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Performance of Fly ash based Self-Compacting concrete

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Abstract

self-compacting concrete (SCC) has gained significant attention in the construction industry due to its ability to flow and fill formwork under its own weight without the need for mechanical consolidation. This paper presents a comprehensive review of the utilization of fly ash (FA) in enhancing the properties of self-compacting concrete. Fly ash, a by-product of coal combustion, possesses pozzolanic properties that contribute to the improvement of concrete durability, workability, and sustainability.

The review begins with an overview of the key characteristics of SCC and the challenges associated with its production and application. It then delves into the properties of fly ash, including its chemical composition, particle size distribution, and pozzolanic reactivity, which make it an attractive supplementary cementitious material for SCC.

The effects of fly ash on various fresh and hardened properties of self-compacting concrete are thoroughly examined. These include workability, segregation resistance, bleeding tendency, compressive strength, tensile strength, durability, and microstructure. Additionally, the influence of fly ash content, particle size, and fineness on SCC properties is discussed based on the available literature.

Furthermore, the paper discusses the mechanisms through which fly ash improves the performance of self-compacting concrete, such as filler effect, pozzolanic reaction, and refinement of pore structure. It also addresses the potential environmental benefits of utilizing fly ash in SCC, such as reduced carbon dioxide emissions and conservation of natural resources.

The review concludes with insights into the current challenges and future research directions in the field of self-compacting concrete incorporating fly ash. The findings underscore the significant potential of fly ash as a sustainable and effective supplementary material for enhancing the properties of self-compacting concrete, thereby contributing to the advancement of eco-friendly construction practices.

Chapter 1

Initial Report

1.1 Project Definition

The development of a country may be directly related to the development of the cement industry. Portland cement is the most man-made material on Earth used to make concrete, and it is the most widely used building material on the planet.The demand for cement is constantly increasing, and the production of cementand concrete is expected to increase in the coming decades. Some economistsuse concrete production as a measure of a country's economic strength. Thecement industry consumes huge amounts of raw materials and energy. Apartfrom this, a large amount of solid waste and gaseous emissions, especiallycarbon dioxide, are produced.

1.2 The Problem

The cement industry is one of the emitters of greenhouse gases, as0.83 kg of carbon dioxide is produced per kg of cement production,which leads to 8% of the total global anthropogenic carbon dioxideemissions. The aforementioned defects of concrete forced researchersto find new bonds as an alternative to traditional cement-concrete sothat better and less energy-consuming raw materials could be obtained with less emissions of greenhouse gases.

1.3 Study Objectives

Study the effect of an additive flyash and Super plasticizers to self-compacting concrete Changing the percentage of superplasticizer while keeping the percentage of flyash in the concrete mixture constant and knowing the importance of additives to self-compacting concrete.

1.4 Existing Solutions

Using the Fly ash , we compare the results of the tests with other research or previous work to reach a better judgment of such material. Tounderstand the effect of using such materials in different fields, the followingparameters have been investigate :-

• The type and properties of self-compacting concrete.

▪The configuration of the tests and their results.

1.5 Composition of self-compacting concrete

The following materials are required for the production of self-compacting concrete:

• Fly Ash: It is a by-product of thermal power plant.

• Cement: s a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials

• Aggregates: Fine and coarse aggregates as required for normal concrete.

• Water

• Super plasticizers : high range water reducers, are additives used for making high-strength concrete or to place self-compacting concrete.

Chapter 2

2.1 Introduction

Self-compacting concrete (SCC) has emerged as a revolutionary material in the realm of construction due to its unique ability to flow and fill intricate formwork under its own weight without the need for external vibration. This innovative concrete technology has not only streamlined construction processes but has also led to improvements in structural performance and durability. In recent years, there has been a growing interest in enhancing the properties of SCC by incorporating supplementary cementitious materials (SCMs) such as fly ash.

Fly ash, a by-product of coal combustion in thermal power plants, is abundantly available worldwide and possesses pozzolanic properties that can significantly enhance the performance of concrete. When properly utilized in SCC, fly ash can contribute to improved workability, durability, and sustainability of the concrete mix. However, the successful incorporation of fly ash into SCC requires a comprehensive understanding of its effects on various fresh and hardened properties as well as the underlying mechanisms governing these effects.

This introduction sets the stage for exploring the potential benefits and challenges associated with the utilization of fly ash in self-compacting concrete.

It provides an overview of the significance of SCC in modern construction practices and highlights the need for sustainable solutions to address environmental concerns associated with traditional concrete production methods.

Moreover, it introduces fly ash as a promising supplementary material that can enhance the performance of SCC while reducing its environmental footprint.

Through a detailed examination of existing literature and research findings, this study aims to elucidate the influence of fly ash on the properties of self-compacting concrete and identify areas for further investigation. By gaining insights into the synergistic effects of fly ash and SCC, stakeholders in the construction industry can make informed decisions regarding the adoption of sustainable concrete technologies and contribute to the advancement of eco-friendly construction practices.

2.2 Use of Self-compacting concrete (SCC)

Self-compacting concrete (SCC) offers several advantages and applications across the construction industry due to its unique properties. Here are some common uses of SCC:

1 .Highly Reinforced Structures

SCC is particularly beneficial in structures with dense reinforcement arrangements, such as columns, beams, and walls, where traditional vibrated concrete may be difficult to place without causing segregation or voids. The ability of SCC to flow easily and fill intricate formwork ensures proper compaction and uniform distribution of concrete around reinforcement.

2.Precast Concrete Elements

SCC is widely used in the production of precast concrete elements, including facades, panels, stairs, and architectural components. Its excellent flowability allows for rapid and efficient casting of complex shapes and textures, resulting in high-quality finished products with consistent surface appearance.

3.Infrastructure Projects

SCC is commonly used in infrastructure projects such as bridges, tunnels, and retaining walls, where high durability, strength, and ease of placement are essential. SCC's ability to flow into congested areas and form tight seals around embedded elements makes it well-suited for applications requiring tight construction tolerances and minimal maintenance.

4.High-rise Buildings

In high-rise construction, where the vertical pumping of concrete over great heights is required, SCC can offer significant advantages. Its self-leveling properties reduce the risk of blockages and segregation during pumping, resulting in faster construction progress and improved quality control.

5.Architectural Concrete

SCC is favored for architectural concrete applications where aesthetics and surface finish are critical. Its ability to flow smoothly into formwork without the need for vibration minimizes surface defects and air voids, resulting in superior surface finishes with intricate textures and details.

6.Repair and Rehabilitation

SCC can be used in repair and rehabilitation projects to fill voids, cracks, and cavities in existing concrete structures. Its self-consolidating nature ensures thorough encapsulation of reinforcement and effective bonding with existing concrete substrates, improving the structural integrity and longevity of repaired elements.

7.Underwater Concreting

SCC's ability to flow and self-compact makes it suitable for underwater concreting applications, such as marine structures and offshore platforms. Its rapid placement and consolidation properties enable efficient construction in challenging underwater environments without the need for specialized equipment or additional compaction efforts.

8.Green Building Practices: Utilizing recycled materials in SCC production can contribute to sustainable construction practices by reducing the environmental impact of concrete production and minimizing waste generation. SCC incorporating recycled aggregates or supplementary cementitious materials can help achieve green building certifications and meet sustainability goals.

Overall, the versatility, durability, and ease of placement offered by SCC make it a preferred choice for a wide range of construction projects, particularly those requiring high-performance concrete with complex geometries and demanding construction conditions.

2.3 Limitations of self-compact concrete

.Higher Material Cost

SCC typically requires the use of high-quality materials, such as high-range water reducers (superplasticizers) and viscosity-modifying admixtures. These specialized materials can be more expensive compared to those used in traditional concrete, resulting in higher material costs.

• Complex Mix Design

Designing an optimal mix for SCC can be more challenging compared to traditional concrete. Achieving the desired flowability, stability, and strength requires careful consideration of the mix proportions, admixture dosages, and particle size distribution of aggregates. Extensive testing and experimentation may be required to fine-tune the mix design.

• Sensitive to Mix Proportions

SCC is sensitive to variations in mix proportions, particularly the water-cement ratio. Small changes in the mix design can significantly impact the flowability and performance of SCC. Careful control and monitoring of the mix proportions are necessary to ensure consistent results.

• Limited Applicability for Certain Structures

SCC may not be suitable for all construction applications. In structures with low reinforcement content or simple geometries, where traditional concrete can be easily compacted with conventional methods, the use of SCC may not provide significant advantages and can lead to higher costs.

• Setting Time and Workability Retention

SCC typically has a shorter setting time compared to traditional concrete. This reduced setting time can affect workability and compaction during placement. It is important to carefully plan and coordinate the placement process to ensure proper consolidation and finishing before the concrete sets.

Risk of Segregation: While SCC is designed to reduce segregation, there is still a risk of segregation if the mix design, admixture dosage, or placement methods are not properly controlled. Segregation can lead to variations in concrete properties, reduced strength, and compromised durability.

2.4 Types of self-compact concrete

• Conventional SCC Conventional

SCC is the most widely used type of self-compacting concrete. It typically consists of a combination of cement, aggregates, water, and chemical admixtures, such as superplasticizers and viscosity-modifying agents. Conventional SCC offers excellent flowability, stability, and workability, making it suitable for a wide range of construction applications.

• High-Strength SCC High-strength

SCC is specifically designed to achieve higher compressive strength compared to conventional SCC. It utilizes a carefully proportioned mix design, including high-performance cement, fine aggregates, and optimized chemical admixtures. High-strength SCC is commonly used in applications where structural strength is critical, such as high-rise buildings and bridges.

• Fiber-Reinforced SCC

Fiber-reinforced SCC incorporates fibers, such as steel, polypropylene, or glass fibers, into the concrete mixture. The addition of fibers enhances the tensile strength, toughness, and crack resistance of the concrete. Fiber-reinforced SCC is commonly used in applications where improved post-cracking behavior and durability are required, such as tunnel linings and industrial flooring.

