

FROM FIELDS TO FOUNDATIONS: ADVANCEMENTS IN SUSTAINABLE CONCRETE TECHNOLOGY

Submitted in partial fulfillment of the requirements for the award of Bachelor of
Technology degree in Biotechnology

Interdisciplinary project

By

AFRAH.A (41230004)

RENIE LEORA CASILDA.D (41230047)



**DEPARTMENT OF BIOTECHNOLOGY
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

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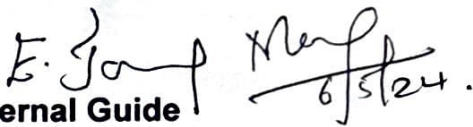
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Afrah.A (Reg.No: 41230004)**, **Renie Leora Casilda.D (Reg.No: 41230047)**, who carried out the Interdisciplinary Project entitled **"FROM FIELDS TO FOUNDATIONS: ADVANCEMENTS IN SUSTAINABLE CONCRETE TECHNOLOGY"** under our supervision from **Ms. Jancy Mary, M.Sc., M.Phil., Ph.D.**, and **Er.J.Vanjinathan, M.Tech.**, from January 2024 to April 2024.


Internal Guide


External Guide

Ms.JANCY MARY, M.Sc., M.Phil., Ph.D

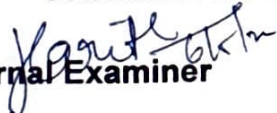
Er.J.VANJINATHAN, M.Tech.

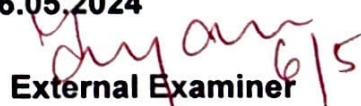


Head of the Department

Dr. V. RAMESH KUMAR , M.Phil., Ph.D.,

Submitted for Viva voce Examination held on 06.05.2024


Internal Examiner


External Examiner

DECLARATION

We, **Afrah.A (41230004)** and **Renie Leora Casilda.D (Reg.No: 41230047)**, hereby declare that the Project Report entitled **"FROM FIELDS TO FOUNDATIONS: ADVANCEMENTS IN SUSTAINABLE CONCRETE TECHNOLOGY"** done by us under the guidance of **Ms. Jancy Mary, M.Sc.,M.Phil., Ph.D.**, and **Er.J.Vanjinathan, M.Tech**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biotechnology.

DATE: 06.05.2024

PLACE: CHENNAI



SIGNATURE OF THE CANDIDATE

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ABSTRACT

The utilization of sugarcane bagasse as a viable alternative in concrete production offers promising opportunities for advancing sustainable construction practices. This project explores the feasibility of incorporating sugarcane bagasse directly into concrete formulations, bypassing the conventional conversion to ash, to enhance the material properties and sustainability of concrete. Sugarcane bagasse, a byproduct of the sugar industry, is abundant and largely underutilized. Traditionally, it has been converted into ash through combustion processes and then incorporated into concrete as a pozzolanic material. However, this approach entails energy-intensive processing and may not fully harness the potential of bagasse in concrete applications. In this project, we investigate the direct use of sugarcane bagasse fibers within concrete mixes. The bagasse fibers are evaluated for their physical and mechanical properties, including their impact on the workability, strength, and durability of concrete. Through experimental testing, such as compressive strength tests the performance of bagasse-based concrete is analyzed and compared against conventional concrete mixes. Furthermore, the environmental implications of directly utilizing sugarcane bagasse are examined. This includes assessing the carbon footprint reduction achieved by avoiding the energy-intensive ash production process and diverting waste from landfills. Life cycle assessments will be conducted to quantify the overall environmental benefits associated with using bagasse in concrete. The project aims to contribute to the advancement of sustainable concrete technology by offering an innovative and efficient method of incorporating sugarcane bagasse into concrete construction. The findings provides valuable insights into optimizing concrete formulations with renewable and locally sourced materials, ultimately promoting eco-friendly practices in the construction industry.

KEYWORDS: Sugarcane bagasse, Viable alternative, Sustainable construction practice, Renewable, Locally sourced materials, Eco-friendly.

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LIST OF ABBREVIATIONS

TKP	-	Tamarind Kernel Powder
CO ₂	-	Carbon Dioxide
LCA	-	Life Cycle Assessment
OPC	-	Ordinary Portland Cement
GPC	-	Geopolymer Concrete
NaOH	-	Sodium Hydroxide
Na ₂ SiO ₃	-	Sodium Silicate
ACTM	-	Automatic Compression Testing Machine

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CHAPTER 1

INTRODUCTION

1.1 TOWARDS SUSTAINABLE CONCRETE

The construction industry is facing increasing pressure to adopt sustainable practices, particularly in the development of concrete, one of the most widely used construction materials globally. Cement, a key component of concrete, is responsible for a significant portion of carbon dioxide emissions due to its production process. To address this challenge, alternative materials and innovative formulations are being explored to reduce the environmental impact of concrete. **(Walach D, 2020)**

Sugarcane bagasse, the fibrous residue left after extracting juice from sugarcane, is a promising renewable resource that can be utilized in concrete production. Conventionally, sugarcane bagasse is converted into ash through combustion and then used as a pozzolanic material in concrete. However, this process requires energy and may not fully capitalize on the potential benefits of bagasse. **(Batool F ,et al,2020)**

