

Consequently, it minimizes the amount of cement used in concrete, and it is also regarded an environmentally benign building material. Therefore, this substance will be used as a concrete additive in the present thesis to improve the concrete's properties[7][8].

1.3 HIGH STRENGTH CONCRETE

Concrete with a compressive strength of at least 55 MPa (8000 psi) is regarded to be of high strength. The functionality and longevity of high-strength concrete surpass those of its conventional counterpart. In order to accomplish their numerous desired effects, these designed concretes are composed of both common and uncommon components. The manufacturing and maintenance of high-performance concrete may necessitate specialized techniques, including but not limited to mixing, placing, and curing[9]. Frequently, comprehensive performance evaluations are required to demonstrate that a project satisfies its requirements. Due to its extraordinary strength, durability, and modulus of elasticity, high-performance concrete has found broad application in tunnels, bridges, and skyscrapers. It has also been utilized in shotcrete repair, pole building, parking garages, and agriculture, among other applications[10]. The characteristics of high-performance concrete vary based on the intended application and the surrounding environment:

- a. High strength
- b. High modulus of elasticity
- c. High early strength
- d. High abrasion resistance
- e. Low permeability and diffusion
- f. High durability and long life
- g. Resistance to chemical attack
- h. Toughness and impact resistance
- i. High resistance to frost
- j. Volume stability

- k. Compaction without segregation
- l. Ease of placement
- m. Inhibition of bacterial and mold growth

For that, in the resent work, the HSC will be used to investigate the properties of the used concrete with the new laboratory conditions.

1.4 FIBER REINFORCED CONCRETE

Concrete that has been strengthened with fibers is called fiber-reinforced concrete. Modern composite materials excel in terms of both structural integrity and dependability. The fibers used to support the concrete are short and distinct, and they are randomly orientated and distributed throughout the material. Separate strands have been linked to fine and coarse particles[11]. Fibers added to concrete strengthen the material and reduce the concrete's tendency to crack. The mechanism of concrete failure is affected by a number of factors, such as loading speed and concrete size. Under these stresses, rebar or steel rods can only exert so much force before they break or slip out of the concrete. Addition of fibers to the matrix of concrete increases its strength[12]. Fibre-reinforced concrete causes the fault type to behave differently, as seen in Figure 1.1, with multiple little fractures rather than a sinuous pattern.

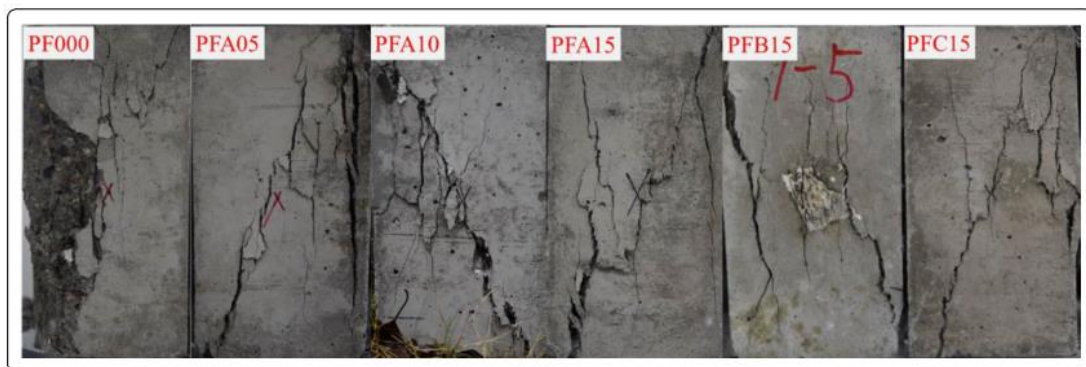


Figure 1.1: FRC Additives Concrete Enhancement [13].

Among the fibers, a wide variety of materials can be discovered. Cement matrices contain synthetic fibers such as polypropylene (PP), polyethylene (PE), acrylics (RAN), polyamides (PA), polyvinyl acetate (PIA), polyester (PES), carbon, and aramid[14]. Figure 1.2 displays

an assortment of commonly accessible fiber types. Steel fiber reinforced concrete is one of the most modern types of concrete (SFRC). You may consider it a composite material in which the fibers serve as the additional components. Fiber reinforcement works by inserting hard inclusions into the matrix of the concrete, where their tensile strength boosts the overall material's strength. Due to the intrinsic material properties of fibers, the introduction of fibers into concrete increases the resistance of traditionally reinforced structural components against deflection, cracking, and other serviceability conditions. There are three distinct methods for incorporating fiber reinforcement into concrete. One alternative is random one-dimensional distribution, which boosts fiber shear resistance and crack control[15]. When the SFRC mechanism's load increases, it displays unanticipated behavior. Once concrete begins to crack, the steel fibers within it will assume the load, transferring the mechanism's dependence to the shape and characteristics of the steel fibers alone. There are numerous ways to obtain steel, including the manufacturing of hot melt extract and the slicing of wires machined from ingots or steel sheets. The two basic varieties of steel fibers are smooth and deformed. As seen in Figure 1.2, it is available in numerous shapes, including circles, rectangles, hooks, and others[16].

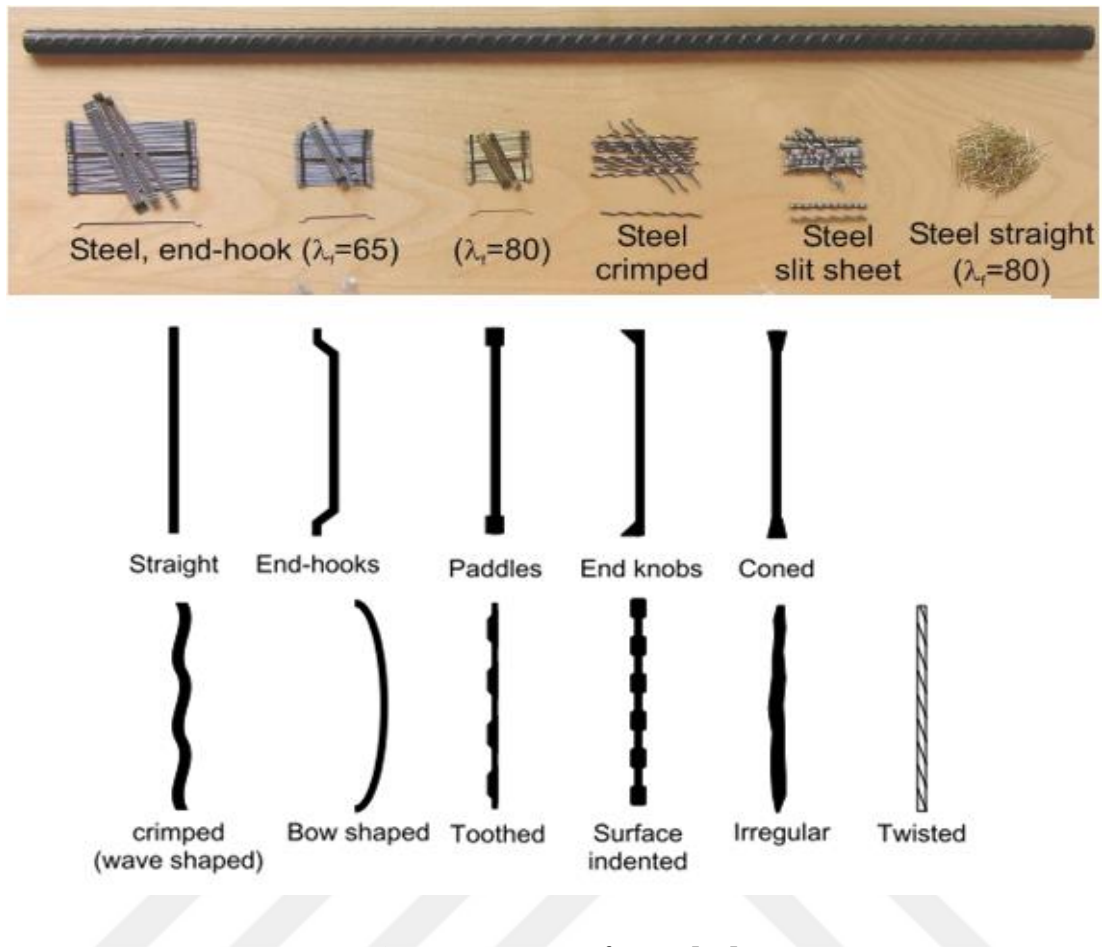


Figure 1.2: Types of SFRC[17].

Due to the influence of surface area, the cement matrix adheres more strongly to the deformed steel fibers, making them more resistant to separation. The likelihood of a fiber bursting or cracking is dependent on both the length of the steel and the strength of the concrete. There are numerous sorts of steel fibers, including high tensile steel fibers, stainless steel fibers, and common steel. The steel's characteristics vary based on its production method. The properties of steel are altered during either the hot or cold working operations. The straight, undeformed fibers must rely on friction and chemical adhesion to bond with the concrete. The lengths of steel fibers range from 10 mm to 65 mm, and their diameters range from 0.5 mm to 1.2 mm.

1.5 PROBLEM STATEMENT

The most prevalent type of concrete, Portland cement concrete, can be poured or molded into practically any shape or surface texture, and it is also strong, resilient, adaptable, and cost-effective. However, structural beams may endure displacements and internal forces

when loaded. Due to its construction, shear and torsional reinforcement cannot be added to beams. Failure may occur unexpectedly owing to shear and/or torsional forces. Recent extensive experimental research has utilized fibers and chemicals to improve beam performance. Among the several benefits of fibers is a reduction in plastic shrinkage cracking in terms of the total number of cracks and their maximum width and area. Moreover, the incorporation of fibers dramatically decreased crack indexes. The additions known as nanoparticles also improve the mechanical properties of high-strength concrete. The ACI363 seems suitable for evaluating concrete quality, but it cannot yield precise findings. Regarding compressive strength and further characteristics. In engineering practice, control determination and quantifying the effects of the major effective components are context-dependent. External stresses are primarily responsible for deflection reaction and fragility. The brittleness and limited performance of concrete are attributed to the concentration of shear stress and the structural behavior effect. Despite the extensive research conducted on the subject matter, several issues remain unresolved. These include the challenge of enhancing both the strength and ductility of concrete concurrently, as well as the interplay between reinforced concrete and multiple additives.

1.6 OBJECTIVES AND SCOPES

An experiment was conducted to investigate the effect of multi-additives on the residual toughness of high strength concrete beams. In order to attain this objective, various forms of reinforcement are analyzed:

- a. This study aims to compare the mechanical characteristics of the residual behavior of SFRC beams under normal conditions, with a focus on the effects of different fibers and beam types.
- b. Comparison between different mechanical characteristics of the residual behavior of beam characteristics with Nano-Glass Powder beam.
- c. Investigate water cement ratio on beam mechanical characteristics with SFRC and Nano-Glass Powder.

1.7 AIM AND IMPORTANCE OF STUDY

Portland cement, water, aggregates, and admixtures make up the rest of the ingredients in concrete. When the cement and water mix, they create a paste that dries and binds the aggregates together. The strength of concrete is proportional to the quantity and quality of its constituent elements, as well as the method of laying, finishing, and curing. The versatility of concrete as a construction material means it may be used in many different contexts, including the agricultural and domestic ones. When built with the right materials and methods, it can withstand damage from fire, water, fertilizers, water, and abrasion as well as a wide variety of acids, silage, milk, manure, and fertilizers. Its surface might be smooth as glass or quite rough, and it can be tinted with pigments or painted. Even though its tensile strength is minimal, concrete has a high compressive strength. Reinforced concrete uses both the compression strength of concrete and the tension strength of steel, making it ideal for a wide variety of structural applications like beams, slats, and manure tank coverings. Because of its intended use as a building material, concrete's durability is highly prized. For that, that aim of this thesis is to enhance the properties of high strength concrete by adding Nano-materials. Testing for compressive strength is often more extensive than testing for tensile strength for assessing the compressive strength of a material. Existing correlations between these parameters and compressive strength values can be utilized to approximate these qualities with reasonable accuracy. Existing correlations may not be applicable to mixtures with greater compressive strengths, as the majority of them were calculated for mixtures with compressive strengths of less than 80 MPa. Using national codes, we assess the expected and alternative results for compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity in this study.

1.8 THESIS ORGANIZATION

This thesis has five chapters. Chapter one The text encompasses an initial section that provides an overview of the beams, followed by a subsequent segment that outlines the specifications of the additives. Additionally, the problem statement, objectives, and aim of the study should be clearly defined.

chapter two presents a general view of fibers' effects 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 No-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 considers a summary of the overall objectives of the research that was conducted. Also, it presents an analysis of the previous work and a discussion of the possibilities for additional work in the future. This also includes the characteristics of nano glass powder and steel fiber, which are both important for environmentally responsible building practices in the modern world. Green architecture has emerged as a significant topic of discussion among architects and urban planners in the recent times for the rise in the risks associated with global warming and the climatic shifts that have a detrimental impact on natural resources. As we go through the literature, this is because green architecture has emerged as a significant topic of discussion because of these factors. High Strength Concrete (HSC) is one of the techniques that has been recommended to reduce the main implications that the concrete problem has had on the economy, society, and the environment. This is one of the strategies that has been proposed to mitigate the major repercussions. The substantial amount of research that has been carried out on the kinds of building materials that can give the infrastructure more strength is evidenced by the rapidly growing number of articles that have been published over the past few decades. This research can give the infrastructure more strength. Studies that are extremely comparable to these ones have been undertaken in both industrialized and developing nations, demonstrating that this is a problem that affects individuals all over the world. Despite this, there hasn't been a much of in-depth consideration of doing the research with additional construction materials, which is really important for the future initiatives of that particular country. This article covers a variety of topics, including the definition of "high strength concrete," the environmentally friendly materials considering the waste reduction capabilities that are a part of "green construction," and how the ideas of reinforced concrete can be strengthened with the help of fiber incorporation. All of these topics are discussed in this article.

2.2 BACKGROUND

The majority of research on high-performance concrete has been done on specialized concrete materials, which have properties that are distinct in the way of considering traditional concrete at the material level. But there aren't a lot of lab-oriented test

consequences on the capacity considering flexural and deflection properties of HSC girders at the various level of structural elements that are currently known. More data is needed to create and refine algorithms that predict the flexural behavior of HSC girders. Thus, the aim of current research is to examine the flexural behavior of HSC girders with embedded steel rebar. When building the HSC, builders relied solely on fine aggregate and kept the volumetric ratio at 2% throughout. Static loading experimental test findings on UHPC girders revealed the features of HSC girders' flexural behavior. The flexural behavior was analyzed by measuring deformation, failure pattern analysis, deflection, and flexural capacity. The consequences of the experiments performed for this study add to the available information that might be used to create a sustainable model considering the capacity of flexural behavior for HSC girders into some conditions of bending.