• Lightweight SCC Lightweight

SCC is formulated using lightweight aggregates, such as expanded clay, shale, or lightweight synthetic materials. This type of SCC offers reduced density, making it suitable for applications where weight reduction is desired, such as in precast elements and high-rise buildings

2.5 Self-compacting concrete production :

Self-compacting concrete (SCC) is a specialized type of concrete that doesn't require vibration for compaction and can flow under its own weight to completely fill formwork, even in congested reinforcement areas. The production of SCC involves careful selection and proportioning of materials to achieve the desired properties. Here's an overview of the production process:

1. **Material Selection**

The selection of materials is crucial for producing SCC. Cement, aggregates, water, and admixtures need to be chosen carefully to meet the desired flowability, stability, and strength requirements.

2. **Mix Design**

SCC mix design is based on achieving the required flowability, passing ability, and stability without segregation or bleeding. Various tests, such as slump flow test, V-funnel test, and L-box test, are conducted to optimize the mix proportions.

3. **Aggregate Grading**

The aggregate grading plays a significant role in SCC. Typically, a well-graded combination of coarse and fine aggregates is used to optimize packing density and reduce segregation.

4. **Admixtures**:

Various types of chemical admixtures are used in SCC to enhance its properties. These may include superplasticizers to improve flowability, viscosity modifiers to control bleeding, and stabilizers to prevent segregation.

5. **Mixing**

SCC is usually mixed using high-speed, high-shear mixers to ensure thorough dispersion of ingredients and achieve the desired consistency. The mixing process should be carefully controlled to prevent overheating and maintain the properties of the concrete.

6. **Quality Control**: Quality control measures are essential throughout the production process to ensure consistency and performance of SCC. This includes regular testing of fresh and hardened concrete properties, as well as monitoring of production parameters.
7. **Placement**: During placement, SCC is poured into formwork without the need for vibration. It flows easily and fills the formwork without segregation, even in complex or congested areas.
8. **Curing**: Proper curing is essential to achieve the desired strength and durability of SCC. Curing methods may include moist curing, curing compounds, or other specialized techniques depending on the project requirements.

By carefully controlling the materials, mix design, and production process, high-quality SCC can be produced to meet the specific requirements of construction projects, offering benefits such as improved construction speed, reduced labor costs, and enhanced durability.

2.6Types of Waste Materials Used Self-compacting concrete production :

Several waste materials can be effectively used in the production of self-compacting concrete (SCC), offering both environmental and economic benefits. Here are some common types of waste materials utilized in SCC production:

1. **Fly Ash:** Fly ash is a byproduct of coal combustion in power plants. It is commonly used as a partial replacement for cement in concrete production, including SCC. Fly ash can improve workability, reduce heat of hydration, and enhance long-term strength and durability.

2. **Ground Granulated Blast Furnace Slag (GGBFS):** GGBFS is a byproduct of iron production in blast furnaces. Like fly ash, it can be used as a partial replacement for cement in SCC. GGBFS improves workability, reduces permeability, and enhances sulfate resistance and durability.

3. Silica Fume

Silica fume is a byproduct of silicon metal production or ferrosilicon alloys. It is a highly reactive pozzolan that can be added to SCC to improve strength, durability, and resistance to chloride ion penetration.

4. Recycled Aggregates

Recycled aggregates, obtained from crushed concrete waste or demolished structures, can be used as replacements for natural aggregates in SCC. Using recycled aggregates reduces the demand for virgin materials and helps to manage construction waste.

5. Waste Glass:

Crushed waste glass can be used as a partial replacement for fine or coarse aggregates in SCC. Glass aggregates can improve workability, reduce the environmental impact of concrete production, and provide aesthetic benefits.

6. **Rice Husk Ash (RHA):** RHA is a byproduct of rice milling. It contains high levels of silica and can be used as a pozzolanic material in SCC. RHA can improve workability, reduce permeability, and enhance strength and durability.

6. **Plastic Waste**

Certain types of plastic waste, such as recycled plastic fibers or particles, can be incorporated into SCC to improve its mechanical properties, such as impact resistance and ductility. However, the use of plastic waste in concrete should be carefully evaluated to ensure compatibility and long-term performance.

7. Industrial Byproducts

Various other industrial byproducts, such as quarry dust, ceramic waste, and bottom ash, can also be utilized in SCC production to replace conventional materials and reduce environmental impact.

Utilizing waste materials in SCC production not only reduces the consumption of natural resources but also helps to mitigate environmental pollution by diverting waste from landfills. However, it's essential to conduct thorough testing and quality control to ensure that SCC incorporating waste materials meets the required performance standards and durability criteria for specific applications.

2.7 Difference Between Self-compacting concrete (SCC) and cement concrete

Self-compacting concrete (SCC) and conventional cement concrete (often referred to simply as concrete) share similarities but also have distinct differences in terms of composition, properties, and applications. Here's a breakdown of the key differences between SCC and cement concrete:

1.Workability and Flowability:

•**SCC: SCC** is designed to have high flowability and self-compactability, meaning it can flow into and fill intricate formwork under its own weight without the need for external vibration. It has a higher level of workability compared to conventional concrete.

•**Cement Concrete**: Conventional concrete typically requires vibration during placement to ensure proper compaction and consolidation. While it can be made workable, achieving the same level of flowability as SCC usually requires additional water, which can compromise strength and durability.

2.Consolidation

•**SCC: SCC** consolidates itself under its own weight, filling formwork evenly and effectively without the need for mechanical vibration. This results in reduced labor and equipment costs and eliminates the risk of honeycombing or voids.

•**Cement Concrete:** Conventional concrete requires external vibration to consolidate and remove entrapped air, ensuring proper compaction and bonding between aggregates. Without proper consolidation, conventional concrete may exhibit reduced strength and durability.

3.Mix Proportioning

•**SCC: SCC** typically requires careful selection and proportioning of materials, including fine and coarse aggregates, cementitious materials, water, and chemical admixtures, to achieve the desired flowability, stability, and strength without segregation.

•**Cement Concrete**: Conventional concrete also requires appropriate mix proportioning, but the emphasis is primarily on achieving adequate workability and strength through the use of suitable aggregates, cement, and water-cement ratio.

4.Applications:

•SCC: SCC is commonly used in applications where high flowability, tight formwork spaces, and complex geometries are required, such as heavily reinforced structures, precast elements, architectural concrete, and underwater concreting.

•Cement Concrete: Conventional concrete is used in a wide range of applications, including foundations, slabs, pavements, structural members, and general construction, where workability, strength, and durability are paramount but the need for self-compaction is not critical.

5.Construction Process:

•SCC: The construction process with SCC is typically faster and more efficient compared to conventional concrete, as it eliminates the need for vibration equipment and allows for rapid and easy placement of concrete in congested areas.

•Cement Concrete: Conventional concrete placement may require more time and labor due to the need for vibration equipment and additional compaction efforts to ensure proper consolidation and compaction.

2.8 Structures That Used self-compacting Concrete

Self-compacting concrete (SCC) finds application in various types of structures due to its unique properties, including high flowability, self-compactability, and ability to fill intricate formwork without the need for vibration. Some common structures that utilize SCC include:

1.Bridges: SCC

is extensively used in the construction of bridge elements such as bridge decks, abutments, piers, and columns. Its ability to flow easily around congested reinforcement and into complex formwork makes it well-suited for bridge construction, where tight construction tolerances and high durability are essential.

2.High-rise Buildings

In high-rise construction, where the vertical pumping of concrete over great heights is required, SCC offers significant advantages. Its self-leveling properties reduce the risk of blockages and segregation during pumping, resulting in faster construction progress and improved quality control.

3.Tunnels

SCC is used in the construction of tunnel linings, particularly in segments where access is restricted and manual compaction is difficult. Its ability to flow smoothly and self-consolidate ensures proper compaction and bonding with the existing substrate, reducing the risk of voids and improving structural integrity.

4.Dams and Hydraulic Structures

SCC is employed in the construction of dams, spillways, and other hydraulic structures where high fluidity and resistance to segregation are critical. Its self-compacting nature allows for efficient placement and consolidation of concrete in tight spaces and around embedded elements such as gates and conduits.

5.Precast Elements:

SCC is widely used in the production of precast concrete elements, including facades, panels, stairs, and architectural components. Its excellent flowability enables rapid and efficient casting of complex shapes and textures, resulting in high-quality finished products with consistent surface appearance.

6.Underground Structures

SCC is used in the construction of underground structures such as tunnels, subway stations, and underground parking garages. Its ability to flow easily and fill formwork without the need for vibration makes it ideal for applications where access is limited and manual compaction is impractical.

7.Marine Structures

SCC is employed in the construction of marine structures such as seawalls, jetties, and offshore platforms. Its ability to withstand harsh marine environments and provide durable concrete with minimal maintenance requirements makes it a preferred choice for coastal and offshore construction projects.

8.Architectural Concrete

SCC is favored for architectural concrete applications where aesthetics and surface finish are critical. Its ability to flow smoothly into formwork without the need for vibration minimizes surface defects and air voids, resulting in superior surface finishes with intricate textures and details.

These are just a few examples of the diverse range of structures that utilize self-compacting concrete. SCC's versatility, durability, and ease of placement make it a preferred choice for various construction projects, particularly those requiring high-performance concrete with complex geometries and demanding construction conditions.

Advantages:

Ease of Placement: SCC flows easily into intricate and congested reinforcement without the need for vibration, making it highly suitable for complex structures like bridges and high-rise buildings.

Improved Surface Finish: Due to its self-leveling properties, SCC produces a smoother surface finish, reducing the need for manual finishing work.

Reduced Labor Requirements: Eliminating the need for vibration reduces labor requirements and can speed up construction time.

Enhanced Durability: SCC typically has higher strength and durability due to its lower water-cement ratio and better compaction around reinforcement.

Reduced Noise Pollution: Since SCC eliminates the need for vibrating equipment, it reduces noise pollution on construction sites.