This project proposes a novel approach by directly incorporating sugarcane bagasse fibers into concrete mixes, eliminating the need for ash production and simplifying the material's integration into concrete formulations. Additionally, the project explores the synergistic effects of adding geopolymer and tamarind kernel powder (TKP) alongside sugarcane bagasse to further enhance the sustainability and performance of concrete. **(Faruk M.O ,et al, 2020)**

Geopolymers are alternative binders that can replace cement in concrete production, offering lower carbon emissions and improved durability. By combining geopolymer with sugarcane bagasse fibers, we aim to develop a composite material that exhibits superior mechanical properties while reducing environmental impact. **(Singh N.B ,et al ,2020)**

The inclusion of tamarind kernel powder (TKP), a natural biopolymer, is investigated for its potential to enhance the workability and strength of sugarcane bagasse-based concrete. TKP has shown promising results as a partial replacement for conventional chemical additives, contributing to the eco-friendliness of the concrete mix. **(Khalil M.J ,et al,2021)**

The primary objective of this study is to investigate the feasibility and efficacy of using sugarcane bagasse fibers directly in concrete mixes. By examining the physical, mechanical, and durability properties of bagasse-based concrete, we aim to assess its performance compared to conventional concrete containing pozzolanic materials like sugarcane bagasse ash. **(Memon, S.A ,et al,2022)**

Furthermore, this project will evaluate the environmental impact of incorporating sugarcane bagasse fibers in concrete production. Life cycle assessments will be conducted to quantify the potential reduction in carbon footprint and resource consumption associated with this innovative approach. The outcomes of this research are expected to contribute significantly to the advancement of sustainable concrete technology. By demonstrating the effectiveness of sugarcane bagasse fibers as a direct alternative to bagasse ash in concrete, this study seeks to promote the adoption of eco-friendly practices in the construction industry while utilizing a renewable resource and reducing waste. **(Chen ,et al,2010)**

1.2 TAMARIND KERNEL POWDER (TKP)

Tamarind kernel powder (TKP) is a natural polysaccharide obtained from tamarind seeds. It is a versatile ingredient used as a thickening agent, binder, and stabilizer in food, pharmaceuticals, textiles, and cosmetics. Tamarind kernel powder (TKP) (Fig1.1) has interesting potential applications in the concrete industry, primarily due to its unique chemical properties. TKP exhibits excellent water-holding capacity and forms viscous solutions, making it valuable for enhancing texture, moisture retention, and product stability in various applications also it is an eco-friendly alternative for fly ash.

The chemical composition of tamarind kernel powder (TKP) typically includes the following components:

- **Polysaccharides:** TKP is primarily composed of polysaccharides, particularly xyloglucans and galactoxyloglucans, which constitute about 55-65% of its composition.

Xyloglucans: These are hemicellulose polysaccharides composed of a backbone of glucose units with side chains of xylose and galactose. Xyloglucans contribute to the thickening and gelling properties of TKP.

Galactoxyloglucans: Similar to xyloglucans but with additional galactose units attached to the xylose side chains. Galactoxyloglucans are responsible for TKP's ability to form viscous solutions and provide stability in various applications.

- **Proteins:** TKP also contains proteins in the range of 15-25%, albeit in smaller amounts compared to polysaccharides. These proteins can contribute to certain functional properties of TKP.
- **Lipids:** The lipid content in TKP is relatively low, usually around 1-3%.
- **Moisture:** Moisture content in TKP can range from 6-10%.
- **Fiber:** TKP contains dietary fiber, which can vary depending on the extraction and processing methods, which can range from 5-10%. (**Mishra & Malhotra, 2009**)



Fig 1.1 Tamarind Kernel Powder

1.3 ALKALINE LIQUID

Alkaline liquids are prepared by mixing of the sodium hydroxide solution and sodium silicate as shown in Fig1.2 at the room temperature. When the solution mixed together the both solution start to react i.e. (polymerisation takes place) it liberate large amount of heat so it is recommended to leave it for about 24 hours thus the alkaline liquid is get ready as binding agent. **(Phoo-ngernkham, et al, 2015)**



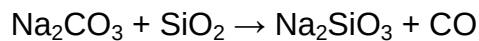
Fig 1.2 Alkaline Liquid

1.3.1 Sodium hydroxide

Pure sodium hydroxide is a whitish solid, sold in pellets, flakes, and granular form, as well as in solution. It is highly soluble in water, with a lower solubility in ethanol and methanol, but is insoluble in ether and other non-polar solvents. Similar to the hydration of sulphuric acid, dissolution of solid sodium hydroxide in water is a highly exothermic reaction in which a large amount of heat is liberated, posing a threat to safety through the possibility of splashing. The resulting solution is usually colourless and odorless. As with other alkaline solutions, it feels slippery when it comes in contact with skin. **(Shabbirahmed , et al,2022)**

1.3.2 Sodium Silicate

Sodium silicate is the common name for compounds with the formula $\text{Na}_2(\text{SiO}_2)_n\text{O}$. A well-known member of this series is sodium metasilicate, Na_2SiO_3 . Also known as water glass or liquid glass, these materials are available in aqueous solution and in solid form. The pure compositions are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities. They are used in cements, passive fire protection, textile and lumber processing, refractories, and automobiles. Sodium carbonate and silicon dioxide react when molten to form sodium silicate and carbon dioxide.



