INVESTIGATION OF THE POTENTIAL OF ETHIOPIAN GUM (XANTHAN GUM) AS WATER REDUCING AND RETARDING ADMIXTURES IN CONCRETE PERFORMANCE

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Investigation of the potential of Ethiopian gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that this thesis entitled "Investigation of the potential of Ethiopian gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance" is my work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation. It is being submitted for partial fulfillment for the award of the degree of Master of Science in Civil Engineering (Construction Engineering and Management) at Adama Science and Technology University School of Civil Engineering and Architecture.

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I hereby certify that I have read and evaluated this thesis entitled "Investigation of the potential of Ethiopian gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance" prepared under my guidance by **Debebe Girma Geleta** submitted in partial fulfillment of the requirements for the degree of Masters of Science in Civil Engineering (Construction Engineering and Management). Therefore, I recommend that the candidate has fulfilled the requirements and hence he/she can submit the thesis to the department.

Bahiru Bewket (PhD)	________________	________________
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Approval Page

we, the advisors of the thesis entitled “Investigation of the Potential of Ethiopian Gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance” and developed by (name of student)Debebe Girma, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Reviewers of the Thesis open defense by Debebe Girma Geleta have read and evaluated the thesis entitled "Investigation of the Potential of Ethiopian gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance" and assessed the understanding of the candidate about the thesis research. This is, therefore, to certify that the thesis/dissertation thesis research is accepted.

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List of Acronyms

PlA	polylactic acid
PhA	polyhydroxy alkanets
ASTM	American Society for Testing and Materials
CTA	chain transfer agent
CRT	cathode ray tube
CBC	Cbt-Biopolymer-concrete
TCLP	Toxicity Characteristic Leaching Procedure
SCC	self-compacting concrete
XG	xanthan gum
CLSM	confocal laser scanning microscopy
FTIR	Fourier –transform infrared spectroscopy
XRD	X-ray diffraction
DTS	diametric tensile strength
TgA	Thermogravimetric Analysis
SEM	scanning Electron microscopy
GA	Gum Arabic
GIC	Glass Ionomer cement
DTS	Diametric tensile strength
CS	Compressive strength
CMS	Carbon molecular sieve
PPC	Portland -pozzolana cement
EBCS	Ethiopian Building Code of Standard
ESC	Ethiopian Standard Construction

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Abstract

The study delves into the utilization of Ethiopian acacia tree gum as a natural bio-polymer to enhance concrete properties. The lack of extensive long-term studies presents a challenge in fully understanding the durability and effectiveness of gum-modified concrete. The primary goal of the research is to evaluate how Ethiopian gum can improve the longevity and performance of concrete. In laboratory settings are some of the common laboratory test procedures used to determine the mechanical properties of concrete. It is essential to follow standardized testing procedures and protocols to ensure accurate and reliable results., experiments have shown that Ethiopian gum can extend the setting time of concrete, resulting in impressive compressive strengths of 32.8N/mm2 and flexural strengths of 3.3N/mm2. Analysis using X-ray diffraction has unveiled that acacia tree gum is predominantly amorphous, with a distinctive peak at 18.76 degrees. The elemental composition data also reveals crucial minerals found in Ethiopian gum such as SiO2, Al2O3, Fe2O3, CaO, MgO, Na2O, K2O, MnO, P2O5, and TiO2. These minerals offer specific advantages in various applications. Moreover, Ethiopian gum serves a dual purpose as a water-reducing admixture, contributing to the enhancement of material strength. The study places significant emphasis on sustainability and environmental considerations. By exploring Ethiopian gum's potential as a bio-polymer to enhance concrete performance through its interactions with cementitious materials, this research aims to position it as a valuable asset within the construction industry.

keywords: Bio-polymers, Ethiopian gum, concrete, strength, natural gum.

1

INTRODUCTION

1.1 Background

Concrete is a widely utilized construction material on a massive scale, with global annual production reaching approximately 35 billion tons.(Akhtar and Sarmah, 2018). Comprising a mixture of cement, sand, and various aggregates, concrete sets and hardens at room temperature upon hydration with water. Despite its widespread use, concrete experiences deformation over time and under load, a phenomenon known as concrete creep. The underlying causes of this degradation are still not fully understood. Remarkably,statistics highlight that concrete ranks as the second most consumed material globally, trailing only water in consumption. An estimated 25 billion tons of concrete are manufactured annually, with its production benefiting from cost-effectiveness and a diverse range of raw materials, enabling the creation of structures in various shapes as required(Imbabi et al., 2012). This versatility has established concrete as a cornerstone material in construction, transportation, and underground engineering. Nevertheless, in tandem with technological advancements, engineers now strive for elevated engineering standards, necessitating improved mechanical properties, durability, and environmental sustainability in concrete. Many modern projects demand thinner and lighter structural elements to meet evolving design requirements (Abbas and Mohsen, 2020)