2.9Advantages and disadvantages of Self-compacting concrete (SCC)

Advantages:

1. Ease of Placement: SCC flows easily into intricate and congested reinforcement without the need for vibration, making it highly suitable for complex structures like bridges and high-rise buildings.
2. Improved Surface Finish: Due to its self-leveling properties, SCC produces a smoother surface finish, reducing the need for manual finishing work.
3. Reduced Labor Requirements: Eliminating the need for vibration reduces labor requirements and can speed up construction time.
4. Enhanced Durability: SCC typically has higher strength and durability due to its lower water-cement ratio and better compaction around reinforcement.
5. Reduced Noise Pollution: Since SCC eliminates the need for vibrating equipment, it reduces noise pollution on construction sites.
6. Improved Structural Integrity: SCC typically exhibits fewer voids and honeycombs, resulting in better structural integrity and resistance to environmental factors such as freeze-thaw cycles and chemical attacks.

7. Enhanced Workability: SCC's high fluidity allows it to flow effortlessly into complex forms and tight spaces, reducing the need for formwork modifications and facilitating the construction of intricate shapes.
8. Increased Safety: Eliminating the need for manual compaction reduces the risk of musculoskeletal injuries among construction workers associated with repetitive vibration tasks.
9. Potential for Reduced Construction Time: While initial setup and testing may take longer, the ease of placement and reduced need for rework can contribute to overall time savings during construction.
10. Green Building Benefits: SCC's ability to achieve higher strength with lower cement content can lead to reduced carbon emissions associated with concrete production, contributing to sustainable construction practices.

Disadvantages

1. Cost: SCC can be more expensive than conventional concrete due to the additional materials required for its mix design and the specialized testing needed to ensure its performance.

2. Initial Learning Curve: Adopting SCC may require additional training for construction workers to understand its properties and proper handling techniques.

3. Risk of Segregation: Improper mix design or handling can lead to segregation, where heavier aggregates settle at the bottom and lighter materials rise to the top, compromising the uniformity and strength of the concrete.

4. Setting Time: SCC typically has a longer setting time compared to conventional concrete, which may affect construction schedules, especially in time-sensitive projects.

5. Quality Control Challenges: Maintaining consistent quality with SCC can be challenging due to variations in materials and mix proportions, requiring strict quality control measures throughout the production and placement process.

6. Sensitive to Mix Design: Achieving the desired properties of SCC requires precise control over mix proportions, including the selection of appropriate admixtures and aggregates, which may vary depending on project requirements and conditions.
7. Limited Pumping Distance: SCC's high fluidity may lead to increased pressure and friction during pumping, limiting the distance it can be transported without segregation or excessive bleeding.
8. Temperature Sensitivity: SCC's setting time and rheological properties are sensitive to temperature variations, requiring adjustments in mix design and construction practices in extreme weather conditions.

Literature review

Introduction

In this chapter, laboratory mixtures were made to identify theproperties of self-compacting concrete and the use of somematerials. These materials will be identified in this chapter. The following materials are required for the production of self-compacting concrete.

3.1 Fly ash:

Fly ash is manufactured by electric shock, where coal is burned in moisture generating plants. It is dried The embers are blown through the air inside the steam boiler chamber so that they are burned immediately, causing the temperature to rise.

In addition to manufacturing molten metal. Steam boiler tubes derive relatively warm from the steam boiler, and then cooling gas Chimneys, which lead to the solidification of the molten metal from the coarse ash fractions, in the form of bottom ash or slag, and then transferred to the bottom combustion chambers, while the lighter fine ash fractions, called fly ash, continue to be postponed in the flue gas. Then it empties

Fly ash by particles such as electrostatic precipitators or physical bag filtration.

Mineral properties of fly ash:

Fly ash contains particles that are mostly spherical in shape and their size ranges between 0.01 and 0.1 microns These small balls give new properties to concrete, the most important of which is the softness property, as the softness property is One of the important properties derived from fly ash is Coal composition, combustion conditions, ash collection systems, and other variables greatly influence fly ash formation.

So the formation of fly ash is affected by the cooling rate and is approximately (51-61%) in the form of glass particles [07, 00].

Chemical properties:

The fly ash coagulates while being deferred in the emission gases and is also collected by electrostatic precipitators or beams.

Purification. The parts coagulate as they are postponed in the released gases. It consists mainly of silicon dioxide, which is available In two forms, such that it is shapeless or surrounded by a circle and smooth, and also crystalline in form, whatever aluminum oxide or iron oxide Sharp, pointed, and dangerous. Fly ash is very diverse, reaching a mixture of glassy particles with crystalline phases Various recognizable minerals such as quartz, mullite, and various iron oxides It can be noted that concrete has a compressive strength ranging between 05-45 MPa, corresponding to chloride penetration at a rate ofFrom 2 to 1, when the resistance increases from 71-01 MPa, there is a penetration of chloride at a rate of 211-0111.

Results using flyash:

Through the experiments and research presented by the researchers in this study, we can summarize some results related to the use of

Fly ash to form lightweight concrete in several points:

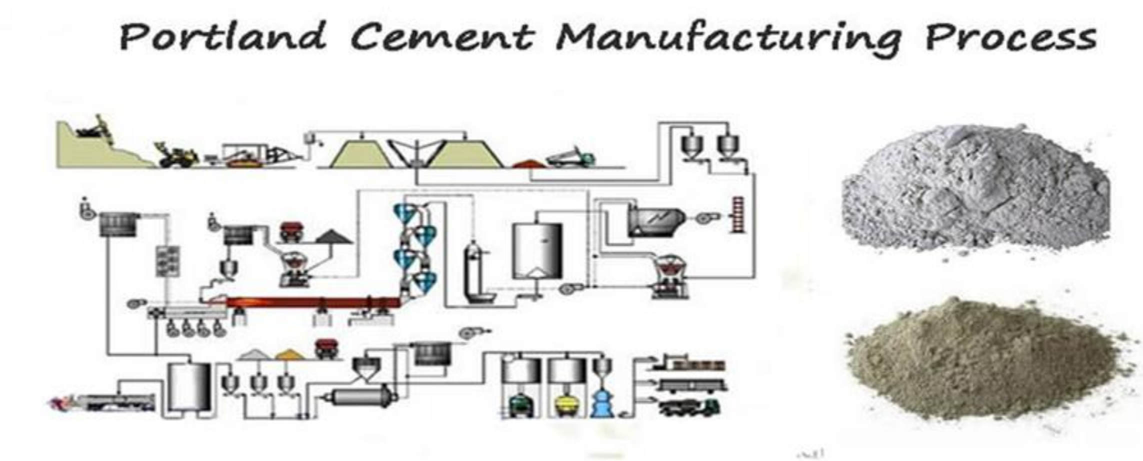
- When using fly ash in the concrete mixture, it gives good smoothness to the concrete mortar and good workability, which It gives concrete an advantage in the finishing process, such as the process of placing and transporting concrete, especially via concrete pumps.
- The mixture consisting of fly ash gains strength and durability at an advanced age.
- The water/cement ratio greatly affects the permeability of the mixture consisting of fly ash.
- The use of lightweight aggregate from fly ash led to a reduction in the unit weight of concrete, and in return, it was necessary to takePrecautions in terms of improving durability to chloride ion penetration as well as in terms of permeability.

3.2.Ordinary Portland Cement (OPC)

This cement is actually a clinker comprising four parts of silicate and one part of aluminates, which leads to much slower reactions with the water. SO3 contents in OPC is up to 3%, which contributes to the good bond between the cement and the aggregates. Higher content of SO3 also contributes to high resistance upon the sulfate attacks. OPC is available in many different grades, the most common ones are the 33, 43 and 53 grades. These numbers reflect the characteristic strength of the cement after 28 days. In other words, higher the grade, higher the strength. The slower a cement hydrates, the more fluid it remains. In fact, it is the fine and hard clinker that slows the rate of cement hydration. Because of this, in general, fluidity and cement strength are inversely proportional. Consequently, lower grade cements generally show better flow.

For the SCC, generally 33 grades are used due to their high workability. Currently, some manufacturers have produced the 22 grade OPC which can offer extremely high flow required for the successful SCC. The cement has been ground much finer than normal and the strength at later age is provided by much higher C3S content in this cement.

Although reduced strength development due to less C3S might be a problem for this cement in normal concretes, this product has great potential for the SCC.Ordinary Portland cement has been found to be the most usual type of cement around the world.



3.3Silica Fume

This is a very fine material composed of amorphous silica produced by electric arc and is a by-product of silicon and ferrosilicon alloy production. Silica fume is often used to increase the strength and durability of concrete. It does this by filling pores within the hydrated cement paste of the concrete. As a result of this, it reduces the permeability of the concrete to chloride and hence reduces the rate of corrosion of any steel in the concrete. This aspect of silica fume is particularly desirable for those precasting concrete and is often used to replace microsilica. Depending on the reactivity and fineness of the silica fume, it can be cost-effective. It also enhances the strength of concrete with just a small addition of silica fume. It has been suggested that an addition of 10% of microsilica can increase the strength of concrete by up to 30%.

There are, however, both positive and negative aspects to using silica fume as a way to improve the strength and durability of concrete.

An obvious benefit of silica fume is its effectiveness in enhancing the durability of concrete, and it is a material that is relatively cheap to acquire. However, the addition of silica fume may also increase the viscosity of the concrete, and the effect it has on the time it takes concrete to set and cure is largely still unknown.

The use of silica fume in concrete, therefore, may require more exploration in its chemical reactions and its effects on the long-term properties of concrete. As it stands, silica fume presents a potential for enhancing the strength and durability of concrete, and over time it may be used to replace the additional cement content and improve the strength of structures.

SILICA FUME (WHITE) SILICA FUME (GREY)

3.4Rice Husk Ash

Rice husk ash (RHA) is used in concrete cement mainly to improve the overall performance. Due to the relatively high silica content in the rice husk, it acts as a good source of reactive silica. Thus, it can be used to produce high-performance concrete. Before adding RHA into your concrete/cement, it must be burned and ground. This will enhance the chemical reactivity of RHA and followed by a flurry of benefits of RHA. The amorphous form of silica produced will help to fill in spaces in the structure, which further helps in reducing the porosity of RCC.