1.4 SUGARCANE BAGASSE

Sugarcane bagasse is the fibrous residue left after extracting juice from sugarcane (Fig1.3). It consists of cellulose, hemicellulose, lignin, and small amounts of pith and wax. Bagasse is abundant globally as a byproduct of sugar production.

Use in Concrete Industry

- **Aggregate Replacement:** Sugarcane bagasse can be used as a partial replacement for conventional aggregates (sand and gravel) in concrete production. It helps in reducing the overall density of concrete while utilizing a renewable and sustainable material.
- **Lightweight Concrete:** Bagasse can contribute to the production of lightweight concrete due to its lower density compared to traditional aggregates. This can be beneficial for applications where weight reduction is desired, such as in construction of non-load-bearing structures.
- **Improved Insulation:** Concrete containing sugarcane bagasse exhibits improved thermal insulation properties. This makes it suitable for use in buildings and structures where thermal comfort and energy efficiency are important.

- **Environmental Sustainability:** Utilizing sugarcane bagasse in concrete reduces the demand for natural aggregates, thereby conserving natural resources. It also provides a beneficial use for an agricultural waste product, promoting sustainable practices.
- **Strength and Durability:** While bagasse can enhance certain properties of concrete like thermal insulation, its effect on mechanical properties (such as compressive strength) can vary. Careful testing and mix design adjustments are necessary to ensure that the concrete meets required strength and durability standards.
- **Challenges and Considerations:** Incorporating bagasse into concrete may pose challenges related to achieving proper mix consistency, handling, and ensuring adequate bonding between bagasse particles and cement matrix.



Fig 1.3 Sugarcane Bagasse

CHAPTER 2

LITERATURE SURVEY

Sustainable concrete production has become a paramount focus within the construction industry due to the environmental impact associated with conventional cement-based materials. One promising avenue for enhancing the sustainability of concrete is the utilization of agricultural waste materials, such as sugarcane bagasse, directly in concrete mixes. This literature review provides an overview of relevant studies synergies achieved by incorporating geopolymer and tamarind kernel powder (TKP) alongside sugarcane bagasse fibers. **(Thomas B.S,et al,2021)**

SUGARCANE BAGASSE IN CONCRETE: Sugarcane Bagasse is a fibrous residue generated from sugarcane processing, typically burned to produce ash for pozzolanic applications in concrete. However, recent research has focused on utilizing sugarcane Bagasse directly as a reinforcement material in concrete mixes. Bagasse fibers possess desirable properties such as high tensile strength and low density, making them attractive alternatives to synthetic fibers in concrete reinforcement. The study of exploration of feasibility of incorporating sugarcane bagasse fibers into concrete and found improvements in flexural and compressive strength compared to conventional concrete . This demonstrates the potential of bagasse fibers to enhance the mechanical properties of concrete while reducing reliance on traditional cementitious materials.**(Rajani P,et al, 2021)**

GEOPOLYMER AS A CEMENT SUBSTITUTE: Geopolymer, an inorganic polymer synthesized from industrial byproducts like fly ash or slag, has gained attention as a sustainable alternative to cement in concrete production. Geopolymer-based concrete exhibits superior mechanical properties, durability, and reduced carbon emissions compared to conventional cementitious materials . The development of geopolymer technology and highlighted its potential to significantly reduce CO₂ emissions associated with concrete production. The incorporation of geopolymer in combination with sugarcane bagasse fibers represents an innovative approach towards sustainable concrete formulations. **(Albidah, A.S,et al,2021)**

TAMARIND KERNEL POWDER (TKP) AS AN ADDITIVE: Tamarind kernel powder (TKP), derived from tamarind seeds, is a natural biopolymer that has been investigated for its potential as a concrete additive. TKP exhibits water-retaining properties and improves workability, setting time, and strength characteristics of concrete. The beneficial effects of TKP on concrete properties, highlighting its potential as a sustainable alternative to synthetic additives. When combined with sugarcane bagasse fibers and geopolymer, TKP could further enhance the performance and sustainability of concrete mixes. **(Sujatha, E.R, et al,2023)**

SYNERGISTIC EFFECTS OF COMBINED MATERIALS: While individual studies have examined the use of sugarcane bagasse, geopolymer, and TKP in concrete separately, limited research exists on their combined effects. The integration of these materials presents an opportunity to develop high-performance, eco-friendly concrete formulations that reduce carbon emissions, enhance durability, and utilize renewable resources. By investigating the combined use of geopolymer and natural fibers (including sugarcane bagasse) in concrete composites, demonstrating improvements in mechanical properties and sustainability metrics [8]. This underscores the potential synergies achievable through the integration of geopolymer, TKP, and sugarcane bagasse fibers in concrete.**(Hassan H ,et al,2020)**

This paper presents results of an experimental study on the strength and absorption characteristics of geo-polymer concrete. The experiments were conducted on fly ash based geo-polymer concrete by varying the concentration of NaOH and curing time. From the study compressive strength increases with increase in concentration of NaOH from 8M to 16M. Increase in compressive strength was also observed with increase in curing time. Tensile strength increased with increase in concentration of NaOH except for 72 hours. curing time. Water absorption decreased with increase in concentration and curing time. However, in two cases very small increase was observed. **(Anurag mishra ,2008)**