Due to its superior mechanical performance, steel fiber reinforced concrete (commonly known as SFRC) has considering an exceedingly popular and desirable material in structural engineering during the past several decades. The greatest advantages are the prevention of macrocrack formation, the late effect of microcrack propagation to the macroscopic level, and proper improvement of ductility following the formation of microcracks. In addition, the concrete mixture is quite tougher and possesses large strengths considering residual impacts after the appearance of the first crack. This study's goal is to investigate the impact that steel fibers with various arrangements paired with steel bar reinforcement have. This article presents the findings of an experimental research program that looked at the impact of different kinds and quantities of steel fiber on reinforced high-strength concrete beams with steel bars within the casting's flexural tensile strength, fracture behavior, and workability.

Each year, the shares of glass which is from waste generated in the world is measured in million tons. Because it does not break down naturally, waste glass is typically thrown away in landfills, which is an unsustainable practice due to the fact that glass does not biodegrade. Silica makes up the bulk of glass's chemical makeup. Sustainable infrastructure may advance significantly if milled (ground) waste glass was used as a partial cement replacement in concrete (systems that are environmentally benign, energy efficient, and cost effective). It is anticipated that waste glass that has been ground down to micro size particles will engage in pozzolanic interactions with cement hydrates, ultimately leading to the subsequent

production of Calcium Silicate Hydrate (C–S–H). Within considering scope of this study, the chemical characteristics of both transparent and opaque tinted glass were investigated. The X-ray fluorescence (XRF) technology was considered to conduct chemical analysis of glass and cement samples. These consequences showed that there are only minute changes in the structure of transparent and opaque tinted glasses. The addition of 0–25% ground glass to mortar and concrete was used in the flow and compressive strength tests. The proportion of water to binder (cement + glass) was maintained all the way of the replacement levels. There was a little improvement in the mortar's flow as the quantity of glass added increased, but there was little difference in the concrete's workability. Additional studies were carried out with the same mix parameters and 1% super plasticizing admixture dosage (by weight of cement), and it was shown that the compressive strength of mortars with admixture was typically enhanced. The purpose of these experiments was to assess the packing and pozzolanic effects. The refined nano glass powder, which may be added to the mixture as an additional cementitious material, is shown in Figure 2.1.



Figure 2.1: Refined Nano Glass Powder.

The behavior that is shear of the hardened mixture material is going to be investigated through the use of this experimental effort by adding steel fibers to a high strength concrete mix considering differences of volume fractions in order to achieve this goal. This is accomplished by looking at the internal characteristics that have an effect on the shear resistance, as well as doing assessment, both qualitatively and quantitatively, of the acts that steel fibers play in shaping the behavior in a structural way of this innovative concrete material. 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. In particular, there would

be far less of a chance of abnormally wide cracking, which over time could cause durability issues or even premature collapses. High strength concrete, according to the literature [1-3], has poor shear resistance. This is because cracks in high strength concrete tend to be transgranular and generally smooth. In addition, aggregate particles are not locked together, suggesting that the aggregates contribute less to the material's shear strength. The considerable propagation of cracks in the HSC takes the appearance of a linear fracture that gradually spreads as it progresses. This occurs when there is insufficient interlocking of the aggregate particles. To get the facts of proper desired improvement in shear behavior, steel fibers need to be incorporated into the concrete mixture in the same way as aggregates are. This will allow for more efficient patching. The making of high-strength concrete is depicted in Figure 2.



Figure 2.2: High Strength Concrete Production.

For the better part of the last few decades, the building industry has made extensive use of concrete due to the material's remarkable strength of mechanical, exceptional transport properties, and numerous economic advantages. However, concrete's extreme brittleness, poor ratio between the strength and weight, and strength in the lower tensile position is limited the material's employment in specialized uses for tension-dominated and slender constructions. These issues prevented concrete from being a viable option. Concrete's low tensile strength and high brittleness make it vulnerable to damage, and corrosion of internal steel reinforcing bars can further shorten the lifespan of concrete structures. This can happen if water is allowed to sit on the concrete for too long. Numerous research [4-9] have been carried out considering the goal method of increasing concrete's ductility and tensile strength through the application of discontinuous fibers in an effort to mitigate the negative effects of the aforementioned limitations. There are currently many different kinds of discontinuous

fibers on the market, including carbon fibers, metallic fibers, and polymeric fibers. Deformed steel fibers have a number of different benefits, one of which is owing to the fact that they have a modulus of high elasticity and excellent bonding capability with the cementitious matrix that is around them [10]. In particular, because of the method by which they anchor themselves, they make an important consideration to the evolving of the resistance of concrete to crack formation and its capacity to absorb energy. Because of these factors, the ACI 318-14 code [11] Shear resistance can be increased by using concrete with deformed steel fiber reinforcement, as suggested by the results of a bending test performed in accordance with ASTM C 1609 [12], The $L/300$ and $L/150$ deflections at midspan considering first-peak strength that exceed 90% and 75%, respectively $7.5 \times (f_c')^{0.5}$, where L is the span clear length and f_c' is the compressive strength. The application of deformed steel fibers to structures in marine environments corrosion of the steel fibers has reduced toughness and bond performance, limiting their use [13]. Despite the fact that deformed steel fibers have the advantages that have been noted, their application has been limited. Recently produced amorphous metallic fibers are useful from an environmental point of view because their manufacture possessing a low energy footprint and CO₂ emissions. This development came about very recently. When compared to the manufacture of conventionally deformed steel fibers, the production of amorphous metallic fibers results in an approximate 20% reduction in CO₂ emissions [14]. Additionally, the uneven chain of atoms that generated in the time of solidification prior to the special production technique they use, wherein the temperature of molten metal is lowered by more than 105 K/s. Because of this, metallic fibers can be made extremely thin and flexible while yet maintaining desirable properties like as low specific gravity, high strength, minimal friction, and great corrosion resistance [14]. Because amorphous metallic fibers were composed of 80% (Fe, Cr) and 20% (P, C, Si) by mass. Submerging the fibers in 0.1 N HCl and 0.4 N FeCl₃ for 24 hours showed no signs of corrosion, as discovered by Redon and Chermant [15]. This was the case even though the fibers were exposed to both chemicals at the same time. Therefore, amorphous metallic fibers show promise as a potential solution to the significant drawback (corrosion) of standard steel fibers when used in environments that are characterized by a high salt content. This is because amorphous metallic fibers are comprised of a much smaller number of atoms than standard steel fibers. Because the majority of laboratory studies are carried out on a smaller scale, it is necessary to resort to generalizations when attempting to apply findings

to real buildings that are far larger. As a result, having a grasp of the size impact in concrete is absolutely necessary in order to transfer the data from laboratory tests to actual constructions [16]. Due to micro-cracks, concrete displays a gradual transition from the yield criterion. Several prior researches have provided extensive analysis of this phenomenon [16-18]. In most cases, the presence of fibers inside the cementitious matrix serves to prevent the propagation of cracks, which results in a more ductile reaction. The size effect is mostly determined by how brittle the concrete is, thus if fibers are added to the mix to make it less brittle, the resulting concrete may have a different size impact than regular concrete. However, there are not a lot of studies looking at the size effect of concrete with fibers [19-21] presently reachable. As far as the author is aware, no earlier studies on the size impact of amorphous metallic fiber reinforced concrete SFRC have been published. This highlights the urgent need for more research on the size impact in SFRC. This study's main objective was to ascertain how the specimen size influenced the flexural performance of SFRC produced with two different fiber volume fraction w/c ratios and the ratio of water to cementitious material. Different sample sizes were used in the study. As an additional measure, a steel fiber reinforced concrete (SFRC) containing 0.75 percent by volume of hooked end steel fibers was manufactured with combination proportions comparable to SFRC and tested in accordance with ASTM C 1609 [12]. This was done considering examine size-effect fiber type dependence. Last but not least, a quantitative investigation of the size effect was carried out on the SFRC as well as the SFRC beams, using the two distinct size considering effects that were given by Weibull [20] and Hoover and Bazant [18].

2.3 PREVIOUS STUDIES

Cement manufacture necessitates large CO₂ emissions as well as a lowering impact in the quantity of raw materials used. As a result, using recycled materials as a replacement for cement may be a feasible choice for preventing pollution and disposing of wastes [22-24]. Shruthi and colleagues discovered that adding 15% glass powder with a particle size of less than 90 micrometers, which serves as both considering material with pozzolanic effect, increases the material's strength [24]. Researchers led by Islam et al. looked at the effects of replacing 0% to 25% of the cement in a mixture while maintaining the same ratio of cement to glass throughout the board. Twenty percent glass in the concrete mix is ideal, yielding a two percent increase in compressive strength after ninety days compared to the control

concrete specimen [25]. Mohammad and colleagues looked at the effects of replacing a certain percentage of cement in concrete with glass powder at 5%, 10%, 15%, 20%, 25%, and 30% respectively. They came to the conclusion that replacing 20% of the cement with glass powder led to decisions. After 28 days, the material's compressive and flexural strengths improved by up to 18% and 27%, respectively, when compared to the reference mix. In addition, they found that powdered waste glass with a particle size of less than 75 micrometers is stronger than the same powder with a particle size of 90 to 150 micrometers [26]. Al-Zubaidi and colleagues employed a variety of trash glasses, including neon, brown, and green glasses, to replace the weight of cement. The percentage of waste glass used was 11%, 13%, and 15%, respectively, for each type of glass. They discovered that replacing 13% of the weight of the cement with neon glass produced the best results for the strengths of compressive and flexural [27]. In the creation of concrete, a new method is emerging that involves cement weight added to or subtracted from a nano-silica mix [28-30]. The addition of nanomaterials to concrete led to noticeable improvements in the material's transport and mechanical properties, particularly in the case of a mixture inhalation of silica dust and nanoparticle es [31]. A pozzolanic reaction takes place when Portland cement is mixed with nano-silica, but this time it happens much more quickly due to the nano-enhanced silica's surface area. Cement mortar and concrete benefit from densification of their microstructure as a result of the addition of nano-silica to the hydration process, as this generates an extra cementitious gel [32-37], the high fineness combined with a high silica concentration speeds up the hydration process between calcium hydroxides. Similar results in increasing the compressive strength of self-consolidation concrete can be achieved by combining colloidal silica with superplasticizer, as can be achieved by using nano-silica (7% as substitute of additives) [37]. The high C-S-H formation in both conventional and self-consolidating concretes raises the bar for the materials' mechanical and durability properties [38]. The greatest results for compressive strength can be achieved by replacing cement with glass powder having a specific surface area of 800 m²/kg (around 5 percent of the total weight) [32]. Utilizing recycled glass as a renewable resource is the primary emphasis of the current study (natural pozzolana) [39-41] after being processed into a nano-powder dispersion, its strength-enhancing properties can be more readily activated. while maintaining the lowest possible cost. Additionally, adding the steel fiber really brought about an increase in this study's ductility.

Reinforced concrete's tensile strength can be preserved using a number of different methods; one of these methods is the addition of steel fibers (SFs), which can be a successful strategy. Concrete receives its residual strength as a result of the bridging mechanism that is provided by the fibers, which permits tensile stress to be transferred across fractured portions [42-45]. In addition, the stitching activity of the fibers in an effective manner, controlling the proper resilient fractures and restricting the openings of cracks [46, 47]. It was revealed that increasing the quantity of SFs in concrete not only increased its impact strength but also increased its toughness and its stiffness [48-50]. New types of reinforced concrete (RC) combinations with the wanted qualities of RC combinations of nano glass powder (NGP) and silica fumes are being created for use in their fresh condition, with properties including high flowability, passing ability, and self-compactability (SFs). The incorporation of SFs and NGP into the toughened state is responsible for these characteristics. However, there is a substantial problem involved in improving the fresh qualities of RC while simultaneously combining NGP and SFs. Previous studies found that when NGP was added to RC, as there was more friction between the particles, the mixture became less fluid and was more difficult to sift [51-53]. In addition, rubber has a low density, which means that its particles are more likely to float toward the surface of the concrete when it is being mixed. This results in segregation, which in turn decreases the mixture's stability. The addition of SFs significantly reduces concrete's flowability and passing ability because of the increased interference and obstruction in mixtures [54, 55]. Combining coarse aggregate with NPG and SFs exacerbates the issue. A review of the relevant published research makes it clear that only a small amount of study has been done on the behavior. There has been no study on the effect of NGP and SFs on the flexural behavior of full-size beams, particularly when SCC is employed, and there have been no testing of concrete integrating SFs, either on a small or large scale. This work consequently examined the flexural behavior of large-scale beams made from RC, VRC, SFRC, and SFVRC. The beam's stiffness, ductility, toughness, initial cracking moment, flexural capacity, and cracking properties were studied, along with its reaction to deflection under load. Comparisons are made between the predicted cracking moment and flexural capacity from the code design equations and the experimental data. Because this particular concrete kind is so unusual, comparable examples cannot be found in the available literature. The fundamental goal of this research is to widen the range of concrete-related fields in which NGP can be employed, either with or without the addition of SFs. This will

be accomplished through the employment of a combination of both approaches. The beams that were subjected to the test were made with variable percentages of NGP (ranging from 0% to 35%), various volumes of SFs (ranging from 0% to 0.35% and 1%), and various lengths of SFs. The proportion of NGP used in the construction of the beams ranged from 0% to 35%. (35 mm and 60 mm). It is possible to adjust the percentages based on a variety of parameters, and it also is dependent on the curing processes.

To learn how to put self-compacting concrete's qualities to use, it's important to go back over the experimental database established via prior research and the related literature. This will allow one to gain an understanding of the features' potential applications. Because very little research has been done on FRSCRC, the database that was developed utilizing the data from the literature was based not just on SFRC but also on SCM. This is because SFRC is the more widely studied of the two. Due to the fact that there has been relatively little research done on FRSCRC, this was done. In addition to giving background information and the methodology that was applied in the experiments for the study, this database concentrates considering the structural behavior of the concrete. The experiments were carried out as part of the investigation. Figure 3 considers the reinforced beam testing under load and detailing of the crack distribution and failure mode.

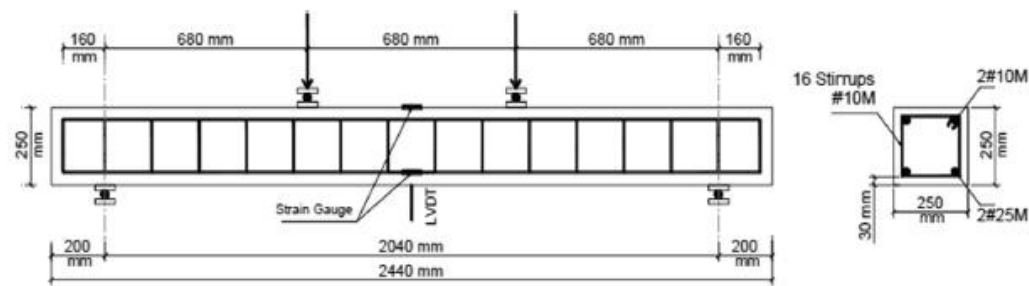


Figure 2.3: Details About The Beam's Dimensions, its Reinforcing, The Way it was Tested, and The Typical Causes of Failure.