This, in turn, reduces the issues of leaking, percolation, and corrosion, and thus resulting in increased durability of the concrete. The amount of RHA to be used in concrete varies at 10-20% replacement of cement. This will then improve the workability which helps to reduce the water. High workability can be highly detrimental to the strength, and hence this replacement rate can help to preserve the strength and improve the other properties of the concrete.

The most awaited benefit from RHA is its pozzolanic reactivity which will be able to prove a long-term strength of concrete. This reactivity is due to its high content of active silica.

This will help in the reduction of Ca(OH)2, the product of hydration of cement. Ca(OH)2 is highly reactive in the presence of water and CO2 and it gradually converts to calcite and will develop some strength-producing crystals.

Unfortunately, this reaction is detrimental to concrete over a long period and is a cause of failure. By reducing the Ca(OH)2, RHA will help to increase the durability of concrete as it will take a much longer period to reach the same stage. RHA can also be used in self-compacting concrete. In high flowability, this will reduce the risk of segregation and simplifies compaction and thus result in a uniform structure. Due to its higher cost than OPC, it is mostly used in small-scale areas and would not be seen much in the common construction industry.

3.5 Fibers

Fibers are a relatively new material to be used in SCC, although it is a material that has been around in the construction industry for a considerable amount of time. Its use in SCC is suggested to attempt to further reduce the requirement of compaction, since the method of consolidation when placing SCC is still of great concern. There are two primary types of fibers to be used in concrete; these are steel fibers and polymeric fibers. Steel fibers can be defined as discrete, short lengths of steel and were first used in concrete in the early 1960s. Their primary function is to improve the material properties in both the plastic and hardened state. There are four major categories for the use of steel fibers in concrete: - To improve the post cracking behavior by improving the toughness and ductility. - To reduce the permeability of the concrete to inhibit the ingress of water. - To increase the fatigue life of the concrete. - To reduce the concrete thickness by allowing higher design stresses.

3.6 Steel Fibers

Steel fibers are mainly used in the field of precast concrete products. They vary in size, but the larger fibers, normally 0.5mm to 1.0 mm, are more effective at reinforcing the concrete. The major drawback of using fibers is the balling of the fibers. This occurs when the concrete is mixed too harshly, too long, or when excessive water is added to the mix.

This process will reduce the concrete's workability and produce an undesirable finish. To combat these effects, hooks can be added to the end of the fiber, which will anchor it better in the concrete and reduce balling. Fibers also have the added benefit of increasing the toughness of the concrete and will reduce concrete's resistance to impact strength - a useful method in increasing the safety of road and pavement concrete. Despite this, concrete with fibers mixed in it is still easy to recycle, which mainly benefits the environment.

Fibers are also able to reduce the concrete's permeability, thus limiting the amount of water and other harmful chemicals that can penetrate into the concrete and corrode the steel reinforcements.

3.7 Coarse Aggregates

Coarse aggregates are considered as one of the most important components of self-compacting concrete, due to the volume of these aggregates in the mixes. The percentage volume occupied by the coarse aggregates can be as high as 70-80%. The primary function of the coarse aggregate is to act as a skeleton. These properties set limits on the maximum size of aggregate and affect the pumpability of fresh concrete. Some data are taken from the Japanese experience because they have done a lot of work in this area with SCC. The skeletal structure created by coarse aggregate has three effects, the first is on plastic deformability. The size and shape of the aggregate have a significant effect on the plastic deformability of the paste. Angular and elongated coarse aggregate particles can act as a barrier to the movement of the paste.

Secondly, the aggregate skeleton affects the viscosity of the concrete. With an increase in coarse aggregate content there is an increase in the yield stress and plastic viscosity of the concrete.

This means that higher coarse aggregate contents require more workability to achieve a given flow ability. It is important to be able to remove the air from the paste when using a high coarse aggregate content, because the paste will tend to flow around the aggregate, leaving pockets of air. Finally, the coarse aggregate skeleton can inhibit or prevent flow, notably through blocking the openings in a form. This has led to research into the minimum paste requirement for a given flow ability. The second effect of the coarse aggregate is to act as a lubricant, reducing the friction between the concrete and the form. This is due to the bleeding of the paste to the surface.

Research has shown that the air content at the form surface is higher with SCC than with traditional concrete. This can lead to a blistering effect, with the expansion and drying of the air pockets causing surface blemishes. Finally, the coarse aggregate has an effect on the hardened concrete properties. This is particularly important with SCC as the desire to achieve high strength and durability may be affected by the ease of which SCC can be compacted. The ability to achieve high strength may be compromised if the concrete is placed in congested areas, leading to the inappropriate use of hand compaction to remove air and the possibility of honeycombing. High early strength must also be considered with SCC used in precast sections.

3.8Fine Aggregates

These materials are clean, well-graded river sand with an overall fineness modulus of 2.60, a particle size distribution from 1.18 C to 0.15 A and a water absorption of less than 1%. In the paper, to distinguish between the material to have primary influence and the other materials, the fine aggregate is divided into two categories, which are Materials A and B. Material A is a reference fine aggregate made up of a 50/50 blend of regular and high-porosity silica sands and has a specific gravity of 2.6 and absorption of 5.0%. Material B is a relatively high absorption, natural sand from Wisconsin with a specific gravity of 2.65.

These materials are included as the primary fine aggregate components so that the effects of the other materials on the SCC mixture can be more easily distinguished. Material A has been previously examined in several other studies for use in self-consolidating mixtures.

The high porosity silica sand significantly improves passing ability in comparison to mixtures made with regular silica sand. This is due to the fact that the high porosity sand allows for lubrication between particles while maintaining a stable pore structure. Generally, fillers are added to improve the particle packing of the mixture but they adversely affect passing ability.

Although it is possible to use a highly-graded filler to offset the adverse effects, passing ability is very sensitive to changes in particle size distribution. A more effective way of improving passing ability is to find a way to maintain or improve particle packing while still using fillers and this is the effect that the high porosity sand has. Minimum and maximum packing densities are unaffected but the curves become more continuous with a larger range of well-packed particle mixtures.

3.9.Super plasticizers

Super plasticizers are used to increase the fluidity of the concrete while using the same water-cement ratio. The fluidity of the concrete is essential to ensure the homogeneous distribution of concrete and in ensuring that it surrounds all the reinforcement.

The fluidity of the concrete is measured through various tests. When the concrete is placed, it is desirable that it be self-leveling, i.e. it does not require tamping down of the concrete with rods.

The slump test is the most widely used test. The diameter of the base of the slump cone is the same as the height, i.e. 300mm. The test is carried out on a flat steel base. The slump cone is filled with 3 layers, each rodded 20 times with a 16mm round rod. After the mold is removed, the concrete should subside so that the slump is in the range 20-60mm. This test, however, does not give an accurate indication of the flow of the concrete, and so a newer test has been developed. This test is the flow table test. The flow table test is similar to the slump test, however, the mold is a 300mm diameter steel disc mold, and the table has a 600mm x 600mm steel base.

The concrete is again rodded into the mold, and the mold is removed. The increase in the diameter of the concrete spread is a measure of the flow. The flow should be in the range 50-100mm. Both of these tests are good tests to measure the fluidity of concrete; however, the most accurate test is the V-funnel test.

3.10Water Reducers

The use of water reducers in SCC is based on incorporating sufficient paste volume to allow for easy flow through the formwork without segregating. The amount and type of paste, and thereby the water content, required to give sufficient flow ability should not be so great as to cause segregation. Therefore, use of high range water reducers (HRWR) is the key to successful SCC mixtures. Water reducers can generally be divided into two types, high range and mid range water reducers (HRWR and MRWR). HRWR has the greatest ability to increase fluidity and achieve the highest levels of self-consolidating properties. However, due to the amount normally required to achieve the level of flow ability desired, it can be the most costly admixture used in SCC mix design. There are many different types of HRWR and the properties of different HRWR can vary greatly along with the cost.

Therefore, it is important to test the various HRWR to determine its suitability to the specific mix design and its cost efficiency. MRWR does not increase fluidity or flow ability as much as HRWR, however it can be used in combination with HRWR to increase flow ability and achieve desired levels of self-consolidating properties. Therefore, a balance of HRWR and MRWR can often be a cost efficient method of achieving desired SCC properties. Water reducing admixtures work in two ways: firstly by the dispersion of the cement particles and reduction in inter-particle friction, and secondly through reducing the water demand by improving the paste to void volume. Therefore, the increase in flow ability of the concrete has not only been achieved by increasing the paste volume and water content, this must be considered in mix design, as increasing paste volume and water content may lead to segregation.

An increase in paste volume is likely to cause an increase in shrinkage potential. Therefore, despite the increase in flow ability SCC requires the optimization of the paste volume to minimize the risk of shrinkage and reinforce the original objective of achieving a durable concrete.

Chapter 4 Experimental work

4.1 Preparation of materials and tools







4.2 Mixing concrete

Fresh concrete tests

Some laboratory tests were conducted for self-compacting concrete, some for Fresh concrete tests (non-hardened concrete),Others are for hardened concrete, and this is done after 7 days and 28 days.

Fresh concrete tests (non-hardened concrete) :

1:Funnel Test of concrete flow

2:Slump Flow test

3:L-Box

Test for hardened concrete, and this is done after 7 days and 28 days.