There is no noteworthy gain in the compressive strength of heat cured fly ash based geopolymer concrete with age. The fly ash based geopolymer concrete cured at ambient temperature gains strength with age. The 7th day compressive strength of ambient temperature cured geopolymer concrete depends upon average temperature during the first week after casting. **(S.E. Wallah and B. V. Rangan,2009).**

This paper presents the results of an experimental investigation on the mechanical properties of Geopolymer Concrete Composites (GPCC) containing 90% Fly ash (FA), 10% Ordinary Portland Cement (OPC), alkaline liquids and steel fibers. Mixtures were prepared with alkaline liquid to fly ash ratio of 0.4 with 10% of fly ash replaced by OPC in mass basis . Compressive strength, split tensile strength and flexural strength of steel fiber reinforced Geopolymer concrete .For addition of 0.5% volume fraction of steel fibers the compressive strength, split tensile strength and flexural strength is increased by 13%, 18% and 34% respectively with reference to GPCC mix. Similarly addition of 0.75% volume fraction of steel fibers resulted in an enhanced compressive strength, split tensile strength and flexural strength by 24%, 24% and 44% respectively with reference to GPCC mix. **(K. Vijai 2011)**

Investigated engineering properties such as compressive strength, splitting tensile strength of geopolymer concrete . The grade of concrete used was M 40. The percentages of steel fibres considered include 0.25%, 0.5%, 0.75% and 1.The increase was found to be nominal in the case of compressive strength (8.51%), significant in the case of splitting tensile strength (61.63%) at 1% volume fraction of fibres. The compressive strength of GPC improves slightly with the addition of steel fibres at various volume fractions. The strength increases from 3.22% for 0.25% volume fraction of fibres up to 8.51% for 1% volume fraction. The splitting tensile strength varied from 23.26% up to 61.63% for the increase in fibre volume fractions from 0.25% up to 1 %. The strength models developed for SFRGPC predicts the compressive strength, splitting tensile strength is satisfactorily. **(N. Ganesan. 2013)**

Considered the compressive strength of geopolymer concrete by oven curing method. The geopolymer concrete is cured at different temperatures in the oven i.e. 60°C, 90°C and 120°C. The results were observed and it was seen that compressive strength increases with increase in curing temperature and the duration of curing plays an important role for compressive strength of geopolymer concrete. Longer the curing period, higher the compressive strength as the polymerization process improves with time. **(P.K. Jamdade and U. R. Kawade 2014)**

Sugarcane bagasse ash (SCBA) is a by-product of sugarcane milling, with Brazil, India, and China leading sugarcane production. SCBA contains over 70% silica, making it a potential pozzolanic material for cementitious applications. Traditional disposal methods like landfilling pose environmental risks due to leaching of heavy metals. However, SCBA's high silica content suggests it could replace cement in concrete, reducing carbon emissions from the construction industry. Research indicates SCBA's potential in various construction applications: as a substitute for fine aggregates, in geopolymer concrete, soil stabilization, brick manufacturing, and more. Despite the variability in SCBA's composition due to factors like combustion temperature and impurities, its integration into concrete shows promise for enhancing both mechanical and durability properties. This review aims to bridge the gap between laboratory research and industrial application, promoting sustainable construction practices by repurposing SCBA in concrete production. **(Thomas B.S, et al, 2021)**

CHAPTER 3

AIM AND SCOPE

3.1 AIM

This study investigates direct use of sugarcane bagasse fibers instead of sugarcane bagasse ash in concrete, exploring the addition of geopolymer and tamarind kernel powder for enhanced sustainability and performance.

OBJECTIVES

- To Assess the practicality and benefits of incorporating sugarcane bagasse directly by making it into fine powder into concrete without converting it into ash, positioning it as a sustainable alternative to traditional concrete components.
- To add sugarcane bagasse fibers, geopolymer, and tamarind kernel powder on key concrete characteristics such as compressive strength, durability, and workability.
- To experiment with various combinations and ratios of sugarcane bagasse, geopolymer, and TKP to determine the optimal concrete mix that balances performance and environmental sustainability.
- To assess the ecological effects of using sugarcane bagasse, geopolymer, and TKP in concrete, focusing on carbon footprint, waste reduction, and sustainability benefits.
- To contribute to the development of sustainable concrete technologies by advocating for the use of renewable resources, reducing the dependence on traditional cement materials.
- To perform extensive mechanical and durability testing on concrete incorporating sugarcane bagasse, geopolymer, and TKP to ensure long-term viability and suitability for diverse construction uses.
- To conduct comprehensive life cycle assessments to measure the environmental advantages of bagasse-based concrete in comparison to conventional concrete across the entire product lifecycle.

- To scale up the production of sugarcane bagasse-based concrete and explore innovative applications for sustainable infrastructure and green building projects.
- To promote the benefits of using sugarcane bagasse, geopolymers, and TKP in concrete through educational and outreach efforts, encouraging the adoption of sustainable practices within the construction industry.
- To build partnerships with academic institutions, industry stakeholders, and governmental bodies to share insights, drive best practices, and advance innovation in sustainable concrete through collaborative research.

3.2 SCOPE

The outlined scope areas advance sustainable concrete technology utilizing sugarcane bagasse and associated additives. This includes optimizing mix designs by continuously refining proportions of sugarcane bagasse, geopolymers, and tamarind kernel powder (TKP) to enhance concrete properties such as strength, durability, and workability through varied combinations and ratios.