Aslani [56] conducted research to investigate how the strengths of compressive and tensile with and without fibers were affected by factors such as specimen size and form. Steel fibers measuring 60 millimeters in length and 0.75 millimeters in diameter were utilized in this experiment alongside polypropylene fibers measuring 65 millimeters in length and 0.85 millimeters in diameter. The specimens were both cubic and cylindrical, and each shape was employed in two different sizes. The following are the amounts of fibers that were utilized in the production of each mix containing different ratios with the purpose of ductility consideration. The freshness of each specimen was evaluated using a number of different tests, including as the slump test, the compacting factor test, and the density test. These tests were conducted at 3, 7, 14, 28, and 56 days. According to the findings, the impacts of size are more pronounced for cubes than they are for cylinders. For steel fiber reinforced concrete

SFRC, for some fiber compositions, such as those containing no fibers at all, the cubes' strength was either lower than that of the cylinders or about the same, while for others it was higher. Size effect in HSC mixes is related to the compressive and tensile strength of unreinforced HSC and the fiber reinforcing index in a different equation than that used for plain concrete. The purpose of this study was to evaluate the effects of using untreated waste tyre aggregate on the mechanical and fresh characteristics of HSC, Bignozzi and Sandrolini [57] undertook a study. The diameter of the slump and J-ring tests, which were conducted in line with the Italian standards UNI11041 and UNI11045, were found to be greater than 600 millimeters during tests of the material's fresh qualities. The findings shown that the fresh characteristics of concrete were unaffected in any significant way by the utilization of discarded tyres as a replacement aggregate. When compared to HSC, the SFRC that was developed for this study required just marginally greater amounts of the superplasticizer (SP) to achieve the same level of self-compacting characteristics. After that, mechanical tests lasting twenty-eight days were carried out on specimens measuring one hundred fifty millimeters cubic. The findings demonstrated that both consideration for the concrete in a way where strength and stiffness in main priority, had significantly diminished. This is because the glass powder creates C-S-H gel in the cement paste, which results in voids that are more easily capable of producing a failure. This is a direct influence of the proper content.

The flexural fatigue behavior of SFRC was investigated by Ganesan et al. [58] both considering adding or not adding of steel fibers. The SCM that was employed had a maximum fineness modulus of 1.2, while the steel fibers that were utilized had a length of 30 millimeters and a diameter of 0.45 millimeters. The percentage of steel that was replaced ranged from 0.5 to 0.75 percent, and the mixes were formed into prisms of 100 by 100 by 500 millimeters. According to the findings, including waste rubber in the SFRC formulation raised the strength referring to the fatigue situation by 15%, while including steel fibers in the formulation increased the fatigue strength by an additional 25–50%. The fatigue strength significantly increased, rising up to 13% higher as a result of an increase in the volume fractions of steel fiber.

Ghaffar et al. [59] undertook studies to investigate how the addition of steel fibers to conventional concrete altered the quality of the finished product. The length of the steel fibers that were used was 60 mm, while their diameter was 0.75 mm. The fiber volume

percentage ranged from 0 to 5%, with 0.5 percentage point fluctuations at several stages. Cubes with sides measuring 100 millimeters and beams with sides measuring 100 millimeters and lengths measuring 500 millimeters were the specimens that were molded. After seven and twenty-eight days, the samples were subjected to testing. The results show that when fiber content increases, workability decreases at the same rate as the wet and dry densities do after 7 and 28 days. In compared to concrete that was not reinforced with steel fibers, the concrete's compressive and flexural strengths, as well as its ductility, improved as the fiber content of the concrete climbed. The steel fibers were also discovered to have an effect on minimizing the fracture width along the beam.

Koroglu and Ozdoner [60] studied the effects on hardened concrete qualities of including polypropene fibers and steel fibers into the mix. The steel and Polypropene fibers used were both 33 millimeters in length, with the steel being 0.55 millimeters in diameter and the Polypropene measuring 1.1 millimeters. The concrete was cured for 28 days before being tested in the shapes of cubes (100 mm on a side) and beams (100 mm on a side and 500 mm in length). Compressive strength was not considerably different after steel fiber addition, although flexural strength was improved. Up to an optimum PP fiber level of 1.5%, the addition of PP fibers decreased compressive strength while increasing flexural strength. There was no loss in compressive strength due to the use of PP fibers. Until the optimum concentration of PP fibers was reached, this was the case.

Numerous writers [61-63] have looked into the potential for recycling glass powder in concrete, with most of the research centering on the usage of soda lime glass (SiO_2 70%, Na_2O 12%, and CaO 5%). Glass has a pozzolanic effect if used as a reactive aggregate in concrete also having silica content in high amount; on the other hand, sodium oxide may trigger an alkali-silica reaction (also known as ASR). Among the many reported effects of utilizing NGP as a replacement for traditional Portland cement in concrete are increased alkali-silica reaction (ASR) and pozzolanic activity. However, the pozzolanic effect is seen as beneficial since it causes the formation of more C-S-H gel during the secondary hydration of cement, whereas the ASR is seen as having an adverse impact that encourages blooming in the pattern of cracking propagating in hardened one [38].

Considering the findings of Du et al. [64] the use of NGP considering a particle size 0.75 micrometers as a cement replacement in concrete did not result in any detrimental expansion

or swelling. In a study that compared the expansion of brown glass, clear glass, and any other colored powder of glass with a particle size of 0.75 micrometers, the clear glass had a greater expansion than the other two types, the expansion of the colored glass was three times lower than that of the clear glass, whereas the expansion of the brown glass was nine times lower than that of the clear glass. The fact that colorful glass contains Cr_2O_3 but clear glass does not [64] was cited as the primary rationale for this distinction. The fineness modulus of self-consolidating concrete decreased by 0.015 when 30% LCD glass powder was employed as a cement replacement, it was reported that there was an increase in the material's resistance to sulfate attack, as well as an increase in the material's compressive and flexural strengths. This was also the case [65]. This particular glass powder had a fineness modulus of 3.37. Idir et al. [66] the influence of glass sizes was explored, and the findings revealed that glass powder with sizes greater than 1000 m exhibited significant expansion as a result of ASR. On the other hand, the best pozzolanic behavior was found in glass powder with particle sizes ranging from 10 to 20 m [66]. When used as a partial replacement for cement in concrete, utilizing glass powder with particle sizes of 13 microns produced results that were comparable to those obtained when using cement. It was observed that there was a high pozzolanic reaction, an improvement in microstructure, a reduction in adsorption as well as chloride permeability, and no expansion as a result of ASR [67]. Microstructure changes in concrete can be achieved through the use of glass powder and fly ash as partial cement replacements. Rapid chloride permeability coefficient was decreased as a result of the changed microstructure compared to that of unaltered concrete [68]. This is due to the higher concentration of alumina in fly ash. According to the research done, the effects of glass powder on the performance of concrete are still up for discussion. The chemical makeup of the glass, the particle size, and any impurities or other chemicals added to the glass to give it color all have a role in how the concrete formed with glass powder behaves. Some authors have maintained that the particle size of the glass powder is to fault 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. Bottom-up and top-down processes are two options for creating nanomaterials [69]. When adopting the top-down methodology, the parent material is shrunk by grinding or otherwise decreasing the particles to the nanoscale. This is done in order to use the top-down methodology. This can be accomplished without having any impact on the characteristics of the source material.

By assembling or self-assembling atomic or molecular building blocks, molecular technology takes a "bottom-up" or "bottom-up" method to creating novel nanomaterials. This approach is also known as the molecular technology approach. The term "molecular technology approach" has also been used to refer to this method on occasion [70]. 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 indicated in prior research, incorporating nano glass particles into concrete increases 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 [71], strengthening the material in both compression and bending, steel fibers in concrete are a popular additive. Results also compared the efficiency of steel fibers with three different geometrical shapes: corrugated, straight, and hooked end. This is why the study used steel strands with hooks at one end. Several studies have investigated how the volume fraction of steel fibers affects the mechanical properties of concrete [72-74]. 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 [75] 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 [76], 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.

The mechanical properties of concrete that has been reinforced with glass powder and steel fibers are yet unknown; more study is needed to discover the full extent of these changes.

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 evaluated based on performance basis 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 high strength concrete (HSC). In addition, the production of SFRC included the utilization of steel fibers with hooked ends at a volume fraction of one percent throughout.

Researchers from a wide variety of institutions have investigated the material characterization of a variety of HSC mixes that are either commercially available or manufactured locally. For example, Graybeal and Davis [77] conducted research discusses how the compressive strength of HSC varies with size. Based on their findings, they suggested using 70 mm cube specimens whenever the capacity of the testing machine or the quality of the specimen grinding was an issue. Additionally, a comparison between untreated control specimens and those that were subjected to heat treatment at 90 degrees Celsius (194 degrees Fahrenheit) revealed a compressive strength that was increased by an average of 40%. According to the findings of several experiments [78, 79], the incorporation of substantial amounts of steel fibers did not have an effect on the compressive strength of the HSC. Other research [80-82] found that the inclusion of fiber led to a modest improvement in compressive strength, provided that the material underwent the appropriate thermal treatment. The direction in which the fiber-reinforced concrete was cast did not have a significant impact on the material's compressive strength [83, 84], but it did have a substantial impact on the material's flexural capacity. Beam specimens that contained fibers displayed many cracks and indicated a gradual decrease in load carrying capacity as opposed to a quick decrease in load following the creation of the first crack. For HSC that contained steel fibers. There was one large crack in the vertical direction, and many smaller cracks radiating out from it. [85]. Researchers from a variety of institutions, such as [86], examined the durability of concrete and came to the conclusion that the chloride ions penetration was significantly dependant on the exposure solution and duration, also the w/c and curing regimes. The utilization of HSC has been fruitfully put to use in a variety of construction projects all over the world [87-89]. However, HSC applications in the North, the American construction industry is falling behind due to a number of factors, including a scarcity of suitable design provisions, skilled contractors and pre-casters, high beginning prices, and a

requirement for highly specialized types of high-energy mixers. Previous studies demonstrated that incorporating steel fibers into HSC mixes resulted in a considerable improvement to the material's mechanical characteristics. However, there is a lack of information on how the length and dosage fibers affect the mechanical consideration and durability of HSC. As a consequence, proper planning for this study program aimed to fill up this particular hole in the previously acquired knowledge.

2.4 HSC AS A SUSTAINABLE CONCRETE

Because of its poor permeability, HSC is highly resistant to carbonation. Results showed about 17 years later of usage, the concrete of At a thickness of 6 mm, Toronto's CN Tower was completely carbonated (0.24 in)[90]. The concrete used with the w/c ratio of 0.42 to build the CN tower. If a layer 35 mm thick were applied on top of this concrete, it would prevent corrosion for the next 500 years (1.4 in). Because of the lower water cementing materials ratios commonly used in HSC, substantially longer timelines to corrosion would be envisaged, providing the structure was crack-free.

Production of cement, together with coarse and fine aggregates, has a profoundly negative effect on the environment; meanwhile, the environmental impact of fine aggregate production is growing rapidly. Cement is a key component in building projects all over the world, which means that cement production is a significant source of global carbon dioxide (CO₂) emissions. In 2010, cement production accounted for around 2.4% of total global CO₂ emissions from industrial and energy sources. This was found to be the case [91]. Cement production is a major contributor to the rise in global CO₂ emissions, which now account for around 7% of all anthropogenic emissions. In this case, replacing the cement while keeping or increasing the concrete's strength is an immediate priority. Both outcomes necessitate the use of silica fume. Silica fume, out of all the supplementary cementitious chemicals, has the most positive environmental impact and its crack-free construction is the most lasting. The basic materials used to make concrete (cement, coarse aggregate, and fine aggregate) have a growing negative effect on the environment with each passing day. Cement is used extensively in building projects all over the world, making cement manufacturing a significant contributor to global carbon dioxide (CO₂) emissions. Cement production is responsible for around 2.4% of global CO₂ emissions from industrial and energy sources. Very little extra cementitious material is manufactured in a country like Bangladesh.

Producing and utilizing this material has the potential to reduce overall carbon emissions while yet meeting or exceeding durability and strength requirements [92].

Over the past few years, "high strength concrete" and its abbreviation, "HSC," have become common parlance. High strength concrete's benefits are leading to its increased use in the design of a variety of structural components, especially in the building of bridges and other massive structures. High strength concrete, according to the American Concrete Institute, has a compressive strength of at least 41,4 megapascals (MPa), whereas high strength concrete, according to the Indian Standard Institute, has a compressive strength of at least 60 MPa [93]. One key distinction between high strength and regular strength concrete is the compressive strength of a concrete sample, which is its maximum resistance to applied pressure. For construction purposes, the most crucial aspect of concrete is its compressive strength. Because of the importance of other qualities, such as tensile and flexural strength, concrete with greater compressive strengths is preferred. High-strength concrete has unique properties under certain environmental conditions. Unlike regular concrete, it is more resistant to earthquakes and other natural disasters because to its high modulus of elasticity, high density, and low permeability. This concrete can be made with a wide variety of additives, including fly ash, silica fume, powdered granulated slags, natural pozzolan, fibers, chemical admixtures, and more [94].

In addition to Portland cement, aggregate, and water, high-strength concrete will also often include a superplasticizer and other cementitious components (SCM). Fly ash or crushed glass fiber reinforced concrete is used as a supplemental cementing agent to achieve compressive strengths of up to 14,000 psi (98 MPa). Silica fume is commonly utilized for concretes with strengths between 9000-14,000 psi (53-98 MPa), however it has been demonstrated that its use is necessary to gain concrete strengths in excess of 100 MPa. Significant study on the incorporation of fly ash and silica fume into concrete has been undertaken during the past two decades, leading to their widespread adoption in the building industry. Publication of these studies' findings in scholarly journals attests to their reliability. Many of the specifications that can be obtained from that section combine performance criteria with stipulating norms (e.g., for a material's allowed permeability or allowable strength (such as air content restrictions or doses of additional cementing material) [95].. By making structures more resistant to environmental influences or dramatically boosting their

structural capability, it helps to lengthen their expected lifespan. It also aids in reducing the overall duration of the building process without sacrificing durability. Superior chemical resistance, low heat of hydration, low water cement ratio, good workability, low bleeding, low shrinkage, and high early strength are all hallmarks of high-quality concrete with low porosity and low permeability. In a nutshell, you'll need the following: tiny aggregates and fine sand, a high percentage of fly ash, a low water-cement ratio, and a high dose of super plasticizers [96].