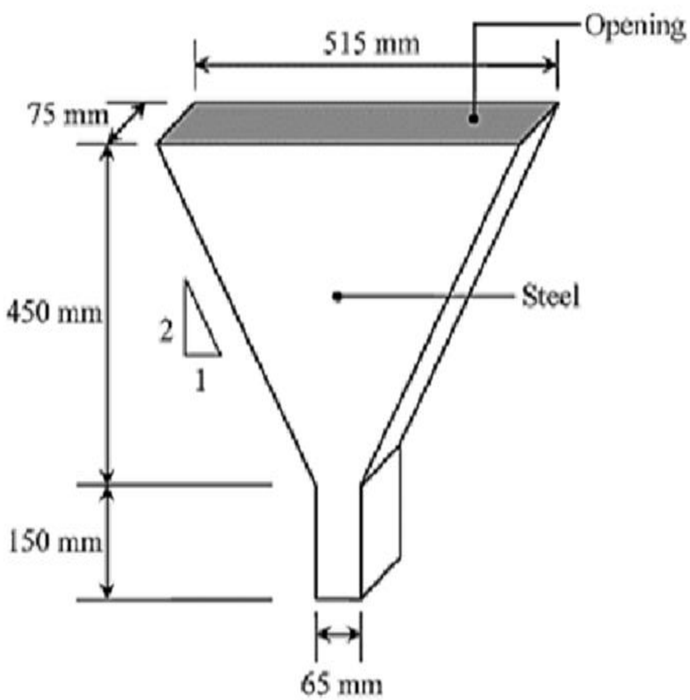
1: Compressive strength

2: tensile strength

3: flexural strength

4.1: Funnel Test of concrete flow

It measures the ability of concrete to change its path and spread through a narrow area without blockage or stopping. The time for the concrete to completely pass through the funnel is measured and the time should not exceed 12 seconds.

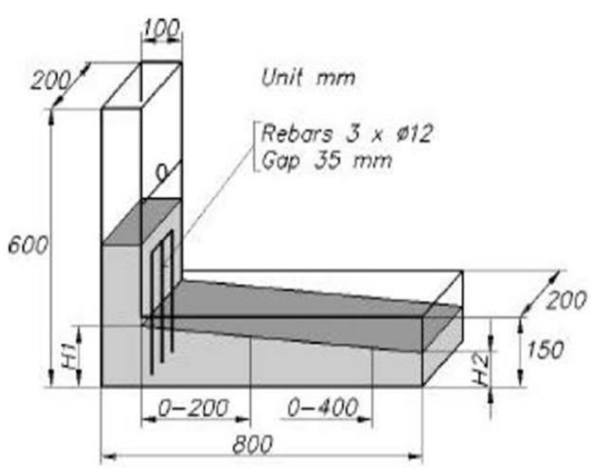


4.2 Slump Flow test

This is to measure the free flow in the absence of obstacles in the path of the concrete, and the traditional landing cone ,The diameter must not be less than70cm

4.3 L-Box

the method covers the evaluation of the self-compacting ability (confined fluidity) of freshly mixed self-compacting concrete . Using the L-box, it is possible to evaluate different properties, such as packing capacity, passability, and separation resistance. Complete with funnel tube and frame to simulate boosting.



4.4 Casting Concrete

4.5 Preparing for Strength tests

4.6 Test for hardened concrete

1: Compressive strength

Compressive strength is a measure of the ability of a material to resist compression or being squeezed. In the case of concrete, compressive strength is one of the most important properties and is typically measured in pounds per square inch (psi) or megapascals or Kn The compressive strength of concrete is determined by testing a standard specimen of concrete in a compression machine. The test involves applying a load to the specimen until it fails, and the maximum load that it can withstand before failure is recorded as the compressive strength.

The compressive strength of concrete can vary depending on avariety of factors, including the mix design, curing conditions, andthe age of the concrete. The compressive strength of concrete is an important factor in determining the structural integrity and load-bearing capacity of concrete structures, such as buildings, bridges, and roads. The compressive strength of concrete is typically used as a quality control measure during the production of concrete, and is also used to assess the perform


MARKET LEADERS
CLOSE GATE BEFORE OPERATING MACHINE

4.6 tensile strength

Tensile strength is the maximum stress that a material can withstand while being stretched or pulled before breaking or deforming. It is a measure of a material's ability to resist tensile forces and is typically expressed in units of force per unit area, such as pounds per square inch (psi) or newtons per square meter (N/m^2) or KN . Tensile strength is an important property of many materials, including metals, plastics, ceramics, and composites, and is used to determine their suitability for various applications, such as construction, engineering, and manufacturing.

4.7 flexural strength

Flexural strength, also known as bending strength or modulus of rupture, is the maximum stress that a material can withstand when subjected to a bending load or force. It is a measure of a material's ability to resist deformation or fracture when a force is applied perpendicular to its longitudinal axis. Flexural strength is typically expressed in units of force per unit area, such as pounds per squareinch (psi) or megapascals (MPa),KN

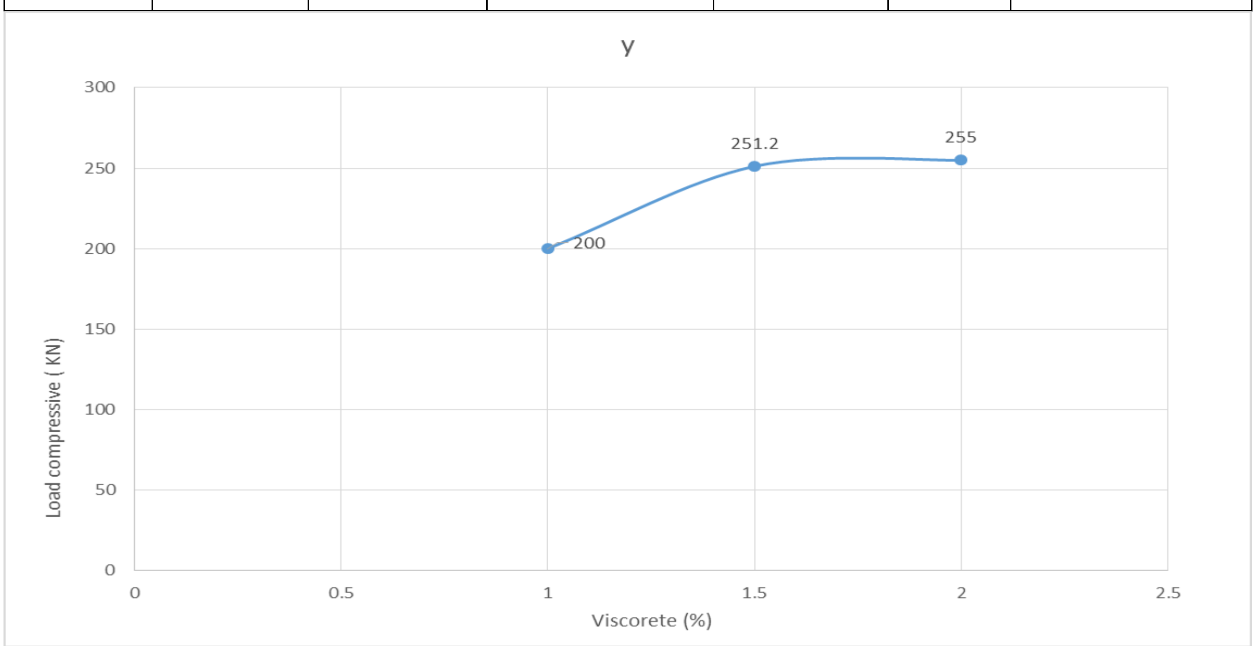
Chapter 5

Results and Discussion

5.1Compressive Strenghth

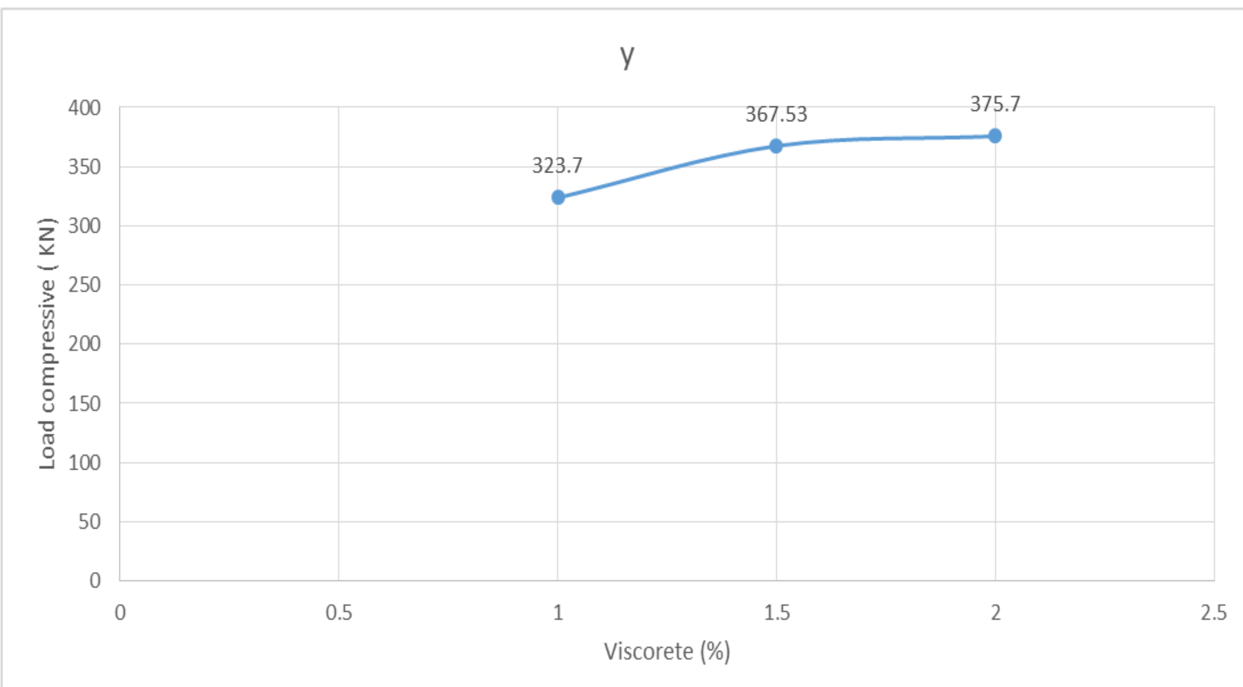
Compressive Strenghth (KN) After 7 day for 20% fly ash

Cube NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
20% fly ash	1	2.337	251.2	25.2	3.35	1%
	2	2.39	200	20	3.35	1.5%
	3	2.68	255	25.5	3.35	2%