Performance testing and evaluation involves conducting thorough mechanical and durability tests on sugarcane bagasse-based concrete with geopolymers and TKP to assess long-term performance and behavior in different environments, ensuring durability and structural integrity.

Life Cycle Assessment (LCA) conducted evaluates the environmental impact and benefits of using sugarcane bagasse in concrete production, quantifying reductions in carbon footprint and waste generation throughout its lifecycle.

Scaling up production explores strategies to expand the production of sugarcane bagasse-based concrete for larger projects, assessing feasibility, cost-effectiveness, and logistical considerations including raw material sourcing and manufacturing processes.

The exploration of innovative applications investigates new uses for sugarcane bagasse-based concrete, leveraging its lightweight, insulative, and eco-friendly properties in sustainable infrastructure and green building projects.

Public awareness and engagement initiatives, raise awareness and promote acceptance of sustainable concrete technologies using sugarcane bagasse, geopolymer, and TKP. Stakeholders gets engaged through education and outreach to highlight the benefits of these technologies for sustainable development.

Finally, collaborative research foster with academia, industry, and government to advance research in sustainable concrete technology, sharing findings and best practices to accelerate innovation and adoption of environmentally friendly construction practices. These scope areas collectively drives greener and more sustainable practices in the construction industry through the utilization of sugarcane bagasse and associated additives in concrete production.

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 MATERIALS

4.1.1 General

Geo-polymer concrete can be made using various source materials, the present study used TKP. Also, as in the case of OPC, the aggregates occupied 75-80 % of the total mass of concrete. The following sections discuss constituent materials used for manufacturing GPC. Chemical and physical properties of the constituent materials are presented in this section.

Following materials are used to produce GPCs:-

- Tamarind Kernel Powder (TKP)
- Alkaline liquid
- Sugarcane Bagasse
- Super plasticizer
- Coarse aggregate

4.1.2 Tamarind Kernel Powder (TKP)

Tamarind kernel powder (TKP) has interesting potential applications in the concrete industry, primarily due to its unique chemical properties. TKP (Fig 4.1) exhibits excellent water-holding capacity and forms viscous solutions, making it valuable for enhancing texture, moisture retention, and product stability in various applications also it is an eco-friendly alternative for fly ash. It typically range from 10% to 20% by weight of the total cementitious materials in the mix.



Fig 4.1 Tamarind Kernel Powder

4.1.3 Alkaline Liquid

Generally, alkaline liquids are prepared by mixing of the sodium hydroxide solution and sodium silicate at the room temperature. When the solution mixed together the both solution start to react i.e. (polymerisation takes place) it liberate large amount of heat so it is recommended to leave it for about 24 hours thus the alkaline liquid is get ready as binding agent.

4.1.3.1 Sodium hydroxide

The sodium hydroxide solids of a laboratory grade in pellets (Fig 4.2) form with 99% purity, obtained from local suppliers. Sodium Hydroxide (NaOH) solution is prepared by dissolving the pellets in water. The mass of sodium hydroxide solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, sodium hydroxide solution with a concentration of 8M consisted of $8 \times 40 = 320$ grams of sodium hydroxide solids (in pellet form) per liter of the solution, where 40 is the molecular weight of sodium hydroxide.



Fig 4.2 Sodium Hydroxide Pellets

4.1.3.2 Sodium silicate

Sodium silicate solution (Fig 4.3) obtained from local suppliers are used. The chemical composition of the sodium silicate solution is $\text{Na}_2\text{O}=8\%$, $\text{SiO}_2=28\%$, and water 64% by mass. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.



Fig 4.3 Sodium Silicate

4.1.4 Sugarcane Bagasse

Sugarcane bagasse are used as a partial replacement for conventional aggregates (sand) in concrete production (Fig 4.4). It helps in reducing the overall density of concrete while utilizing a renewable and sustainable material.



Fig 4.4 Sugarcane Bagasse in powdered form

4.1.5 Super plasticizers

To achieve workability of fresh geopolymer concrete, Sulphonated Napthalene polymer based super plasticizer conplast SP 430 in the form of a brown liquid (Fig 4.5) instantly dispersible in water, manufactured is used.



Fig 4.5 Super plasticizer

4.1.6 Coarse Aggregate

Coarse aggregate are naturally found rock particles which are taken by crushing them (Fig 46) . The aggregate which is used are retained on 20mm. The specific gravity of sugarcane bagasse used is 2.67. The properties of the coarse aggregate is listed in Table 4.1



Fig 4.6 Gravel

Table 4.1: Properties of Coarse Aggregate

S.NO	PROPERTY	VALUE
1	Particle Shape	Angular
2	Specific Gravity	2.67
3	Fineness modulus	7.15
4	Water Absorption	0.33%

4.2 METHODOLOGY

4.2.1 Preparation of specimen

Specimens are prepared by batching of materials, preparation of moulds and placing of concrete in the moulds.

4.2.2 Batching

The performance of different percentage of sugarcane bagasse, geopolymer and tamarind kernel powder is influenced by the mixing. This means that a proper and good practice of mixing can lead to concrete for better performance. A proper mix of concrete is essential for the strength of the concrete and better bonding of cement and aggregate. Before the concreting, all the mix materials are weighed and kept ready for concreting as per design mix proportions given in Table 4.2

4.2.3 Preparation of concrete moulds

Concrete moulds such as three cubes (150 mm x 150 mm x 150 mm) are cleaned first and oiled for easy stripping. The moulds for conducting tests on fresh concrete are made ready and inner surface is oiled.