2.5 ELEMENTS OF HSC

2.5.1 Cement

There are two prerequisites that must be met by any cement before it may be used. It must first generate sufficient power. Second, it has to have the right rheological characteristics. Type I, Type II, and Type III Portland cements meeting the specifications of the ASTM Standard Specification C150 have been used successfully in the manufacturing of ultra-high-strength concrete. Cement meeting the vague requirements of ASTM C150 may thus vary widely in fineness and chemical composition, despite the fact that they all technically pass muster. Despite their being no changes to the requirements, this is the case. Therefore, cements of the same type will have highly different rheological and strength characteristics, even if they are of the same type. This is especially true when the cement is combined with chemical additives and additional cementing components. When choosing Portland cements for use in high-strength concrete, it is therefore extremely important to take into consideration the fineness of the cement as well as the chemistry of the cement that is being used. According to the research carried out by Russell, Graybeal, and Russell (2013) [97], cements that have high levels of C3A have greater strengths than those that do not. However, recent studies have shown that excessive quantities of C3A should be avoided in cements when making high-strength concrete. This discovery was made possible by the findings of these studies. There is anything from 400 to 550 kg/m³ of cement in the mix.

2.5.2 Coarse Aggregate

Prior research took into consideration both the desired compressive strength and the largest possible aggregate size when determining the maximum size of coarse aggregate to be

utilized. Coarse aggregate with a maximum size range of 2 to 12 millimeters and a compressive strength of up to 70 MPa may be produced using high-quality coarse aggregate. High-strength concrete requires careful attention to both the aggregate's inherent strength and the connection or adhesion formed between the paste and 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

High strength concrete is made with more cementitious material than regular concrete. Because of this, sand and other fine aggregates have a less impact on high-strength concrete's ability to be worked and finished smoothly. The parameters for strong compressive strength and acceptable workability are usually acknowledged to be met by a coarse sand with a fineness modulus (FM) of around 3.0. Strengths of 70 MPa (10,000 psi) or above should be stated with FM ranging between 2.8 and 3.2, and there should not be more than a 0.10 difference between the FM chosen for the duration of the project and the FM specified for the strength. FM should be between 2.8 and 3.2, and it should not deviate from the FM that was chosen for the duration of the project by more than 0.10. The use of finer sand, such as that with an FM ranging from 2.5 to 2.7, for instance, might result in blends that are weaker and stickier.

2.5.4 Mineral Admixture

In certain circumstances, it is possible to manufacture high-strength concrete without making use of silica fume, and the resulting concrete can have compressive strengths of up to around 14,000 psi (98 MPa). Having said that, there is a higher level of strength than that. Silica

fume is going to be required in an absolute sense. Even at lower pressures of 9000-14,000 psi (63-98 MPa) and lower temperatures, it is simpler to produce HSC using silica fume than it is to produce it without it. As a consequence of this, it must to be incorporated into the HSC mix whenever it is feasible to do so, provided that it can be purchased at a reasonable cost. The composition of silica fume is not particularly well defined because of the fact that it implies as waste materials that is produced at the time of manufacturing specially silicon and silicon alloys. In order to provide an accurate description of the source, it is necessary to identify the specific surface area of each new source of silica fume by the use of nitrogen adsorption. 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/m³). 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/m³, 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 Superplasticizer

To obtain the desired outcomes, chemical admixtures such as water reducers, retarders, high-range water reducers, and superplasticizers must be introduced into the mixture. They aid in achieving the optimal water-to-cementing component ratio and optimizing the usage of the massive amounts of cementitious material included in high-strength concrete. There are three basic categories of superplasticizers, and each one has its own distinct set of properties: It is possible to classify it as one of these three: i) is lignosulfonate-based; ii) is polycondensate of formaldehyde and melamine sulfonate (commonly known as melamine sulfonate); iii) is polycondensate of formaldehyde and naphthalene sulfonate; and iv is lignosulfonate-based (often known as naphthalene sulfonate). In order to achieve the appropriate level of strength in high-strength concrete, lignosulfonate superplasticizers are commonly combined with either melamine or naphthalene superplasticizers. The vast majority of the time, they are not efficient enough to allow for the production of very high strength concretes on their own in a manner that is both economical and efficient. On occasion, lignosulfonates are used for early slump control, and then, following the initial slump control, melamines or naphthalenes are employed for slump management in the field.

So far, it is only anticipated that a single melamine-based superplasticizer will become available for commercial use, and this development took place only very recently. The sodium salt of methylene chloride is the most common form in which to find methylene chloride superplasticizers. These superplasticizers are clear liquids that have around 22 percent solid particles in their composition. The utilization of these superplasticizers has been going on for quite some time, with very favorable outcomes. As a direct consequence of this, manufacturers of high-strength concrete continue to favor using them. Since naphthalene superplasticizers have been in use for a longer period of time than any of the other varieties, there is a greater selection of brand names available for products containing this ingredient. There is a brown liquid form as well as a powder form available; the solids content of the liquid form is roughly 40%, while the solids content of the powder form is around 40%. The majority of the time, you can get them in the form of calcium salts, and occasionally, you can get them in the form of sodium salts. If an aggregate that has the ability to react with alkali is going to be employed, it is strongly suggested to make use of calcium salts in the preparation process.

2.5.6 Effects in Other Studies

In this particular investigation, ordinary Portland cement, often known as OPC, was utilized. It was a type I and it adhered to the standards set forth in ASTM C150 [98]. Delta is the brand name of cement used in commercial settings. MSASA-Construction Solutions for Africa, located in Pomona AH, South Africa, was the supplier of densified micro-silica, also known as SF. Iron Slag Powder (ISP) was collected from a plant in Mosul, Iraq, that specialized in iron manufacture. ISP can be used as the mineral admixture to propagate into the matrix of the structure. Recycling plant with the capabilities of glass consideration in Mosul, Iraq provided the source for the crushed glass powder (GP) that was used. It has been determined that the physical characteristics and chemical compositions of OPC, SF, ISP, and GP are the ones that are most suited for the purpose of carrying out this research. In this particular investigation, sand from a nearby river was used. Following its preparation to have a maximum aggregate size of 0.6 millimeters, it was incorporated into all mixtures as fine aggregate. Both the bulk dry density and the absorption of this sand came in at 2.510, and it had a value of 2.66%. To make the mixes easier to work with, a cutting-edge superplasticizer called polycarboxylic ether superplasticizer (SP) was added to them all. It came from the

Marla-Chemicals company in Istanbul, which is located in Turkey. It is sold under the trade name RB-1070. In order to eliminate pockets of trapped air in the finished mortar, defoamer (abbreviated as De.) was added to each and every mix. It came from the Marla-Chemicals company in Istanbul, which is located in Turkey. Every mixture was made with regular tap water. Nano glass powder (NG) and Nano glass powder type-II were both taken into consideration during the course of this study as potential candidates for the role of local Nano-materials. The SEM pictures of both of the materials are displayed in Figure 2.

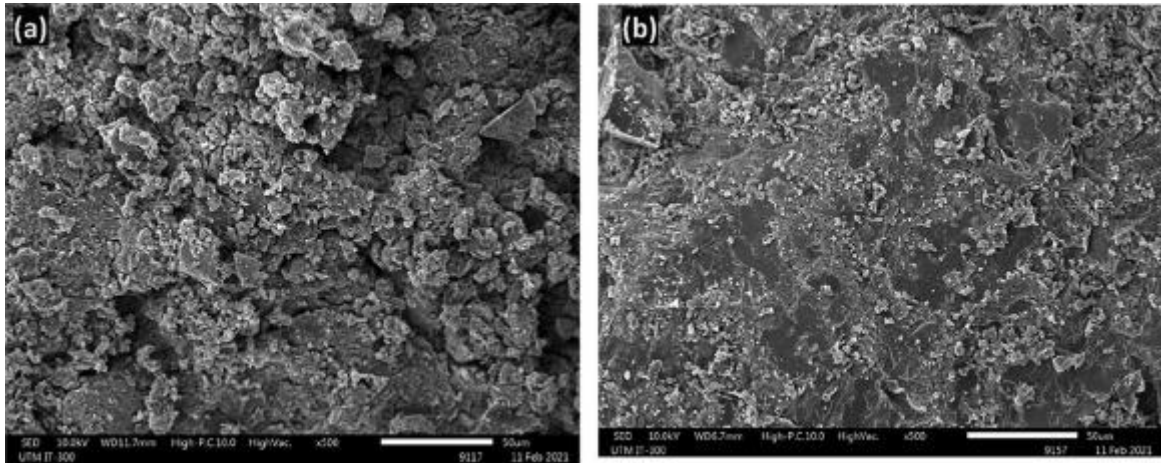


Figure 2.4: Scanning Electron Microscopy with Nano Glass Powder (a) Type-I (b) Type-II.

Steel fibers were purchased from local marketplaces in Mosul, Iraq, where the city is located. The sisal fibers, also known as SIF, were delivered in bundles, each measuring around one meter in length. Before being added to the mixes, they were first separated and then cut into pieces measuring between 16 and 20 millimeters. These fibers were purchased from various local marketplaces in Mosul, which is located in Iraq. In addition, epoxy adhesive was utilized in this study so that its performance could be evaluated alongside that of other RPC mixtures. The Kocaeli, Turkey-based KOSTER Construction Chemicals firm was the one that provided it. This product is known by its brand name in the industry as KOSTER1 KB-Fix. At each and every one of these research stages, the qualities of this substance have to be checked and double checked.

Nano materials especially polymeric metal silicate considerations have been successfully manufactured and developed as a new accelerating addition for cement mixtures. The additive is a breakthrough in the use of nanotechnology for concrete admixtures. It aids to the formation and maintenance of a hydrated cement paste with a high initial strength. The

novel additive promotes CSH crystallization and is made of polysilicate nanoparticles. Its high polymerization degree and low Ca/Si ratio set it apart (calcium-silicate-hydrate). When it comes to the development of cement's strength and resistance to wear and tear, C-S-H is the most prevalent phase by volume considering the matrix alongside with the Portland cement concrete. It was shown that the recently discovered silicate is polymeric using gel permeation chromatography (GPC). Other techniques, such as high-resolution transmission electron microscopy and X-ray photoelectron spectroscopy, as well as nuclear magnetic resonance (^{29}Si -NMR), were used to probe the atomic ordering at the nanometer scale. In-situ XRPD analysis was used to measure the rate of hydration of cement pastes with varying amounts of the new addition. Hydration kinetics of additive-free cement pastes of similar composition were used as a comparison. Both the rate at which alite (the main phase of portland clinker) dissolves and the rate at which C-S-H is formed were shown to be significantly affected by the new silicate hydrate. Additionally, 3D crystal phase formation in the cement paste was studied using synchrotron-based diffraction computed microtomography (XRD-CT). Because of this, the processes of nucleation and the development of the microstructure may be seen in exquisite detail. Recent studies have shown that silicate hydrates, which were just recently found, improve the silicate network. They do this by promoting widespread nucleation and a speedy development of a network between the hydration reaction's final products. The mechanical qualities of the concrete were tested, and the results revealed that the addition accelerated the pace at which the new mix gained strength. New polymeric silicate hydrates enhance the microstructure of the cement paste, decrease water permeability, and increase the service life of concrete structures by driving the precipitation of C-S-H in the capillary porosity. Because of the considerable increase in hydration rate that can be achieved with this addition, steam curing may not be necessary in the precast industry at all, leading to significant energy savings and a corresponding decrease in CO_2 emissions. The rapid strength development of ready-mixed concrete allows for an increase in productivity as well as a reduction in the number of manufacturing cycles.

2.6 SUMMARY

In contrast to traditional normal strength concrete, high-strength concrete, or HSC, is an innovative concrete concept that has made a substantial contribution to the construction industry by resolving a number of the problems that are normally connected with

conventional concrete. Because nano glass powder (NGP) contains ingredients that are cementitious, it is one of the most workable alternatives to cement that may be used in the manufacturing of concrete. Waste glasses or fresh glasses are the source of nano glass powder, which is abbreviated NGP. The quick increase in population, the expansion of urbanization, and the industrialization has all led to the rapid depletion of natural resources that are already in existence, which has necessitated the development of additional high-rise buildings to accommodate the growing population. We need high-strength concrete in order to solve not only the structural problem, but also the problem associated with the concrete in general. In addition, the problem of carbon emission can be reduced to some extent either by reducing the amount of cement that is produced or used. Converting waste glasses into nano glass powder and then using that glass powder in place of cement as a replacement for cement in the construction of the structure is one way that may be used to achieve sustainable development of structures. In that circumstance, it is also advantageous to preserve a green atmosphere and be resistant to the attack of sulfates. The use of NGP in the manufacturing of HSC has been the subject of a great deal of research in the past [99-102]. On the other hand, prior research has not made any considerable attempt to evaluate the rheological and mechanical properties of HSC having both NGP and steel fiber in combination. This is something that has to be done. We were able to determine the combined effect of the NGP and the steel fiber in this inquiry by doing it as a single experiment. According to the findings of the literature review that was presented earlier, only a small number of criteria (such as the percentage of NGP that was replaced and the weight-to-capacity effect) were included in the field of sustainability assessment when relative investigations were carried out. This study was attempted to incorporate a range of different percentages of NGP, such as 5% to 25% with an interval of 5%, within the parameters of this research. The material that has been substituted is capable of producing modest levels of strength when sustainability is maintained as a proper consideration. In order to evaluate the effectiveness of NGP in structures through the use of non-destructive test, each of the tests is performed, and an empirical relationship is established between the various parameters. In addition, this work presents the comparative relationships between DT mainly flexural behavior and NDT for the NGP effect. Some examples of DT include the compressive strength test, flexural strength test and crack distribution analysis. In order to validate the predicted equations in the field of HSC or FRC by the use of NGP and steel fiber, which had not previously been

identified, various correlations were compared with the findings of the previous investigations by the standards or codes that are already established. This was done in order to validate the correlations.



3. RESEARCH METHODOLOGY

3.1 INTRODUCTION

In the current work, compressive, tensile, and residual strengths of concrete that had been reinforced with nano-glass were measured using an SFRC panel model. Because of the load concentration at the column connection, punching shear failure is more likely than bending failure when slabs with a high reinforcing ratio are used. Structural and Materials Laboratories of Anbar University were the sites of the tests. The overall plan for the experiments is as follows:

The major variables are steel fiber volume fraction and nano-glass impact. Forty samples are suggested for analysis, with Table 3.1 describing the split as follows: sixteen SFRC samples to be compared with regular concrete control samples, and twelve nano-glass samples to be compared with regular concrete control samples.