Concrete is a widely used construction material its strength, durability,and versatility. However, it is susceptible to cracking and damage caused by factors such as temperature changes, shrinkage, and external loads. To address this issue, researchers and engineers have been exploring various methods to enhance the stability and performance of concrete. One promising approach is the use of natural bio-polymers as additives in the concrete mixture. This study aims to investigate the potential of xanthan gum, the common bio-polymer, in the stabilization of concrete(Ilman and Balkis, 2023). Concrete is a widely used material in the construction industry due to its numerous benefits. This versatile material offers several advantages, making it a preferred choice for various construction projects.

Gum- and resin-producing species cover substantial areas of Ethiopia. The country also has vast areas that can be considered potentially suitable for cultivating these tree crops all the country's arid and semi-arid lands, which cover an area of 560 000–615 000km2. For instance, available estimates indicate that the total area of oleo-gum resin-bearing woodland species covers about 2.9 million ha of land in the country (Tadesse et al., 2007). In terms of regional distribution, gum- and resin-producing species are found in the Afar, Amhara, Benishangul-Gumuz, Gambella, Oromia, Somali, Southern Nations and Nationalities, and Tigray Regional States(Lemenih et al., 2003).

Concrete is known for its exceptional strength, durability, and workability. It can withstand heavy loads and resist various weather conditions, making it suitable for constructing buildings, and other infrastructure. Its ability to resist compression makes it an ideal choice for supporting structures and foundations in all direction. On the other hand, the raw materials used in concrete production, such as cement, aggregates, sand, and water, are relatively inexpensive and readily available. Additionally, concrete requires minimal maintenance over its lifespan, reducing long-term costs for repairs and replacements. Moreover, concrete offers excellent fire resistance properties. It does not burn or emit toxic fumes when exposed to high temperatures, making it a safe choice for buildings and structures. This quality is crucial in ensuring the safety of occupants and minimizing damage during fire incidentsYavuz et al. (2023).

Furthermore, concrete has excellent thermal properties. It can regulate temperature fluctuations by absorbing and releasing heat slowly, creating a comfortable indoor environment(Santamouris et al., 2011). This thermal mass property helps reduce energy consumption for heating and cooling, leading to energy efficiency in buildings. Additionally, concrete is a sustainable material in the construction industry. It can be produced using recycled materials such as fly ash and slag, reducing the demand for virgin resources. Furthermore, concrete structures have a long lifespan, reducing the need for frequent replacements and minimizing waste generation. Lastly, concrete offers design flexibility. It can be molded into various shapes and sizes, allowing architects and designers to create unique and aesthetically pleasing structures. Concrete can be colored, textured, or stamped to achieve desired appearances, providing endless possibilities for creativity in construction projects. In conclusion, the benefits of concrete in the construction industry are vast. Its strength, durability, cost-effectiveness, fire resistance, thermal properties, sustainability, and design flexibility make it a preferred choice for construction projects. By utilizing concrete, builders can construct safe, long-lasting, energy-efficient, and visually appealing structures(Baikerikar, 2018). Bio-polymers are a class of polymers derived from renewable biological sources, such as plants, animals, and microorganisms. They are distinct from synthetic polymers, which are derived from petroleum-based sources. Bio-polymers offer several advantages over their synthetic counterparts, including reduced environmental impact, biodegradability, and the potential for renewable production(SATHYA et al., 2016).

The production of bio-polymers typically involves extracting or synthesizing polymers from biological materials. These materials can include cellulose, starch, proteins, and various types of sugars. By utilizing these natural resources, bio-polymers help reduce dependence on fossil fuels and contribute to the development of a more sustainable and circular economy. One of the most well-known bio-polymers is polylactic acid (PLA), which is derived from corn starch or sugarcane. PLA is biodegradable and has a wide range of applications, including packaging, disposable cutlery, and medical implants(Sin, 2012). Other bio-polymers include polyhydroxyalkanoates (PHA), which are produced by microorganisms through fermentation, and chitosan, derived from the shells of crustaceans. .