4.2.4 Preparation of Alkaline Activator Solution

The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid. A combination of alkaline silicate solution and alkaline hydroxide solution are chosen as the alkaline liquid. Sodium-based solutions are chosen because they are cheaper than potassium-based solutions. The Alkali activator solution has to be prepared 24 hours advance before use. The Sodium hydroxide is available in small pellets and Sodium Silicate in crystal forms depending on the required solution of different morality to be prepared.

The solids are dissolved in water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in different molar. The mass of NaOH solids in a solution varies depending on the concentration of the solution. For instance, NaOH solution with a concentration of 12 molar consist of $12 \times 40 = 480$ grams of NaOH solids per litre of water, where 40 is the molecular weight of NaOH. This amount of NaOH solids in one litre of water will be large of its volume so it is reduced to 361 grams for 12 molar concentrations.

4.2.5 Preparation of Concrete

The components of concrete ingredients like sugarcane bagasse, coarse aggregate are collected and mixed with the pan mixture for about 5 min. The coarse aggregate are prepared in saturated surface dry condition. The Alkaline liquid is then added to the mixture and the mixing is done for another 5 min. The fresh concrete could be handled up to 120 minutes without any sign of setting and without any degradation. The workability of fresh concrete is measured by means of the conventional slump test, Slump values are measured in the number of inches fresh concrete “slumps,” or sinks, when removed from an inverted 12-inch-tall cone. The value can range from nearly zero, which means the concrete is extremely stiff and has almost no workability, to a degree where the concrete is so wet and flowable that it completely collapses when removed from the cone. On most projects, the ideal slump is somewhere in between these two extremes, with the concrete being workable enough for easy placing and finishing but having adequate cohesion to prevent segregation and loss of strength. The basic items used to perform the test included a slump cone, a baseplate to rest the cone on during the test, a steel rod to tamp down the concrete, and a tape measure or ruler to measure the slump of the concrete after the cone is removed. Geo-polymer concrete stick hard to the mould so oiling the moulds is very important to release each cube specimen, while cast in three layers by compacting manually. Each layer received 25 strokes of compaction by standard compaction rod for concrete.

By Water/TKP ratio the amount of water in concrete mix is determined, if more water or less water is added to mix it will decrease the strength of concrete. After concrete is well mixed, Slump Test is conducted to determine its workability and slump value which is the degree of workability of the concrete, which allows to determine if it's suitable for application.

4.2.6 Mix Proportions

Table 4.2: Mix Proportions

Ingredients	Without sugarcane bagasse	30% Sugarcane bagasse	50% Sugarcane bagasse	75% Sugarcane bagasse	90% Sugarcane bagasse
Tamarind Kernel Powder (kg/m³)	405	405	405	405	405
Sugarcane bagasse(kg/m³)	0%	30%	50%	75%	90%
Coarse aggregate (kg/m³)	1268.66	1268.66	1268.66	1268.66	1268.66
Sodium Silicate (kg/m³)	70.88	70.88	70.88	70.88	70.88
Sodium Hydroxide (kg/m³)	70.88	70.88	70.88	70.88	70.88
Super plasticizer (kg/m³)	7.5	7.5	7.5	7.5	7.5

4.2.7 Tests on Fresh Concrete

In this investigation, the workability tests are conducted on fresh concrete as shown in Table 4.3. Workability affects the rate of placement and the degree of compaction of concrete. Slump test is conducted on fresh concrete.

Table 4.3 : Slump test reading and workability

CONCRETE SLUMP READING	WORKABILITY
0 to 1 inches	Very Low
1 to 2 inches	Low
2 to 4 inches	Medium
4 to 7 inches	High

4.2.8 Preparation of Samples

During the placing of fresh concrete into moulds, proper care is taken to remove entrapped air by using a damping rod to attain maximum strength. Vibrators were used after every one third filling of material into the mould and the top surface is properly levelled at the end.

4.2.9 Demoulding

After levelling the fresh concrete in the mould, it is allowed to set for 24 hours. The Identification marks of concrete specimens are done with permanent markers and the specimens are removed from the moulds. The moulds are then cleaned and kept ready for next batch of concrete mix.



Fig 4.7 Demoulded concrete

4.2.10 Curing

Curing is an important process to prevent the concrete specimens from losing their moisture while they are gaining their required strength. Inadequate curing is also the cause of unexpected cracks on the surface of concrete specimen. Ambient curing at room temperature is kept until the day of testing of specimen.

4.2.11 Compression strength test on Hardened Concrete

Compressive strength is defined as the maximum resistance of a concrete cube to axial loading. Three specimens of size 150 mm x 150mm x 150mm are used for compression testing for each batch of mix. Testing of specimens were carried out as soon as possible after curing. The measurements of specimen dimensions were taken before the testing. Cleaned and surface dried specimens were placed in the testing machine (Fig 4.8). The platen was lowered and touched the top surface of the specimen. The specimen were tested for compressive strength as per IS 516 – 1959 using a calibrated compressive enhance digital indicator – ACTM. The compressive strength of these samples was recorded.