Table 3.1: Study Groups.

	cube	cylinder (200*100)	cylinder (150*300)	Beam mould
case 1	CU	E	ET	CBM
case 2	CN-2.5	EN2.5	ET 2.5	CBN2.5
case 3	CN5	EN5	ET5	CBN5
case 4	CN7.5	EN7.5	ET7.5	CBN7.5
case 5	CF0.25	EF0.25	ETF0.25	CBF0.25
case 6	CF0.5	EF0.5	ETF0.5	CBF0.5
case 7	CF1	EF1	ETF1	CBF1
case 8	CFN-2.5	EFN2.5	EFT 2.5	CBFN2.5
Case 9	CFN5	EFN5	EFT5	CBFN5
Case 10	CFN7.5	EFN7.5	EFT7.5	CBFN7.5

3.2 SPECIMENS GEOMETRY

For these reasons, it was necessary to find a specimen shape that allowed for a wide range of fracture velocities in a single test and made it easier for reflected stress waves to interact with the crack point as it propagated rapidly. Model specimens with the proportions depicted in figure 3.2 are selected: 15 cm * 15 cm * 15 cm cubes, 200 cm * 100 cm and 150 cm * 300 cm cylinders, and 100 cm * 100 cm * 400 cm Beam mould samples.

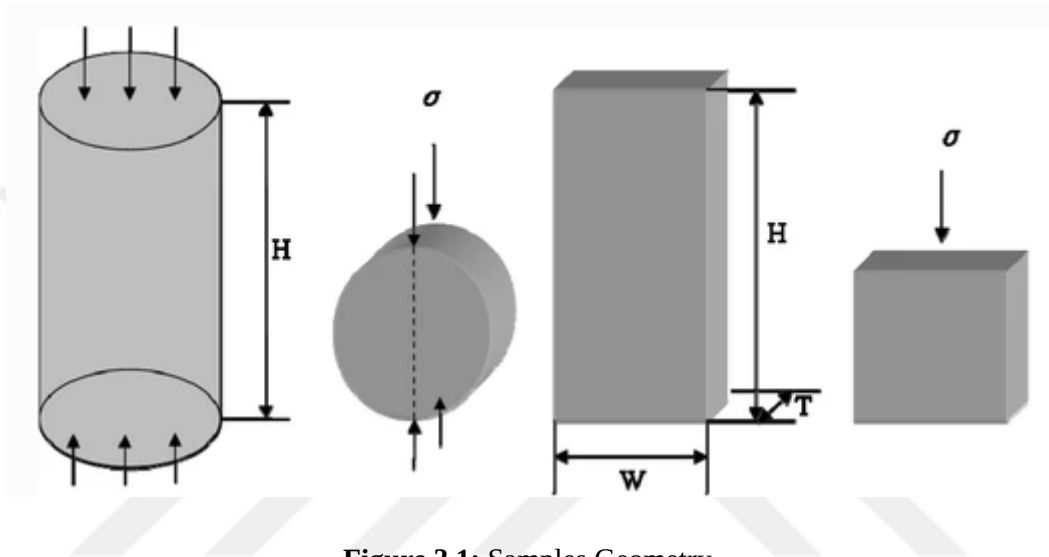


Figure 3.1: Samples Geometry.

3.3 MATERIAL PROPERTIES

Sand and gravel are used in the construction of highways as fill, base, and final layers, coarse and fine aggregates in the production of concrete and bitumen, and fine aggregates in the production of mortar and concrete blocks. In addition to cement and mill residues, they are utilized for backfilling in the mining industry. Typically, river sand is utilized in operations involving concrete and masonry. In addition, they can be used to produce RCC, gypsum, and a variety of other masonry or block works. This sand has a more homogenous grain pattern and smoother grain texture. The river and natural dunes require a negligible quantity of water.

Table 3.2: Sieve Test of Sand.

Sieve opening (mm)	Passing %
12.5	100
9.5	100
4.75	93
2	63
1.18	45
0.6	29
0.3	16
0.15	5
0.075	4

Small prefabricated structures and some portable garages can be installed on a gravel foundation. However, concrete is an excellent option for larger garages or any facility that does not already have a floor. A concrete foundation is effective in the absence of a floor.

Table 3.3 sieve test results for gravel

Table 3.3: Sieve Gravel Test.

Sieve opening (mm)	Passing %
12.5	100
9.5	89
4.75	4
2	1
1.18	0.7
0.6	0.1
0.3	0
0.15	0
0.075	0

Grading, or size distribution, of aggregate is crucial because it determines how much cement is required to produce workable concrete. Cement being the most expensive component, the need for mortar is the primary cost driver. It is therefore preferable to use as little mortar as possible while still producing workable, compactable, and finishable concrete with adequate strength and durability. The quantity of cement material required depends on the total area that must be covered and the amount of empty space that must be filled. The amount of substance required to fill the spaces between particles is greatest when all particles are of the same size, but it is reduced when a range of particle sizes is employed. It is essential to establish a balance between economy and workability, as the concrete becomes less workable as the spaces are filled.

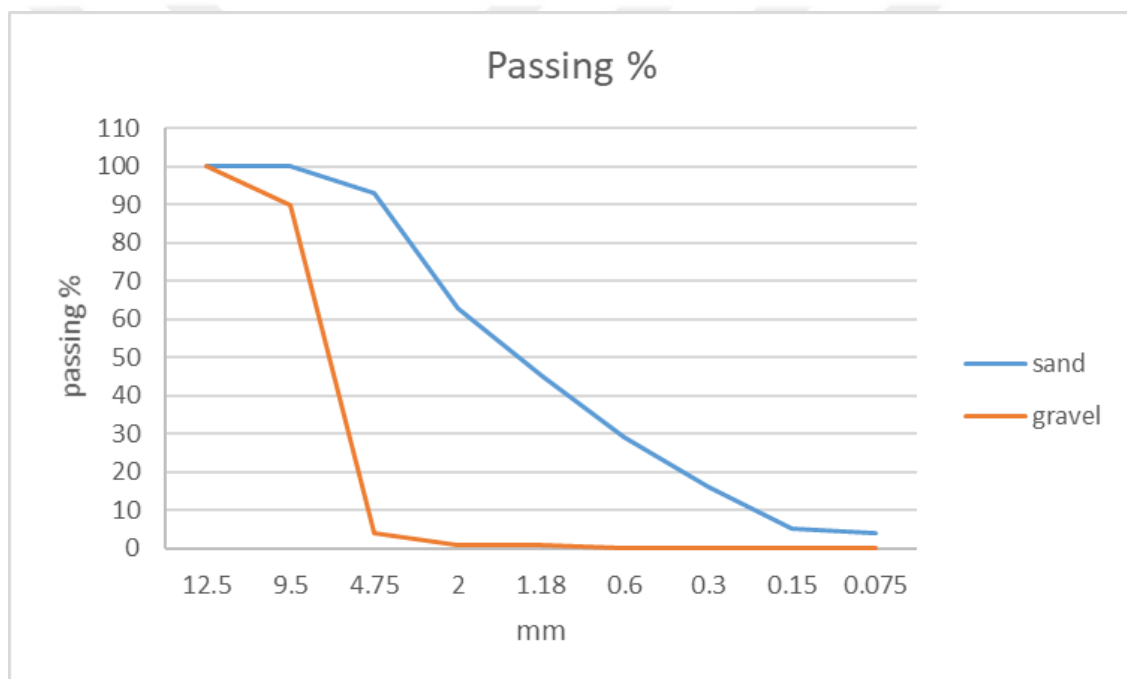


Figure 3.2: Passing Results.

3.4 MIXING DESIGN

The assumption in the present methodology are:

- a. In all of mix designs, drinking water was used.
- b. Maximum size aggregates (MSA) was employed in all mix designs is 10 to 20 mm.
- c. In most of the mix designs, the Portland cement type were utilized.

- d. The limitation amount of cement utilized in the mix designs is 350 to 650 kg/ m³ .
- e. correlations presented in the thesis for estimating 28-day
- f. In most of mix designs, silica fume were utilized, furthermore different kinds of super plasticizer were employed for suitable workability. The selection of cement depends on the desired application. Before testing the cement in the design mix, it should be examined for the performance required by its application. This study utilized Kubaisa cement, which was imported from western Iraq.
- g. Durability: Required strength (N/mm²) of any grade of concrete after 28 days of curing. On-site testing for durability control is essential.
- h. Workability refers to the ease with which concrete can be mixed without segregation or bleeding. It mostly depends on the concrete's planned slump.
- i. In all mix designs were utilized for calculation of 28-day for two types of curing, the limitation employed for w/c (water cement ratio) is 0.32.
- j. Due of the high proportion of fine aggregate, the workability of the stipulated mixture is too low; therefore, a constant amount of a high water reducer is added to each mixture.

The Sika superplasticizer that complies with ASTM C 494 Type A is used. At a particular cement-to-aggregate ratio, it is believed that an increase in cement content has no effect on the strength. In addition, according to the Abrams rule, the paste's potency is determined by its quality, not its quantity. To attain the required strength, more cement must be added when the cement concentration falls below the minimum (American Society of Concrete Contractors, 2005). The Association of American Concrete Contractors In addition, it appears incapable of producing high strength by adding cement when the cement content exceeds 350 kg/m³ (590 lb/yd²). Contrary to the Abrams rule, these studies demonstrate a correlation between cement content and strength. Due to their influence on the porosity of the cement paste and the interfacial transition zone between the coarse aggregate and the cement paste, the Cement to Water Ratio (W/C) and the degree to which the cementitious materials have hydrated determine the strength at any given age. As the temperature of the moist bulb rises, capillary porosity increases, resulting in a decrease in strength. In order to increase strength and decrease the water-to-cement ratio, it is preferable to decrease water

content as opposed to increasing cement utilization. Table 3.4 depicts the proposed implementation of a combination's total mix percentage.

Table 3.4: Mix Design.

group	Fiber type	V _f %	Cement (kg)	Sand (kg)	Gravel (kg)	additives (kg)	Water (kg)
1	none	0	486	851	1215	0.15	159.5
2	none	0	331	956.6	848	0.15	178.7
3	Steel Fiber	0.5% to 1%	331 to 486	851, 956	848, 1215	0.15	0.45 to 0.65
4	Nano-glass	2.5% to 7.5%	331 to 486	851	848, 1215	0.15	0.45 to 0.65

3.5 MATERIAL PROPERTIES

Concrete is utilized in construction due to its strength, durability, and adaptability. Concrete has become the material of choice for both commercial and residential building endeavors due to its durability and resilience. SFRC is utilized in buildings, such as flooring, housing, precast, bridges, tunneling, heavy duty pavement, and mining, to enhance durability, strength, resilience, and stress resistance. SFRC possesses superior tensile strength, flexural strength, impact resistance, fatigue resistance, ductility, and fracture bridging, to name a few of its many advantageous properties. As a consequence, it has found widespread application in the international construction industry. Typically, conventional concrete is combined with steel fibers to create steel fiber reinforced concrete (SFRC) in order to increase its tensile strength. These fiber filaments are dispersed and oriented at random (approximately uniformly) throughout the concrete matrix and are regarded as discontinuous, discrete entities. SFRC may be utilized as a substitute for or in combination with traditional reinforcement bars, depending on the situation. SFRCs are often distinguished by a greater residual tensile strength after cracking due to the fiber reinforcement mechanisms present on the fracture surfaces. This post-peak tensile behavior is affected by the number of fibers that effectively span a fracture, the orientation of those fibers, and the bonding strength qualities

of the fiber type. The brittle matrix is strengthened by the interfacial connection formed between the fibers and matrix, which exploits the strength and rigidity of the fibers. Even after the matrix has fractured, steel fibers may continue to transport load across the fissure faces. As composite tension increases, fiber withdrawal reduces the composite's load-bearing capacity and accelerates the rate of energy loss. In addition, it is well known that increasing the volume percentage of fibers with a high specific surface area increases the composite's fracture-bridging capacity and overall strength. Compared to conventional concrete, SFRC exhibits a significantly distinct flexural behavior. By modifying the number and varieties of fibers utilized, peak load and ductility can be increased. We will discuss why it is so difficult to increase the compressive strength of a material while adding fibers can enhance its flexural strength. As long as the matrix strength permits bending, the flexural load-bearing capacity can be increased even at modest fiber concentrations. Due to its superior flexural strength, tensile strength, shear strength, shock resistance, ductility, fatigue resistance, crack resistance, and failure toughness in comparison to normal plain and reinforced concrete, fiber reinforced concrete has found numerous new applications in the past two decades. In recent years, there has been an increase in interest in the use of fiber-reinforced concrete to improve the mechanical properties of conventional concrete. Depending on the fiber type, percentage of fiber volume, and matrix composition, the material's behavior is drastically altered. By modifying the fiber content, the mechanical behavior of concrete can change from being nearly as brittle as ordinary concrete to even deflection-hardening materials. Figure 3.3 illustrates examples of the utilized SFRC..



Figure 3.3: Steel Fiber.

Table 3.5: The SFRC Properties.

Fiber shape	Hooked-end
Material	High carbon, cold drawn steel
Tensile strength [MPa]	>2200
Length l [mm]	30
Diameter Ø [mm]	0.35
Aspect ratio l/Ø	86
Fiber designation	30/0.35

Nano glass is the additional material used here. Adding glass particles to plastic concrete will make it more workable, thereby reducing the time, money, and effort required to lay and consolidate the concrete. Strength, freeze-thaw resistance, and sulfate resistance are enhanced in concrete that has been hardened with glass particles. Due to their minuscule Nanomaterials possess significant potential for enhancing concrete properties, such as compressive strength, split tensile strength, flexural strength, water permeability, abrasion resistance, and pore structure, due to their increased surface area and fragment size. Figure 3.4 depicts the nano glass employed in this experiment.



Figure 3.4: The Nano-Glass Powder.

The Chemical components of glass powder are shown in table 3.5

Table 3.6: The Nano-Glass Powder Content.

component	content %
Sodium oxide (Na ₂ O)	10.46
Aluminum oxide (Al ₂ O ₃)	3.52
Calcium oxide (CaO)	10.59
Iron oxide (Fe ₂ O ₃)	1.77
Potassium oxide (K ₂ O)	0.89
Magnesium oxide (MgO)	1.56
Sulfur trioxide (SO ₃)	0.03
Loss on ignition (LOI)	0.6
Silicon dioxide (SiO ₂)	71.09

3.6 MIXING PROCESS

Figure 3.4 depicts the initial phase of the process, which consists of mixing the dry ingredients (sand, gravel, cement, and additives) in a Diagonal rotations mixer with three paddles. The components were combined until they formed a homogenous mass. Adding water gently to the mixture, followed by the fibers, which are also added gingerly, produces a slurry suitable for casting.



Figure 3.5: Mixer Type.

The mold was adequately lubricated to prevent adhesion of the concrete to the mold and facilitate the extraction of the sample, as depicted in Figure 3.5.