Additionally, bio-polymers can be blended with synthetic polymers to create hybrid materials with enhanced properties. The development of bio-polymers contributes to the goal of achieving a more sustainable and environmentally friendly society and Eco-friendly. They offer opportunities for reducing plastic waste, decreasing greenhouse gas emissions, and promoting the use of renewable resources. Overall, the introduction of bio-polymers represents an important step towards a more sustainable future by harnessing the potential of renewable resources and reducing reliance on petroleum-based materials. As research and technology continue to advance, bio-polymers are expected to play a significant role in shaping various industries and promoting a greener, more sustainable world(Čolnik et al., 2020)

Gums are hydrophilic polysaccharides of high molecular weight, usually, with colloidal properties, which in an appropriate solvent may dissolve or swell to produce gels or, highly, viscous suspension, thus the term gum is applied to a wide variety of substances of ”gummy” characteristics and cannot be precisely defined. Hydrophobic substances often called gums are high molecular weight hydrocarbons and other petroleum products, rubbers, certain synthetic polymers, chicly for chewing gum, and the resinous saps which often exude from evergreens and which are sometimes commercially tapped yielding, for example, gum balsam and gum resin (Anderson, 1970). Most commonly, the term gum as technically employed in industry refers to plant polysaccharides or their derivatives which are dispersible in either cold or hot water to produce viscous mixtures or solutions. Thus, modern usage includes the water – soluble or water – sellable derivatives of cellulose and the derivatives and modifications of other polysaccharides which in the natural form are insoluble. Usage would classify as gums all polysaccharides or their derivatives which when dispersed in water at low dry substance content, swell to produce gels, highly viscous dispersions, or solutions(Coppen, 1995).

1.2 Statement of the Problem

The application of natural biopolymers for concrete performance comes with various challenges and constraints that impede their broad acceptance in the construction sector(Aher et al., 2023). These obstacles encompass factors such as compatibility and performance variability, where the efficacy of natural biopolymers in enhancing properties like workability and durability needs comprehensive assessment due to their diverse sources. Additionally, cost-effectiveness poses a significant concern as natural biopolymers may exhibit higher costs than traditional admixtures, hindering their widespread utilization. The lack of standardized protocols for natural biopolymer application in concrete production further complicates matters, leading to uncertainty and limiting their industry acceptance. Overcoming these hurdles necessitates further research, extensive testing, standard development, and the establishment of cost-efficient production methods to facilitate their integration into construction practices(Wasim et al., 2022).

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this research is to Investigation of the potential of Ethiopian gum (xanthan gum) as Water Reducing and Retarding Admixtures in concrete performance.

1.3.2 Specific Objectives

The specific objectives of this particular research were::

- To Characterization and Evaluation of Ethiopian gum (xanthan gum) for its rheological properties and compatibility with other admixtures.
- To investigate the mechanical properties(compressive strength and flexural strength)of concrete sample additives with varying concentrations of Ethiopian gum (xanthan gum).
- To evaluate the effect of different concentrations of Ethiopian gum (xanthan gum) on resistance to water absorption was determined

1.4 Research Questions

- What is the impact of Ethiopian gum on the workability of concrete when used in combination with cement, aggregate, sand, and water?
- How does the addition of Ethiopian gum affect the setting time and early strength development of concrete when paired with different types of chemical admixtures?
- What is the optimal dosage range of Ethiopian gum that maximizes compatibility with other admixture concrete properties?
- How does Ethiopian gum influence the long-term durability and resistance to various admixtures commonly used in construction?

1.5 Significance of the study

My research on exploring the compatibility of Ethiopian gum (xanthan gum) with other admixtures carries various important implications.

Sustainability: Biopolymers are essential alternatives to unsustainable goods because of their biodegrade-ability, environmentally acceptable manufacturing techniques, and extensive application ranges. By studying the utilization of xanthan gum, your research can contribute to sustainable and eco-friendly construction practices.

Improved performance: (Ethiopian gum) Xanthan gum, a polysaccharide is made using microbial fermentation of primarily Lactobacillus plant arum campsites bacterium.

Cost-effectiveness: Understanding the economic implications of using (Ethiopian gum) (xanthan gum) in concrete formulation can provide valuable information to industry professionals. If these natural bio-polymers are found to be cost-effective alternatives to traditional chemical admixtures, it can have significant implications for construction practices and material choices.