Fig 4.8 Compression Testing Machine

CHAPTER 5

RESULTS AND DISCUSSION

5.1 INTERPRETATION OF TEST RESULTS

The test results are reported and compared with the values obtained from various codes such as IS 516 -1959. The test such as compressive strength with different proportions of Sugarcane Bagasse for the 7th, 14th and 28th day are measured and presented in Table 5.1, 5.2 and 5.3.

5.2 COMPRESSIVE STRENGTH TEST

Compressive strength is the major parameter which influences other properties of concrete. The effect of addition of Sugarcane Bagasse with different volume fractions, the compressive strength of geopolymer concrete is evaluated and presented in graphical representation as shown in Fig 5.1, 5.2 and 5.3.

Table 5.1: Average Compression Test Results (7 Days Strength)

Sl.NO	MIX	AVERAGE COMPRESSIVE STRENGTH (N/mm ²)
1.	0%	15.6
2.	30%	16.8
3.	50%	18
4.	75%	15
5.	90%	10.8

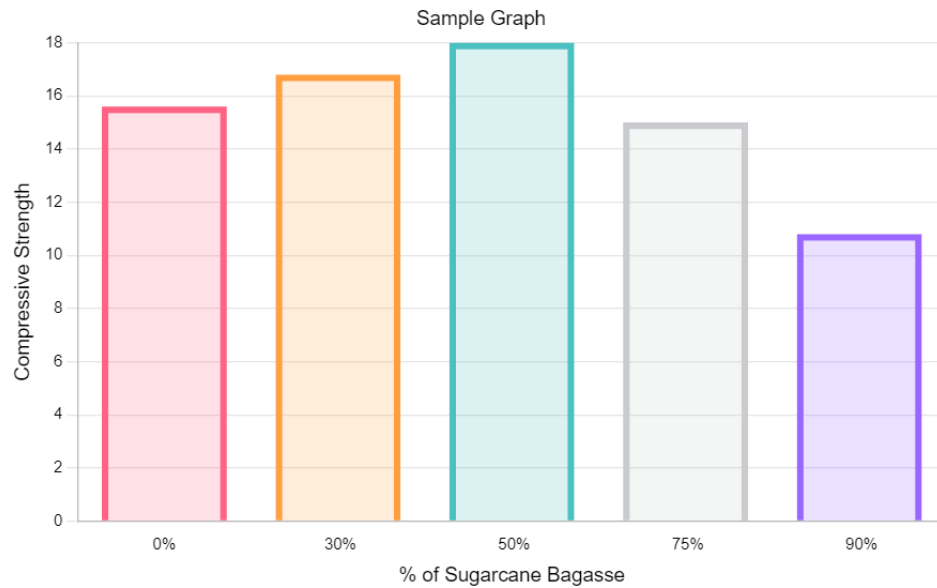


Fig 5.1: Graphical Representation of 7th day Compressive Strength Result

Table 5.1 depicts the average compressive strength test results on 7th day in (N/mm²) and it is graphically represented in Fig 5.1 where, the compressive strength is increased to 18 (N/mm²) with 50% of sugarcane bagasse and gradually decreases from 75% to 90% of sugarcane bagasse.

Table 5.2: Average Compression Test Results (14 Days Strength)

Sl.NO	MIX	AVERAGE COMPRESSIVE STRENGTH (N/mm ²)
1.	0%	20.8
2.	30%	22.4
3.	50%	24
4.	75%	20
5.	90%	14.4

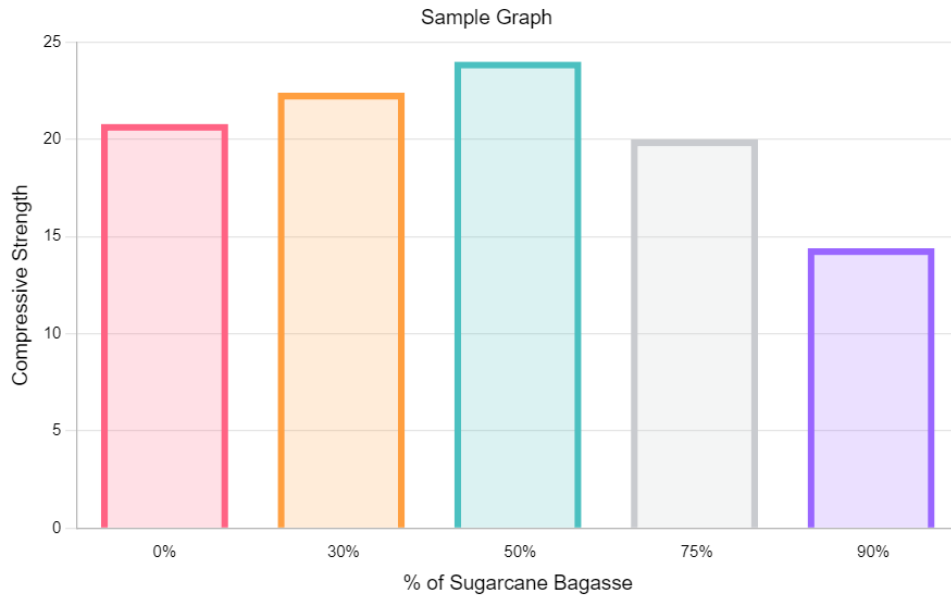


Fig 5.2: Graphical Representation of 14th day Compressive Strength Result

Table 5.2 depicts the average compressive strength test results on 14th day in (N/mm²) and it is graphically represented in Fig 5.2 where, the compressive strength is increased to 24 (N/mm²) with 50% of sugarcane bagasse and gradually decreases from 75% to 90% of sugarcane bagasse.