Figure 3.6: Oiling The Mold.

Following the preparation of the mélange, a vibrating device was utilized to transport it towards the mold, where it underwent the process of being shaped into a panel. The concrete was cast in a conventional manner, consisting of three layers that were carefully leveled using a rod. The steel fiber cylinder adhered to standard dimensions, measuring 100 mm in diameter and 200 mm in length. The penetration of the air bubble into the specimen was facilitated by the sustained vibration process until successful entry was achieved. In order to obtain precise measurements of the compressive strength, modulus of elasticity, and tensile strength of the material, it is necessary to cast three cylinders. Following the application of external vibration to the timbers, the mold is subsequently filled with concrete material. Geometric forms such as pyramids and cylinders.

3.7 SLUMP TEST

In order to compare the textures of various concretes, the slump test can be utilized. A poorly mixed quantity can be identified with a slump test, and the test itself exposes the workability and fluidity of the concrete. Table 3.8 displays the results of the project's collapse test, which has a positive correlation with the amount of steel fiber employed. The presence of steel fibers has been shown to decrease ductility.



Figure 3.7: Slump Test.

The slump test is the most widely used method for gauging the workability of newly mixed concrete, with the droop serving as an indicator of flow qualities. The sag may be measured in this way by starting at the top of the freshly slumped concrete and working your way down. Concrete mixture formulation for on-site construction relies heavily on the prediction of concrete flowability. Material engineers are under growing pressure to provide great workability while keeping the mechanical qualities necessary to fulfill design criteria, especially as the complexity of concrete construction rises. The table presents the results of sag testing.

Table 3.7: Slump Test Results.

Mix code	Slump test results (mm)
C (plain concrete)	97
CN-2.5	91
CN5	89
CN7.5	78
CF0.25	69
CF0.5	65
CF1	62

After pouring the concrete into the mold, the surface was completed by sanding it with a trowel. The concrete mixture without steel fiber is significantly more workable and requires much less effort to finalize with a trowel. As shown in Figure 3.7, after 24 hours of exposure to the cold, the mycelium was transferred to a controlled environment (room temperature).



Figure 3.8: Concrete Samples.

The specimen was subjected to the curing process in a heated water tank, where it was maintained at an average temperature of 25°C for a duration of 28 days. As illustrated in Figure 3.7.



Figure 3.9: Curing Tanks.

Weighting Once the samples had desiccated, they were weighed using a scale that measured weights to three decimal places in grams (Figure 3.10).



Figure 3.10: Weighting Process.

Weighting the specimens.

The moisture content of a substance such as soil (termed soil moisture), rock, ceramics, or wood can be determined by weighing each sample twice. Numerous scientific and technological disciplines employ the concept of water content, which is frequently expressed as a ratio and can range from 0 (completely dry) to the material's porosity at saturation. The results of using this equation to determine moisture content are displayed in Table 3.8.

3.8 CONCRETE MECHANICAL PROPERTIES

3.8.1 Compressive Strength

(ASTM,C39, 1997) There are offered thorough procedures for figuring out the compressive strength of concrete cylinders. A compressive axial force is delivered to the sample once it has been prepared and placed in the machine's center till failure.



Figure 3.11: Cylindrical Test Machine.



Figure 3.12: Cubes Test Machine.



Figure 3.13: Cylinder Test Results.



Figure 3.14: Flexural Machine.

3.9 CYLINDERS TEST MACHINE

3.9.1 Tensile Stress

(ASTM, C496, 2004) Commence preparations for this treatment. Over the length of the specimen, a diametrically compressive load is to be applied until failure occurs.

The cylinder is placed vertically in the center of the test frame, two pieces of plywood are affixed along the cylinder's upper and lower borders, and a steel bar holds the cylinder

securely in position before placing the frame at the core of the compression machine and beginning the test.



Figure 3.15: Splitting Test Results.



Figure 3.16: Splitting Samples Case.

3.10 MODULUS OF ELASTICITY TEST

(ASTM, C469, 2002) The compression modulus of elasticity is determined by subjecting concrete cylinders to a progressively increasing longitudinal compressive force throughout the measurement. Specifying longitudinal stresses with a bonded or unbonded sensor aides in measuring the mean deformation between two diametrically opposed points. ASTM C469 imposes no physical constraints on standard test samples. Using a cylinder with the same diameter and height as the cylinder used to cast the concrete, compression resistance is measured.

While the spacers are fixed in place, the frame rings are first adjusted. The longitudinal fasteners of the cylinder must be tightened in order to hold the rings before the cylinder can be set down on a level surface. Once the cylinder is in position, tighten the horizontal fasteners on the specimen so that each side is the same distance from the ring. When you are finished making adjustments, remove the vertical fasteners and perform a test. The next stage involves positioning the frame in the center of the compression machine and initiating the test.



Figure 3.17: Flexural Test Samples.

After applying the maximum load, the machine was turned down and its crane was removed in order to obtain additional images of the final fractures and failure patterns. The sample is then removed from the testing apparatus, as depicted in Figure 3.10, the radius of failure is determined, the sample is photographed, and a new sample is inserted into the testing apparatus.



Figure 3.19: Sample of Marking The Tested Beams.

4. RESULTS AND DISCUSSION

Existing concrete structures are increasingly required to undergo costly strengthening in order to enhance structural behavior and repair damaged structures in order to restore structural performance. Flexure and shear are the most prevalent failure mechanisms in RC beams. Reinforced concrete is a fragile substance that can break without warning. As opposed to flexural failure, which can be rectified, shear failure always results in complete collapse. Consequently, reinforced concrete structures must be constructed so that their flexural strength can achieve its maximum potential. Reinforced concrete structures are susceptible to shear problems for a variety of reasons. Possible causes include a lack of attention to detail in the shear reinforcement's construction, erroneous calculations during design, ineffective construction techniques, and corrosion in the service environment. Reinforced concrete shear forces are contributed to by dowel action, aggregate interlocking, shear reinforcement, and compression zone concrete. In this chapter, we present the results of an experiment in which numerous concentrations of cube-shaped concrete were analyzed. The shear load capacity of cubes can be monitored up until the point of failure.

4.1 EXPERIMENTAL RESULTS OF REFERENCE CONCRETE

The objectives of the study were accomplished through a combination of an examination of the characteristics of RC obtained from various sources and a comparison of the base properties of concrete made with RCA. Using standards established in Iraq, the grade of the cement was determined. The utilized cement conformed to ESS 4756-1/2009 specifications. All of the experiment's concrete was mixed with potable faucet water. Table 4.1 displays the 10 categories into which 40 concrete mixtures were categorized for the purpose of comparing their properties with those of RA. Preparation and evaluation in the laboratory of standard concrete formulations with water-to-cement ratios of 0.35. Each formula was designed to yield highly practical concrete. The results of plain concrete samples presented in table 4.2

Table 4.1: The Experiments Procedure.

	NG	SFRC	cube	cylinder (200*100)	cylinder (150*300)	Beam mold
case 1	0%	0%	CU	E	ET	CBM
case 2	2.50%	0%	CN-2.5	EN2.5	ET 2.5	CBN2.5
case 3	5%	0%	CN5	EN5	ET5	CBN5
case 4	7.50%	0%	CN7.5	EN7.5	ET7.5	CBN7.5
case 5	0.00%	0.25%	CF0.25	EF0.25	ETF0.25	CBF0.25
case 6	0.00%	0.50%	CF0.5	EF0.5	ETF0.5	CBF0.5
case 7	0.00%	1%	CF1	EF1	ETF1	CBF1
case 8	2.50%	1%	CFN-2.5	EFN2.5	EFT 2.5	CBFN2.5
Case 9	5%	1%	CFN5	EFN5	EFT5	CBFN5
Case 10	7.50%	1%	CFN7.5	EFN7.5	EFT7.5	CBFN7.5

4.2 COMPRESSIVE STRENGTH

The compressive strength of the cubes was measured at a temperature of 25° (+/-2° C) after curing for twenty-eight days. The concrete's strength was determined by averaging the results of three distinct measurements. The compressive strength of concrete is determined by the quality of the volume of cement in the mixture; thus, the study compared two distinct cement combinations (331 kg and 486 kg of cement). Similar results were observed in this investigation, all of which were associated with compressive strength.

Table 4.2: Results of Plain Concrete Tests.

	7 days/331 kg	8 days/486 kg	28 days/331 kg	29 days/486 kg
cubes compressive test MPa	42.21	45.74	59.45	64.43
cylinder compressive test MPa	31.74	36.14	44.70	50.90
splitting strength MPa	4.37	4.41	6.16	6.22
flexural strength MPa	5.41	5.07	7.63	7.14

4.3 SPLITTING RESULTS

Using the split tensile test, the tensile test of concrete may be evaluated in a convoluted manner. A cylindrical specimen is placed on its side and a radial force is applied to its surface during this test. This causes the specimen to shatter along its diameter vertically. A uniform diametric compressive force is applied along the entire length until failure occurs. This loading induces compressive stresses close to the applied load and tensile stresses on the load-bearing plane. Tests of the tensile strength of concrete are frequently conducted in a biaxial stress field where the compressive stress is three times greater than the tensile stress, as it shown in the Figure.

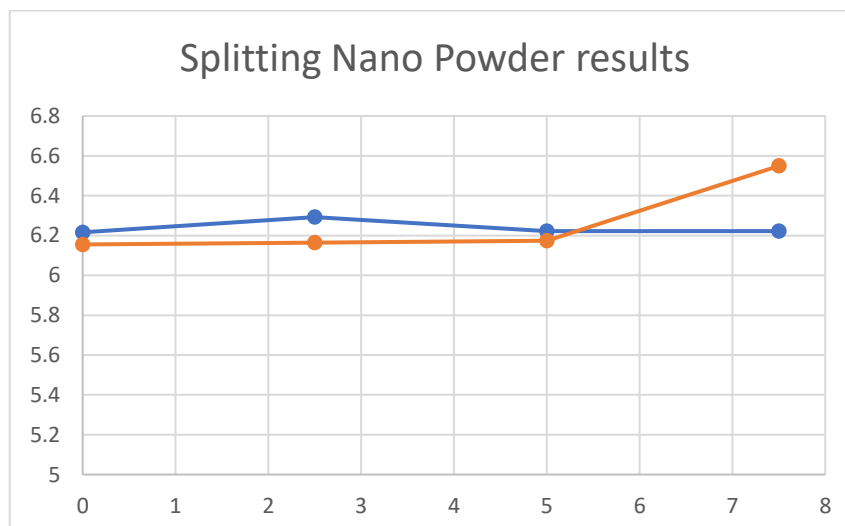


Figure 4.1: Splitting Nano Powder Results.

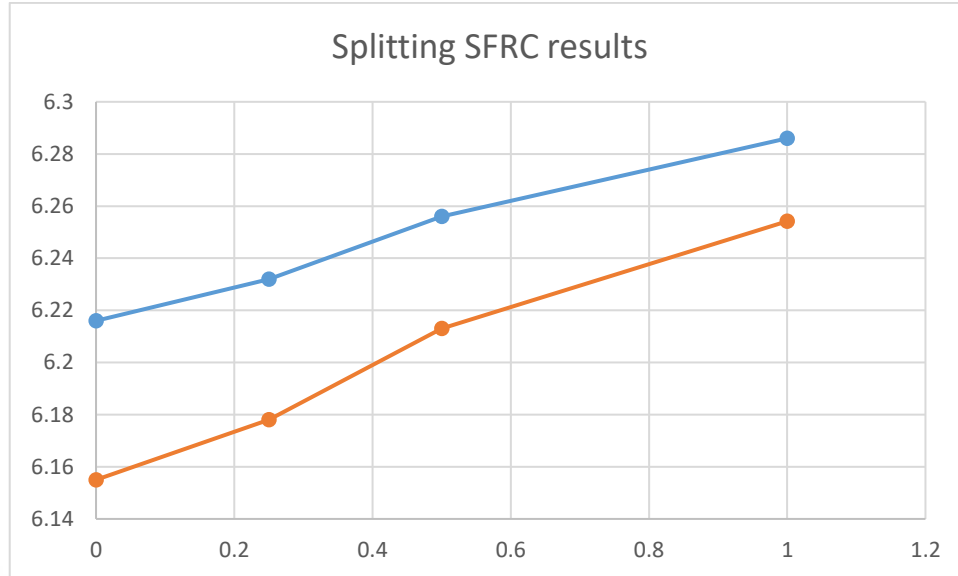


Figure 4.2: Splitting SFRC Results.

It can be seen from the results that increasing the nano glass powder decreased the increase the splitting results in case of 486 Kg especially after 5%, while increasing the SFRC increased the splitting results. Also, the results show that the same behavior observed for 331Kg of cement and 486 Kg of cement test results.

4.4 FLEXURAL STRENGTH RESULTS

A material's flexural strength is a mechanical property that assesses its resistance to deformation under stress. The flexural strength is measured using either the ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading) standard test procedures, and the Modulus of Rupture (MR) is reported in pounds per square inch (MPa). Depending on aggregate type, size, and volume, the flexural MR ranges from 10% to 20% of the aggregate's compressive strength. 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. When a beam is exposed to oxygen, its vitality is diminished. Beams require standardized curing and damp testing. It is quite difficult to satisfy all of these conditions on the job site, resulting in typically inaccurate and low MR readings. Even after a brief period of curing, flexural strength may decrease dramatically. Although flexure can be used during the design phase, concrete should be ordered and accepted based on its compressive strength. All trial samples should undergo flexural and

compressive testing to establish a correlation for use in field monitoring. The results of flexural strength shown in the figures below:

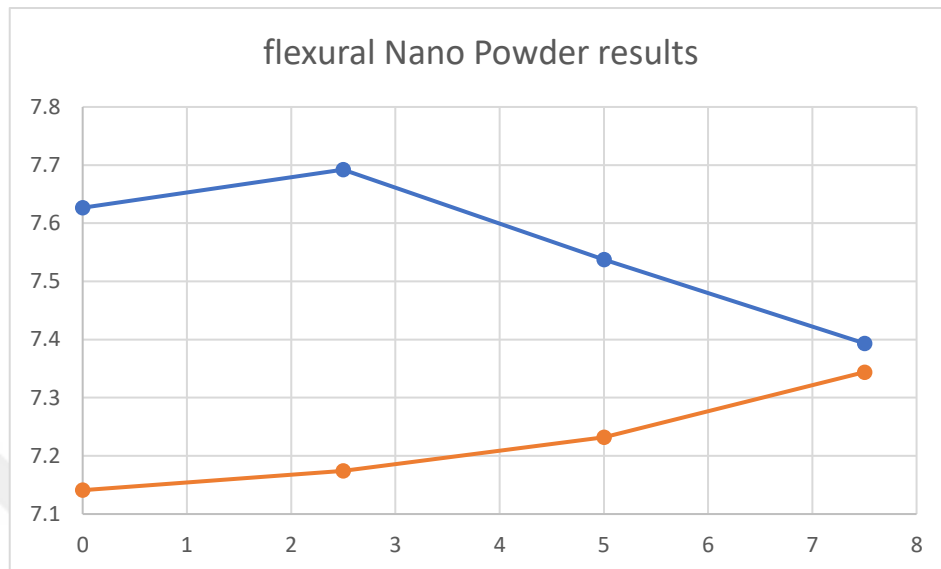


Figure 4.3: Flexural Nano Powder Results.