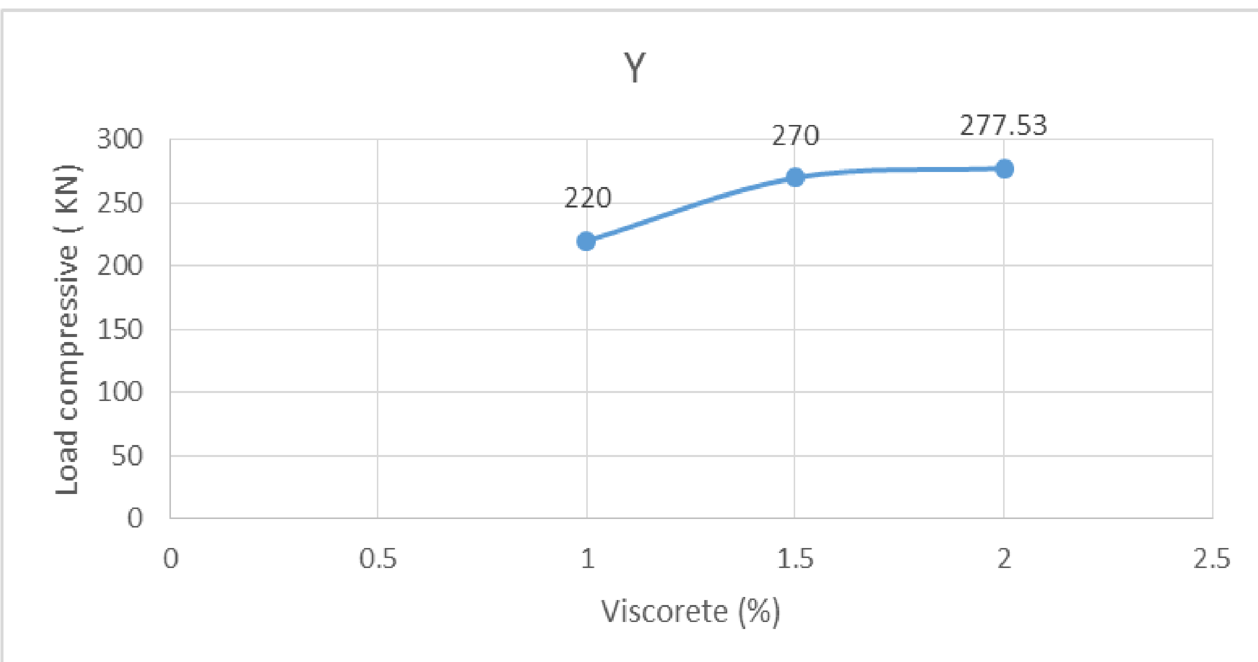
Compressive Strenghth (KN) After 28 day for 20% fly ash

Cube NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
20% fly ash	1	2.306	367.53	36.7	3.35	1%
	2	2.388	375.7	37.5	3.35	1.5%
	3	2.34	323.7	32.3	3.35	2%



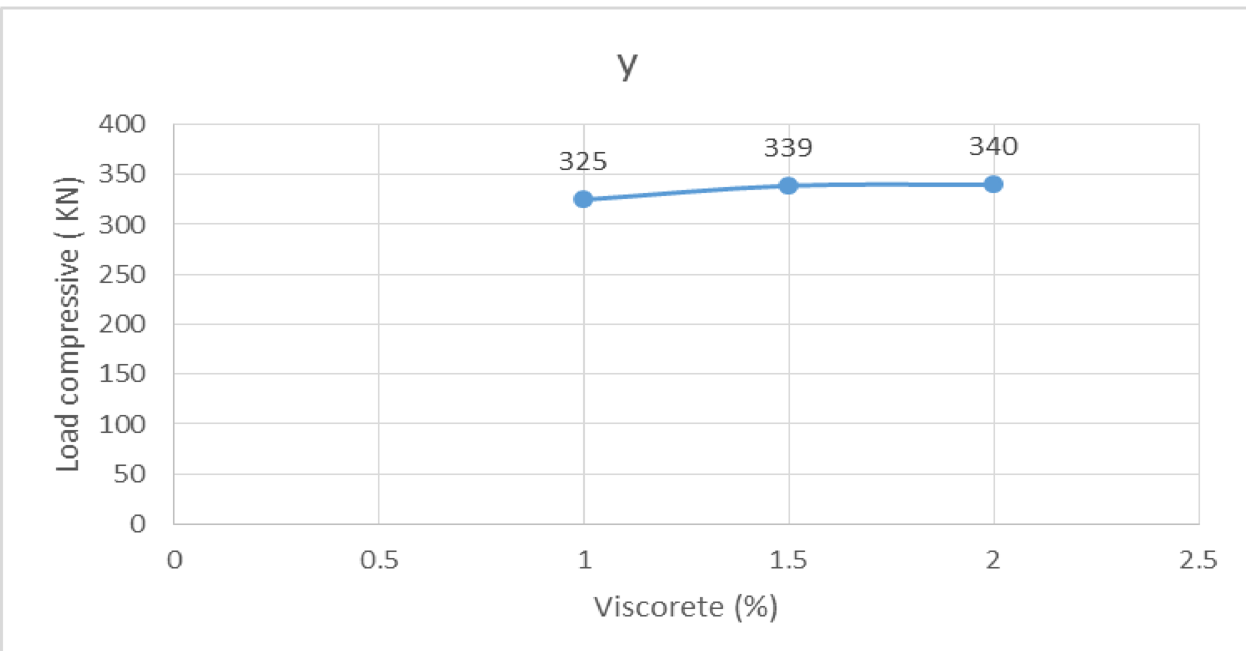
Compressive Strenghth (KN) After 7day for 25% fly ash

Cube NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
25% fly ash	1	2.48	220	22	4.1875	1%
	2	2.37	277.53	27.7	4.1875	1.5%
	3	2.4	270	27	4.1875	2%



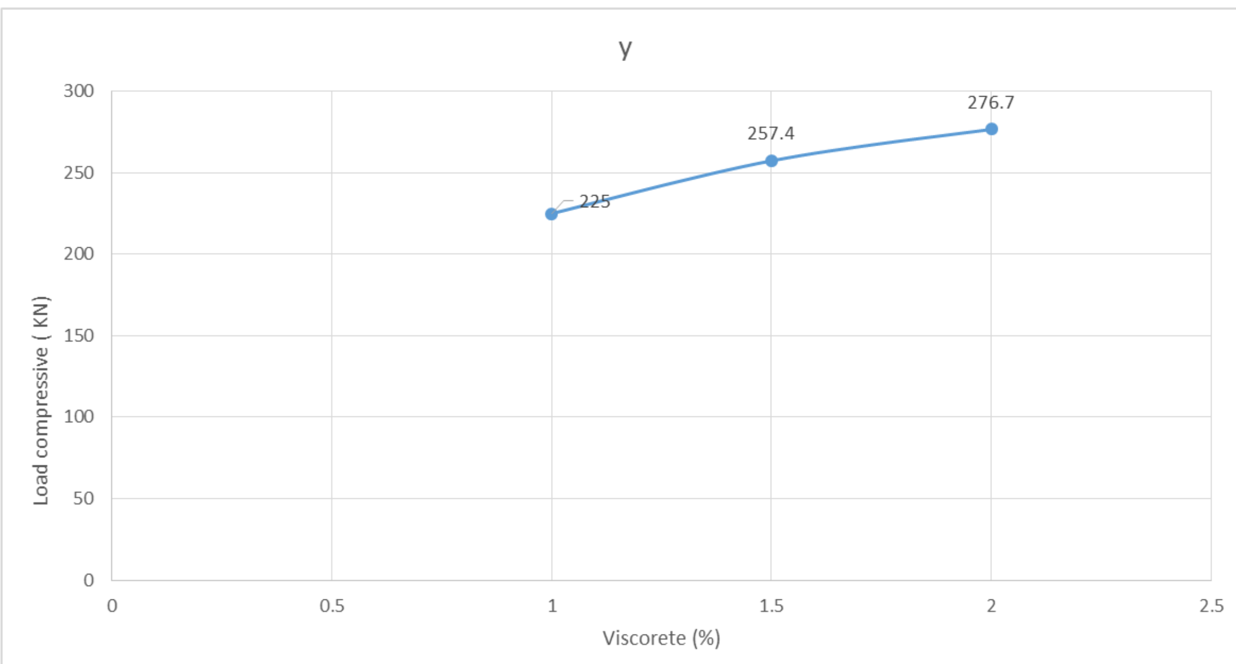
Compressive Strenghth (KN) After 28 day for 25% fly ash

CUBE NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
25% fly ash	1	2.34	340	34	4.1875	1%
	2	2.38	325	32.5	4.1875	1.5%
	3	2.36	339	33.9	4.1875	2%



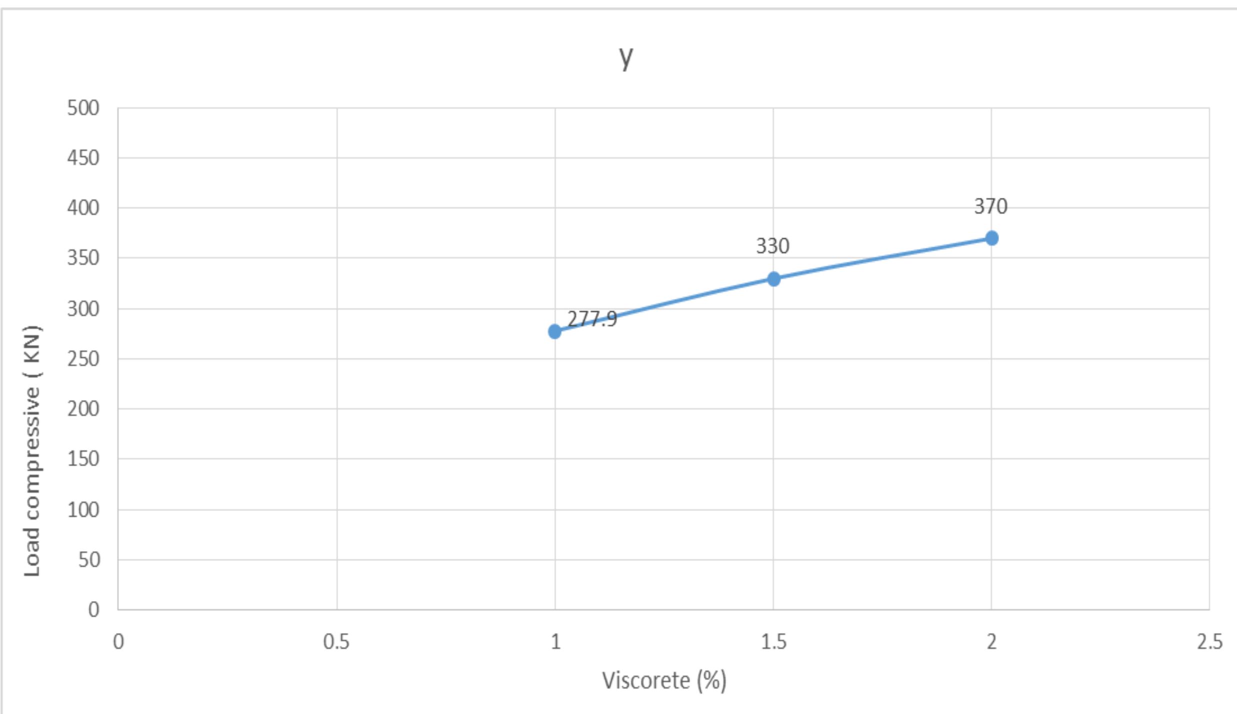
Compressive Strenghth (KN) After 7day for 30% fly ash