Table 5.3: Average Compression Test Results (28 Days Strength)

SI.NO	MIX	AVERAGE COMPRESSIVE STRENGTH (N/mm ²)
1.	0%	26
2.	30%	28
3.	50%	30
4.	75%	25
5.	90%	18

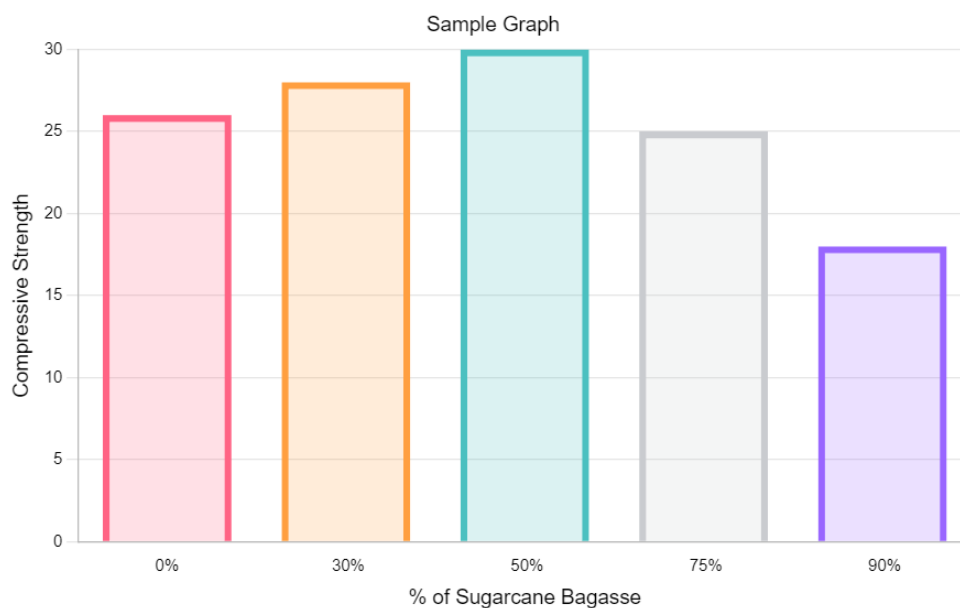


Fig 5.3: Graphical Representation of 28th day Compressive Strength Result

Table 5.3 depicts the average compressive strength test results on 28th day in (N/mm²) and it is graphically represented in Fig 5.3 where, the compressive strength is increased to 30 (N/mm²) with 50% of sugarcane bagasse and gradually decreases from 75% to 90% of sugarcane bagasse.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

This project explores the direct use of sugarcane bagasse in concrete, alongside geopolymer and tamarind kernel powder (TKP), as sustainable alternatives to conventional concretes.

- The Sugarcane Bagasse is found to have high compression strength at 50% of sugarcane bagasse incorporation in the 7th, 14th and 28th day result as shown in Table 5.1, 5.2 and 5.3 and it is graphically represented in Fig 5.1, 5.2 and 5.3. Hence, it is found out that the geopolymer concrete's strength is higher till 50% of sugarcane bagasse is incorporated.
- The result of compressive strength test, indicates that the percentage of Sugarcane Bagasse plays a vital role to increase strength of TKP based geopolymer sugarcane bagasse concrete.
- The strength of the concrete increases gradually till 50% of sugarcane bagasse is added to the volume of concrete and the strength decreases when 75% of sugarcane bagasse is added to the volume of concrete.
- The TKP based geopolymer concrete with the incorporation of sugarcane bagasse directly instead of sugarcane bagasse ash potentially reduces landfill and also reduces CO₂ emission and combustion which is caused during the conversion of sugarcane bagasse into ash. Hence proves that the incorporation of sugarcane bagasse directly into concrete alongside geopolymer and TKP is an excellent eco-friendly and sustainable alternative to traditionally used concrete materials.

6.2 CONCLUSION

In conclusion, this project showcase the potential of utilizing sugarcane bagasse directly in concrete, supported by geopolymer and TKP additives, as a viable strategy for advancing sustainable concrete technology. While challenges exist, such as optimizing mix designs and ensuring adequate performance, the overall benefits in terms of environmental sustainability and material efficiency are promising for future applications in the construction industry. Further research and development in this area can lead to innovative and eco-friendly concrete solutions.

6.3 FUTURE SCOPE

- **Mix Design Optimization:** Refine proportions of bagasse, geopolymer, and TKP for enhanced concrete properties.
- **Performance Testing:** Evaluate long-term durability under varied conditions.
- **Life Cycle Assessment (LCA):** Quantify environmental benefits over the material's lifecycle.
- **Scaling Production:** Explore commercial feasibility and logistics.
- **Innovative Applications:** Utilize in specialized projects requiring eco-friendly properties.
- **Public Awareness:** Educate stakeholders on benefits.
- **Collaborative Research:** Foster partnerships to advance sustainable concrete technologies.

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