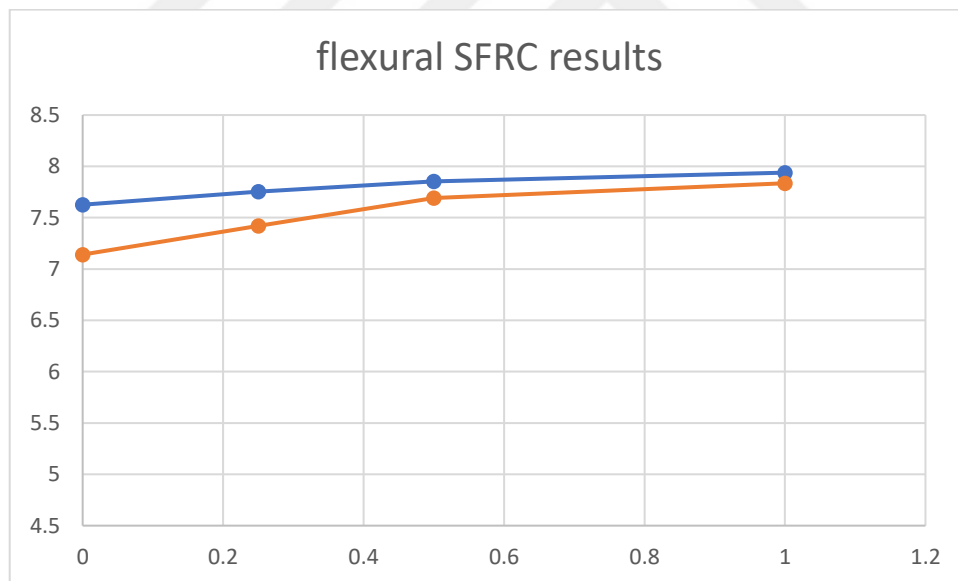


Figure 4.4: Flexural SFRC Results.

It can be seen from the results that increasing the nano glass powder change the results based on the nano powder percentage. Also, increasing the SFRC increased the flexural results especially in 331 Kg. Also, the results show that the same behavior observed for 486 Kg of cement and 331 Kg of cement test results present the same behavior.

4.4.1 Results of Nano Glass Additives

Researchers investigated the reactivity of nano-glass in a variety of methods in an effort to improve its compressive strength. Experimentally, the impact of nano-glass material on compressive strength was measured at 7 and 28 days. The results reveal the nature of the reaction of glass particles, which is to diminish compressive strength. At 28 days, the effects begin to improve. As measured by cumulative percentage increase, compressive strength decreases with increasing nano-glass percentage but increases with increasing cements of all ages.

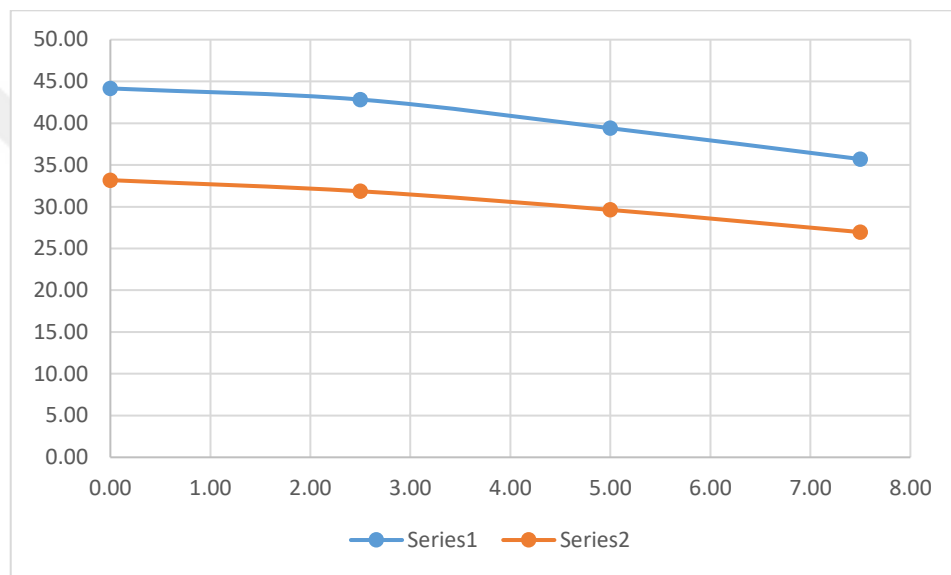


Figure 4.5: Results of Nano Glass/7 and 28 days/WC 0.45/331kg.

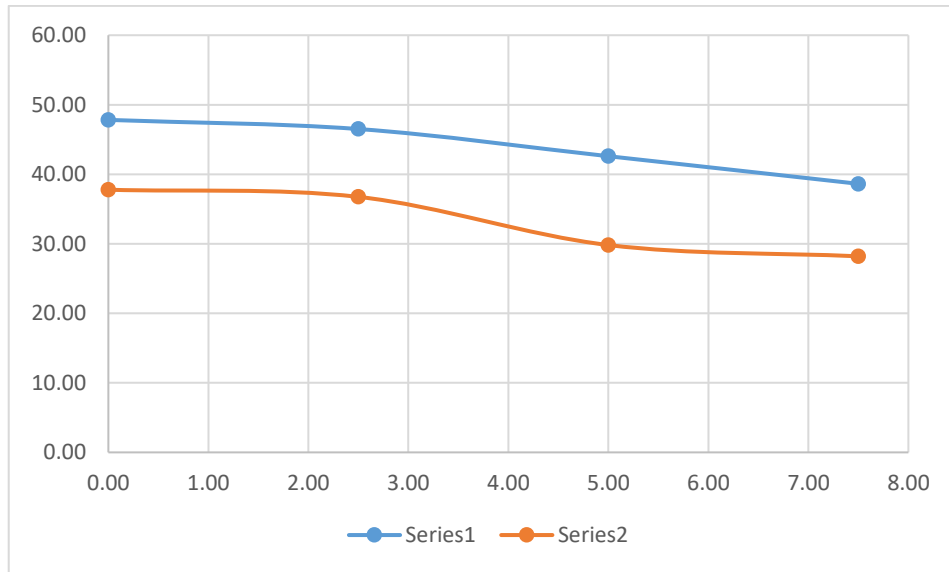


Figure 4.6: Results of Nano Glass/7 and 28 days/WC 0.45/486kg.

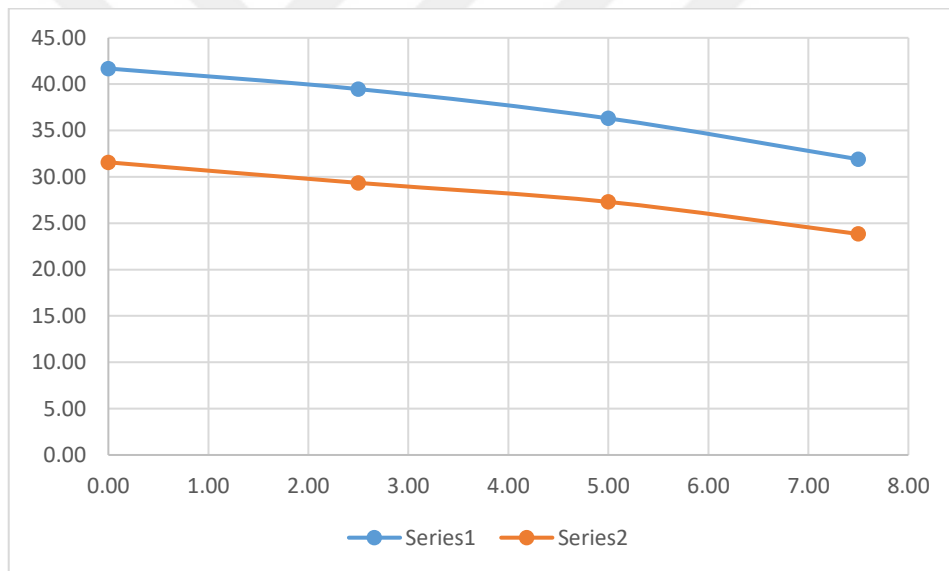


Figure 4.7: Results of Nano Glass/7 and 28 days/WC 0.55/331kg.

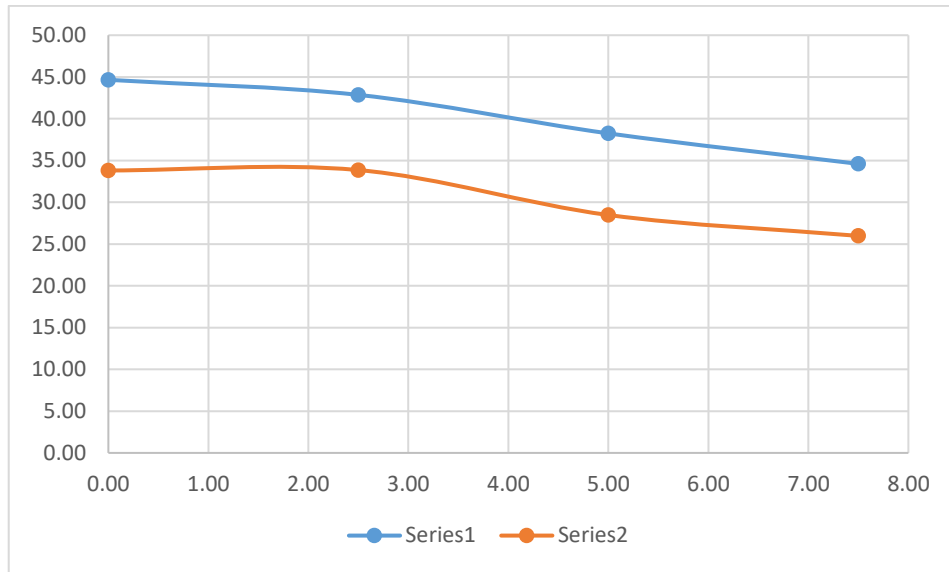


Figure 4.8 : Results of Nano Glass/7 and 28 days/WC 0.55/486kg.

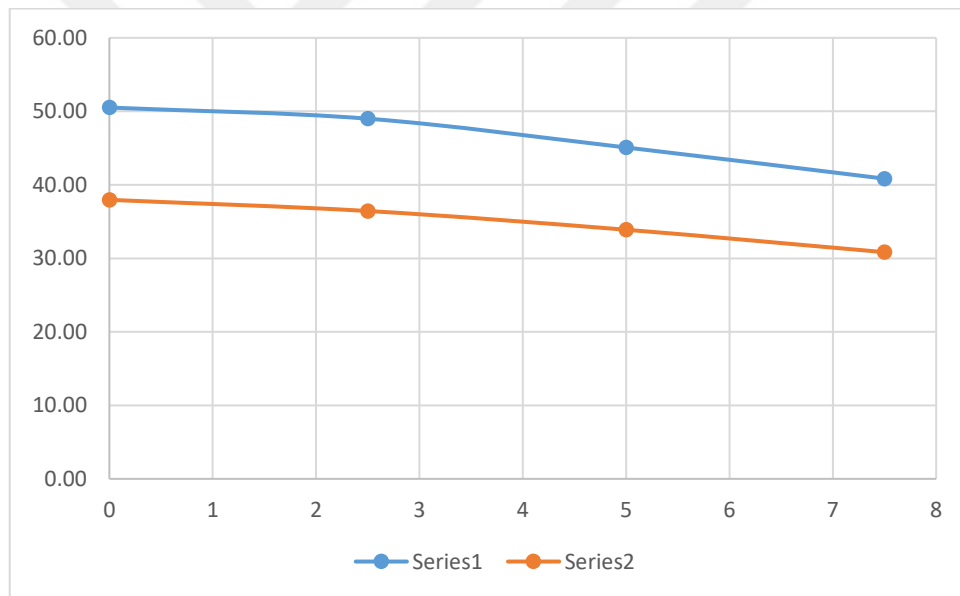


Figure 4.9: Results of Nano Glass/7 and 28 days/WC 0.65/331kg.

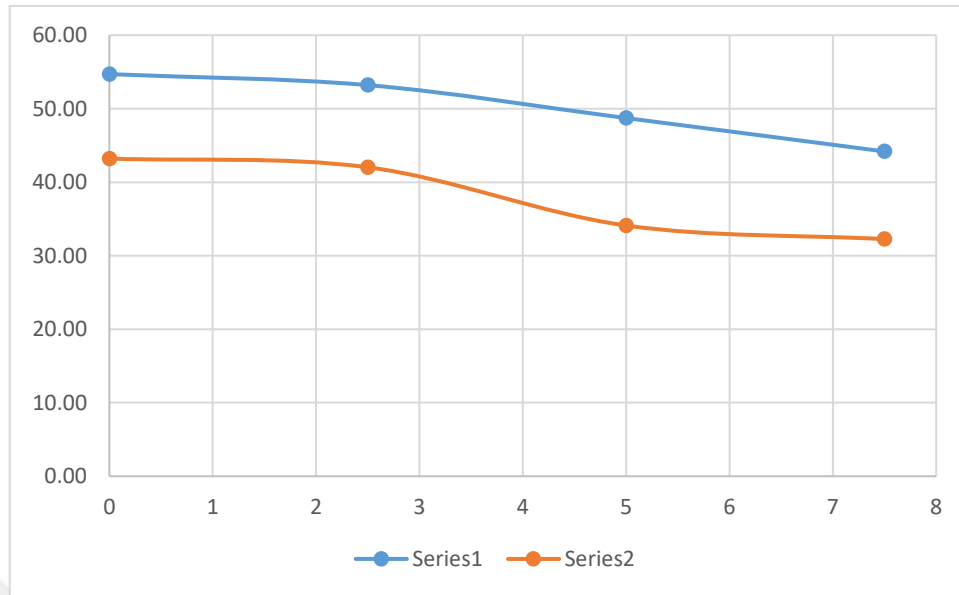


Figure 4.10: Results of Nano Glass/7 and 28 days/WC 0.65/486kg.

It can be seen from the results that increasing the nano glass powder decreased the beam resistance. Also, the results show that the same behavior observed for all cases of beam test results. The results of adding 331 kg of cement observed a reduction about 3.0%, 10.8% and 19.1% while in adding 486 kg of cement observed a reduction about 2.7%, 10.9% and 19.2% in beam resistance based on the percentage additives.