Cube NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
30% fly ash	1	2.32	257.4	25.4	5.025	1%
	2	2.33	276.7	27.7	5.025	1.5%
	3	2.41	225	22.5	5.025	2%



Compressive Strenghth (KN) After 28 day for 30% fly ash

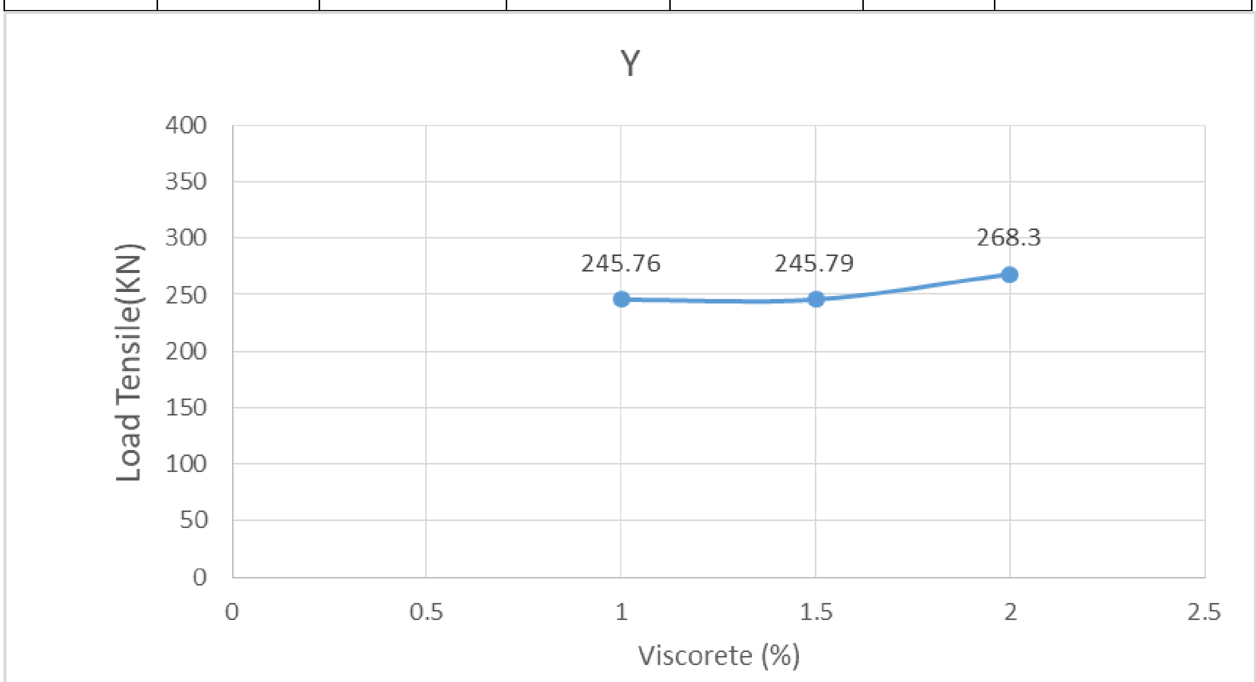
Cube NO.	Mix Number	Weight (KG)	Load (KN) Compressive	strength (N/mm2)	Fly ash	Viscocrete(%)
30% fly ash	1	2.4	370	37	5.025	1%
	2	2.44	277.9	2.7.7	5.025	1.5%
	3	2.36	330	33	5.025	2%



5.2 Tensile strength

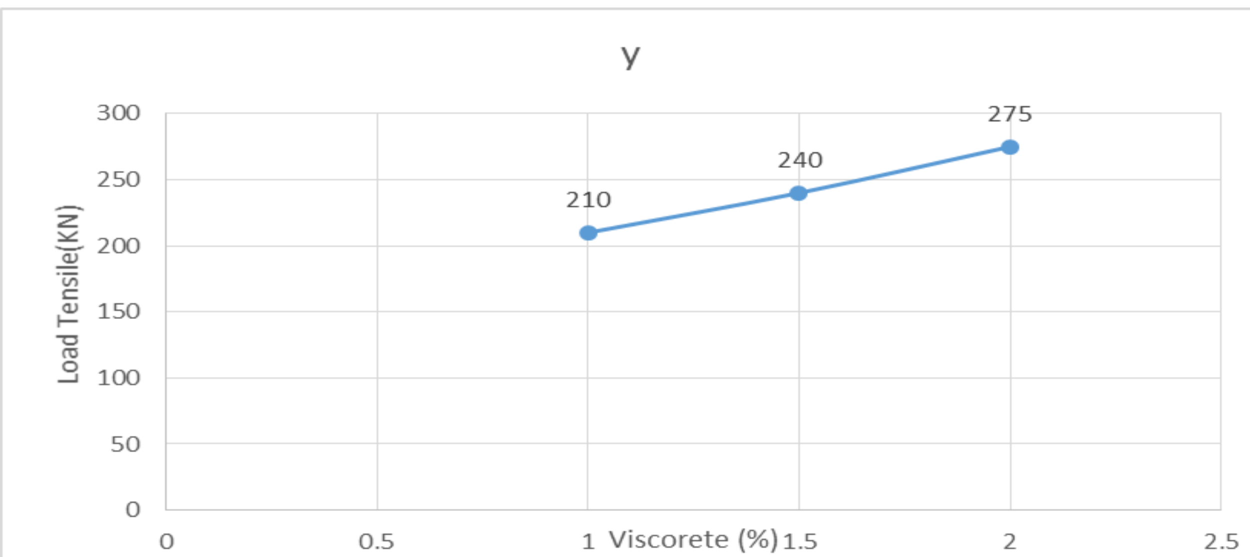
Tensile strength (KN) for 20% fly ash

Cylinder NO.	Mix Number	Weight (KG)	Load (KN) Tensile	strength (N/mm2)	Fly ash	Viscocrete(%)
20% fly ash	1	12.15	268.3	26.8	3.35	1%
	2	12.25	245.79	24.5	3.35	1.5%
	3	12.36	245.76	25	3.35	2%



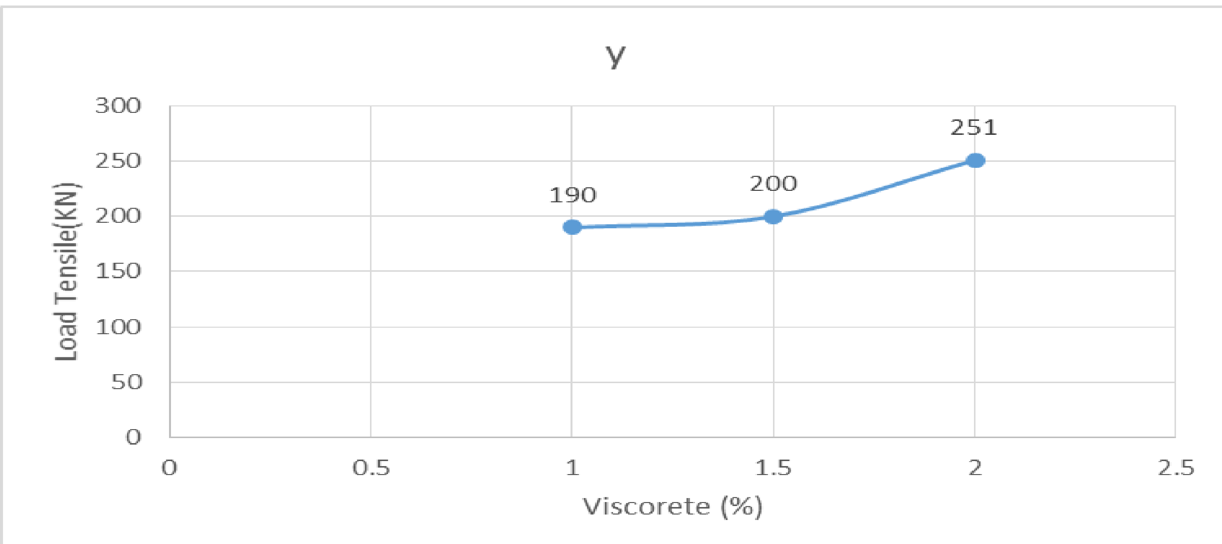
Tensile strength (KN) for 25% fly ash

Cylinder NO.	Mix Number	Weight (KG)	Load (KN) Tensile	strength (N/mm2)	Fly ash	Viscocrete(%)
25% fly ash	1	11.988	210	21	4.1875	1%
	2	12.3	275	27.5	4.1875	1.5%
	3	12.3	240	24	4.1875	2%



Tensile strength (KN)for 30% fly ash

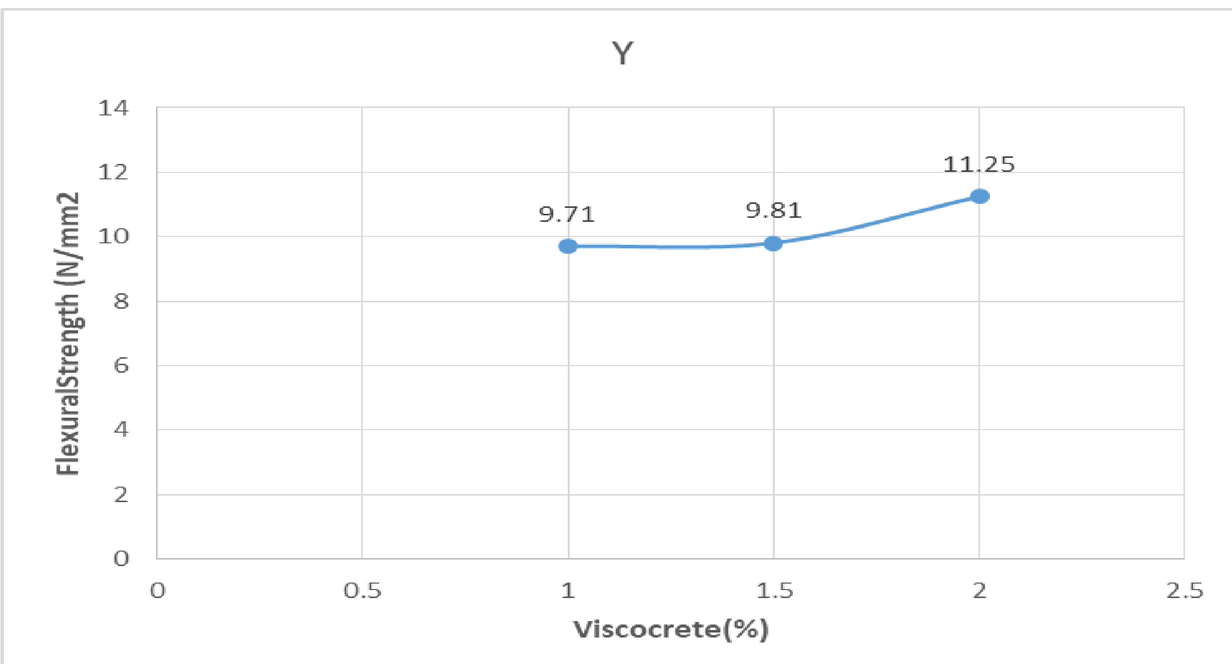
Cylinder NO.	Mix Number	Weight (KG)	Load (KN) Tensile	strength (N/mm2)	Fly ash	Viscocrete(%)
30% fly ash	1	12.12	251	25	5.025	1%
	2	11.98	200	20	5.025	1.5%
	3	12.4	190	19	5.025	2%



5.3 flexural strength

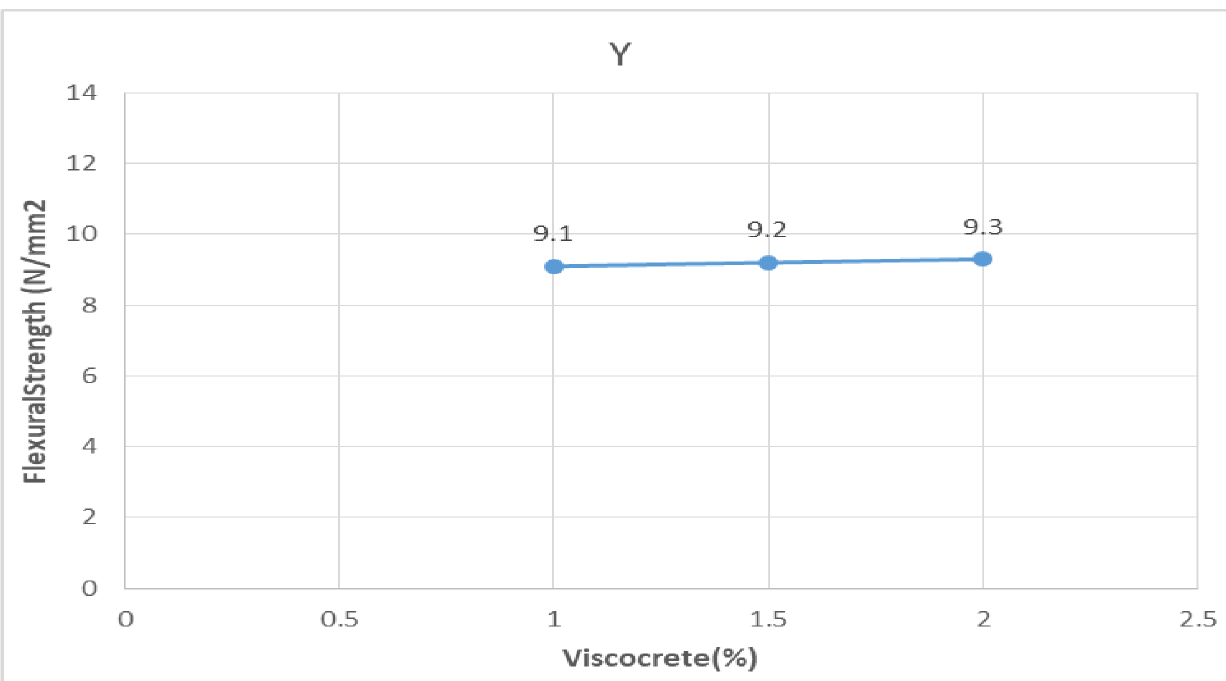
flexural strength(KN)for 20% fly ash

Beam No	Mix Number	Weight (KG)	Fracture Load	Flexural Strength (N/mm2)	Fly ash	Viscocrete(%)
20% Fly ash	1	11.52	9.81	0.98	3.35	1
	2	11.57	11.25	11.52	3.35	1.5
	3	11.53	9.71	0.97	3.35	2



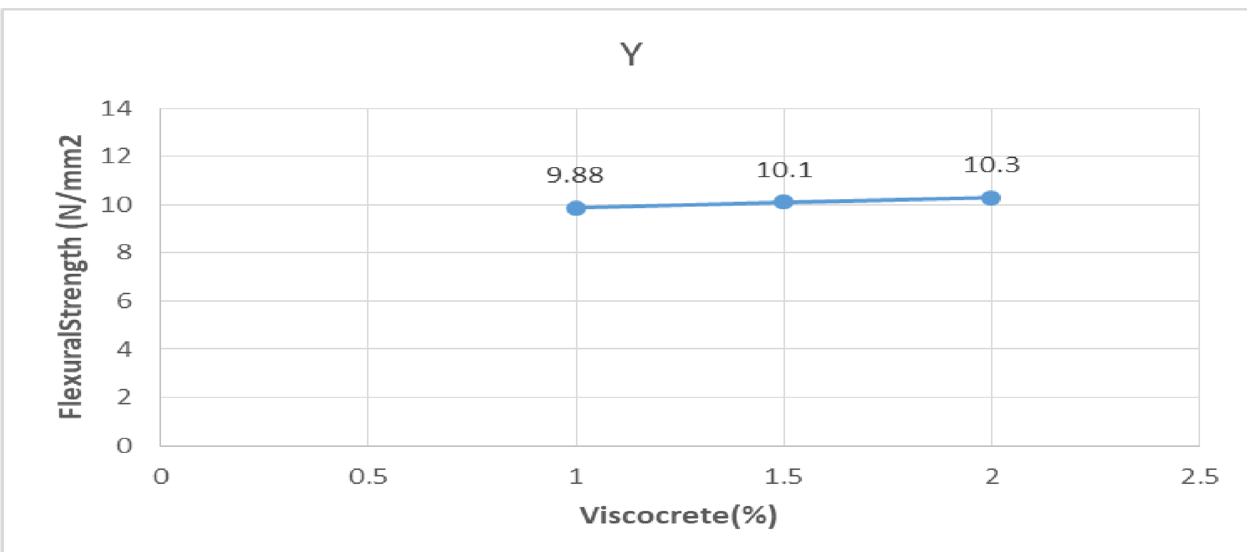
flexural strength(KN)for 25% fly ash

Beam No	Mix Number	Weight (KG)	Fracture Load	Flexural Strength (N/mm2)	Fly ash	Viscocrete(%)
25% Fly ash	1	11.7	9.7	0.97	4.1875	1
	2	11.7	9.2	0.92	4.1875	1.5
	3	11.63	9.1	0.91	4.1875	2



flexural strength(KN)for 30% fly ash

Beam No	Mix Number	Weight (KG)	Fracture Load	Flexural Strength (N/mm2)	Fly ash	Viscocrete(%)
30% Fly ash	1	11.95	10.30	1	5.025	1
	2	11.7	10.1	1.01	5.025	1.5
	3	11.39	9.88	0.98	5.025	2



Conclusion:

SCC is a new type of cementitious material, and at the same time a new type of production method for casting concrete structures. However, SCC mainly remains a cement-based material, which means that most of our knowledge and understanding based on VC is not obsolete. SCC pushes the limits of classical concrete technology. However, the main driving forces and the fundamental chemical, physical, and mechanical laws remain unchanged. Nevertheless, due to its specific mix design, SCC can sometimes behave differently in comparison with VC. After testing the SCC, we reach the following:

- SCC can't be produced without a sufficient amount of S.P.
- In V-funnel test, When the S.P. Increased in patches, the time for SCC to exit the funnel decreased. The flow of Concrete was very slow in the first two patches which means that wasn't a SCC.
- In L-box test, When the S.P. Increased in patches, the height of SCC at the lower end increased. The Concrete didn't reach the end of Hz compartment in the first two patches, which means that wasn't a SCC.

- In J-ring test, When the S.P. Increased in patches, the time for SCC to exit the funnel decreased. The diameter of flowing Concrete

  increased, and The time for SCC to reach 500 mm in diameter decreased. Also, the difference between the inner and outer heights were decreased.
- The compressive and flexure strength were adequate in all patches for the tested samples.

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Thank you