4.4.2 Results of SFRC Additives

Researchers examined SFRC's response in a variety of ways to discover ways to make it more compressible-resistant. Laboratory tests conducted at 7 days and 28 days demonstrate how SFRC affects beam strength. It was discovered that the strength increased, a characteristic of the SFRC reaction. People begin to feel better after 28 days. In addition to the total percentage increase seen in cements of all ages, a rise in SFRC percentage also results in an increase in beam strength.

Compressibility was shown to increase with SFRC percentage as predicted. In addition, all samples exhibit the same behavior in the results. When cement were added, the beam resistance effect was found a rise 1.2%, 6.2%, and 7.2% respectively.

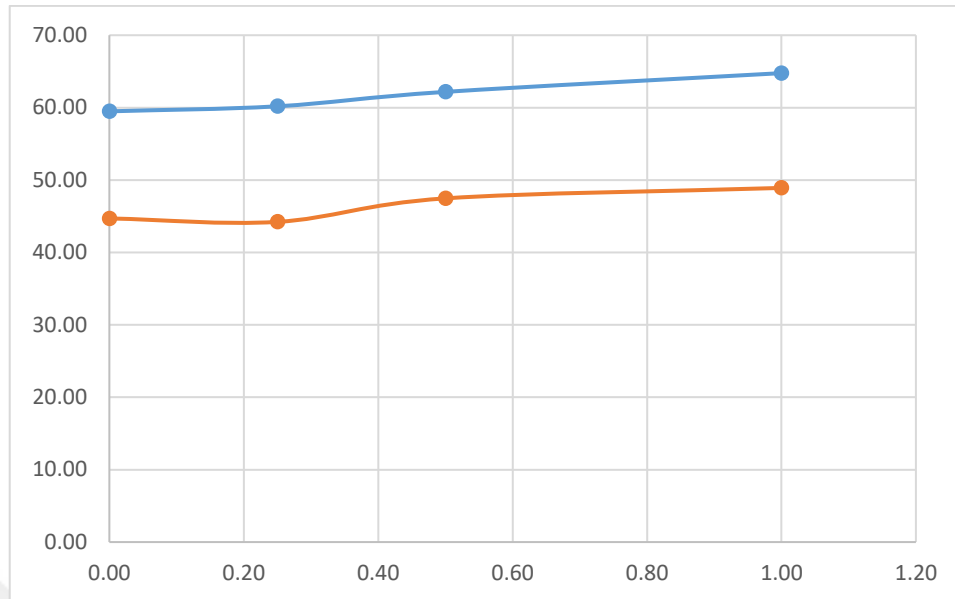


Figure 4.11 : Results of SFRC/ 7and 28 days/WC 0.45/331kg.

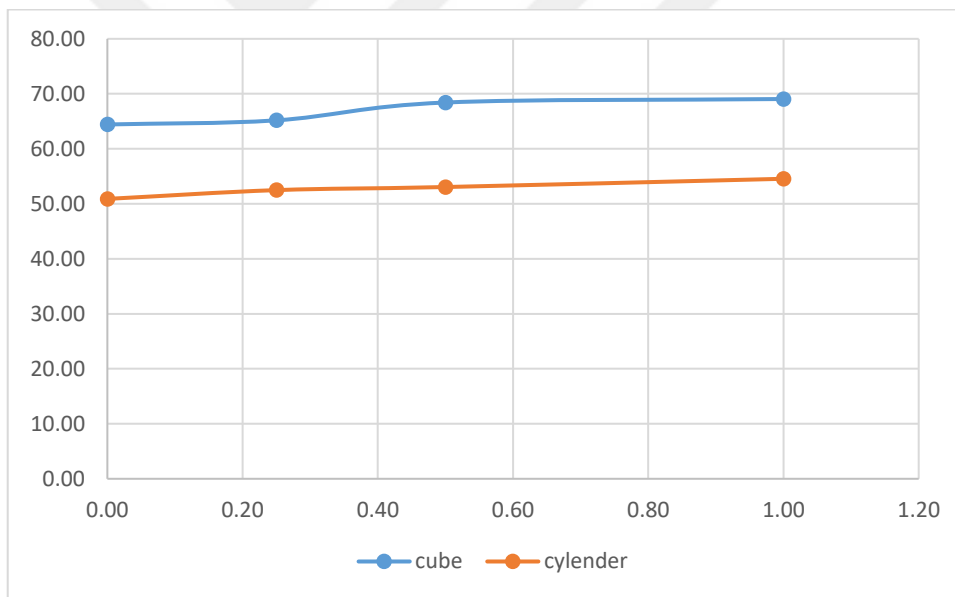


Figure 4.12: Results of SFRC/ 7and 28 days/WC 0.45/486kg.

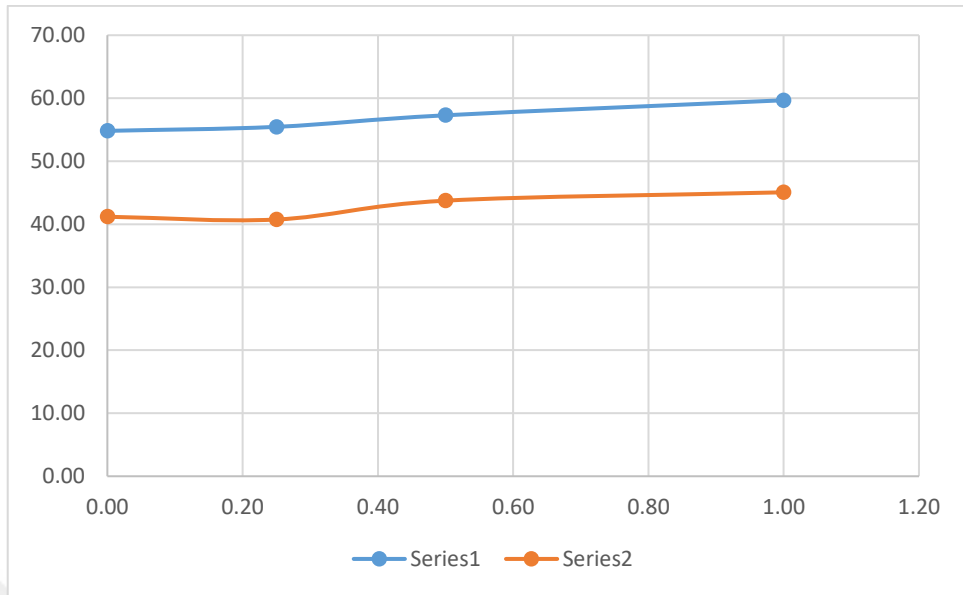


Figure 4.13: Results of SFRC/ 7and 28 days/WC 0.55/331kg.

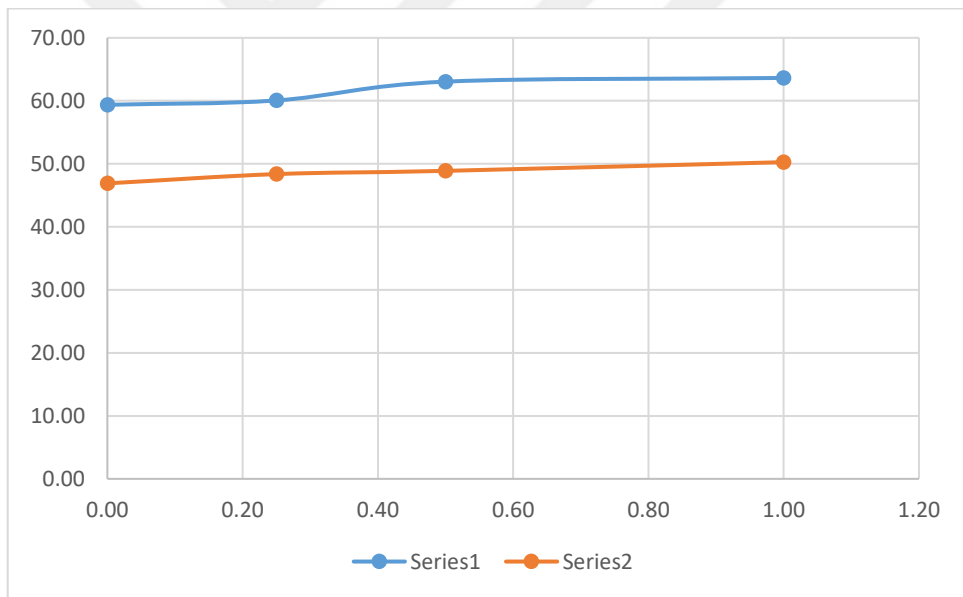


Figure 4.14: Results of SFRC/ 7and 28 days/WC 0.55/486 kg.

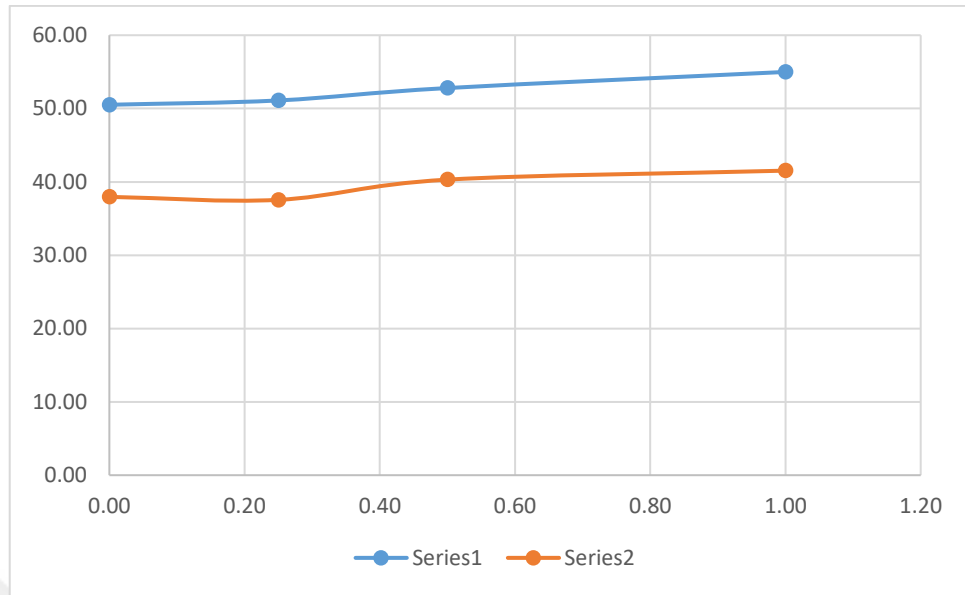


Figure 4.15: Results of SFRC/ 7and 28 days/WC 0.65/331kg.

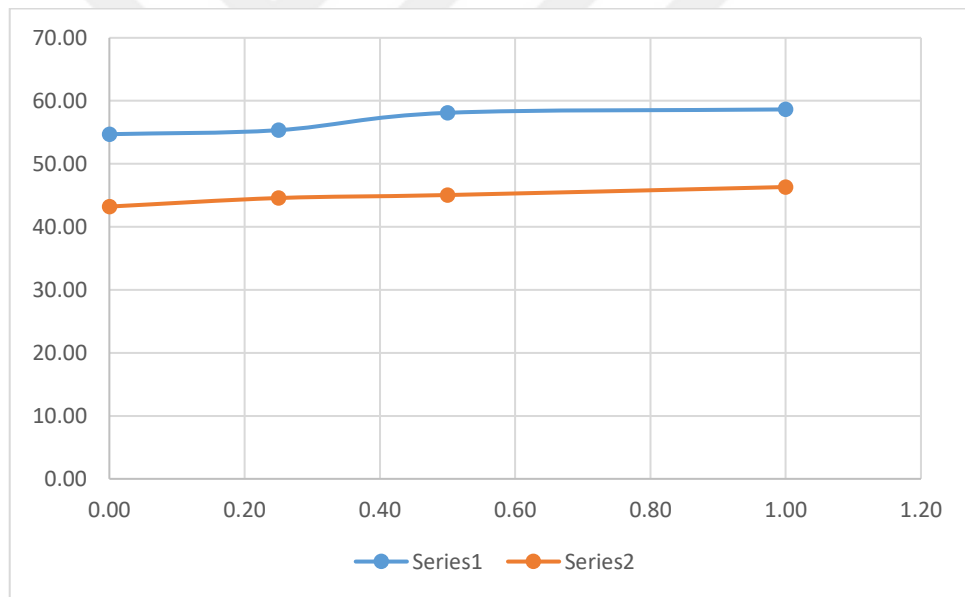


Figure 4.16: Results of SFRC/7 and 28 days/WC 0.65/486 kg.

5. CONCLUSION AND RECOMMENDATION

Most studies on high-performance concrete have focused on specialist concrete materials, which have characteristics that are different from those of regular concrete. However, there are not many results from laboratory tests that take into account the flexural and bending properties of HSC girders at the different levels of structural elements and their effects on capacity. This experimental endeavor will introduce steel fibers to a high strength concrete mix while taking volume fractions into consideration in order to evaluate the shear behavior of the hardened combination material. This is done by evaluating the structural acts that steel fibers play in moulding the behavior of this novel concrete material and by looking at the internal properties that affect the shear resistance.

The purpose of this thesis is to investigate the impact on concrete of varying the concrete percentage, water-to-cement ratio, nano-blanskite powder content, and SFRC impacts. The following inferences can be made in light of the research presented here.

- a. Experiments were conducted to determine the effect of nano-glass material on compressive strength at 7 and 28 days. The results show that increasing the SFRC enhanced the beam properties while increasing the nano glass powder decreased it. In addition, all tests exhibit the same behavior in the results. Additions of 331 kg of cement resulted in a 3.0%, 10.8%, and 19.1% decrease in load response based on percentage additives, whereas additions of 486 kg of cement resulted in a 2.7%, 10.9%, and 19.2% decrease in load response.
- b. As expected, higher SFRC percentages were shown to increase samples reliability. In addition, the outcomes are consistent across all samples. The load effect was found to rise when 1.2%, 4.5%, and 8.9% of cement was added, whereas the effect was found to climb when 1.2%, 6.2%, and 7.2% of cement was added.
- c. The splitting results for 486 Kg were reduced by the nano glass powder, notably after 5%, while they were improved by increasing the SFRC. The data also reveal that the same behavior was seen with 331Kg and 486Kg of cement.
- d. The proportion of nanoparticles in the glass powder influences the outcome. Additionally, in 331 Kg, the flexural results improved as the SFRC was raised. The

results also reveal that the behavior exhibited with 486 kg of cement is the same behavior observed with 331 kg of cement.

5.1 RECOMMENDATION

For future works, the researcher recommends to mix the SFRC with nano glass materials.



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