1.6 Scope and Limitations of the Study

When initiating a research investigation into the potential use of Ethiopian gum (specifically xanthan gum) as a natural biopolymer to enhance concrete performance, it is crucial to define the study's scope and limitations. The following aspects on my research considered:

1.6.1 Scope of the Study:

Focus on Material This research will mainly concentrate on Ethiopian gum, particularly acacia gum, as a natural biopolymer to be used in concrete. Performance of Concrete The study aims to evaluate the influence of incorporating Ethiopian gum on concrete characteristics like strength, durability, and workability. Comparative Analysis This research may compare how Ethiopian gum performs in comparison to conventional polymer additives or other natural biopolymers commonly utilized in concrete. Experimental Testing The investigation might involve carrying out laboratory tests to analyze the effects of Ethiopian gum on different properties of concrete.

1.6.2 Limitations of the Study:

Material Specificity the research exclusively centers on Ethiopian gum (acacia gum) as a bio-polymer additive, which could limit the application of results to other bio-polymers, and Lab Environment Findings from controlled laboratory conditions might not accurately reflect real-world situations or the long-term behavior of Ethiopian gum in concrete structures, Time Constraints the study's duration constraints could hinder the comprehensive assessment of Ethiopian gum's lasting impacts on concrete properties. External Influences Factors like environmental conditions, mixed designs, and curing methods could influence results but may not be fully accounted for in the research Scaling Challenges While laboratory tests offer insight, the study may not address the complexities involved in upscaling the use of Ethiopian gum in concrete performance

In this chapter, the background and statement of the problem have been presented. Further, the study aims, associated objectives, the scope of the study, the significance of the study, and the organization of the thesis to achieve these objectives have briefly been presented. In the next chapter, the literature review and the gaps in the different research papers will be presented.

2

LITERATURE REVIEW

2.1 Introduction

The primary objective of this chapter is to encapsulate the diverse arguments and concepts put forth by different researchers. A comprehension of the significant factors influencing engineering properties is essential for their enhancement. Therefore, this research will concentrate on comprehending the impact of Ethiopian gum (xanthan gum), a natural bio-polymer, on the compressive strength, flexural strength, and durability characteristics of treated concrete for improved performance.

Biopolymers are characterized by their high-molecular-weight compounds featuring repetitive sequences that result in multiple reactive sites for various chemical and physical reactions, facilitating cross-linking mechanisms. In this study, xanthan gum, guar gum, and chitosan were chosen due to their exceptional metal chelation properties. Metals can form complexes with the functional groups present in organic compounds. Xanthan gum, in particular, contains specific functional groups like CH 2 OH, OH, O, COOH, and H within its structure, enabling it to bind with metals, sand, and cement particles. This binding mechanism leads to the creation of a three-dimensional cross-linked network involving the target metal, such as Pb, and the microstructure of the concrete(Albuquerque et al., 2016).

Hence, the biopolymer acts as an adhesive within a calcium-silicate-hydroxide matrix, with a specific affinity for calcium that facilitates the bridging of Pb onto concrete molecules abundant in calcium, derived from the cement material. Various endeavors have been made to incorporate biogenic biopolymers as additives or supplements in construction engineering. For instance, a study utilized curdling as a viscosity agent to enhance concrete workability, while beta-glycan treatment demonstrated a substantial strength improvement in natural soil by up to 300–400%, with minimal impact on CO2 emissions. Additionally, the application of gel-type biopolymers like galactic gum and agar gum has emerged in soil treatment practices. The current research involves conducting experiments to assess the viability of gel-type biopolymers, such as xanthan gum and guar gum, as construction binders for earth buildings, inspired by natural methods(Matsuoka and Jeang, 2011)

Because of the high cost of quality construction materials, transportation engineers are often forced to seek alternative designs using substandard materials, commercial construction aids, alternative pavement materials, and innovative design practices. Nontraditional soil stabilization additives are being marketed as viable solutions for stabilizing marginal materials as a low-cost alternative to traditional construction materials. Nontraditional additives are diverse in their composition and the way they interact with soil. Unfortunately, little is known about their interaction with geotechnical materials and their fundamental stabilization mechanisms.(Tingle et al., 2007).

2.2 Microalgae as Contributors to Produce Biopolymers

The most typical source of biopolymers is polysaccharides, but other sources such as algae and microbes can also be used to produce a biopolymer. The glycerol of the biopolymer was allowed to polymerize in the presence of a reversible additionfragmentation transfer (RAFT) agent, or chain transfer agent (CTA). An initiator was added to remove the free-radical inhibitors and a solvent (methanol) was added to achieve the correct solution (Forrester, 2014).

Biopolymers are polymers synthesized by plants or organisms with more complex chemical structures than human-made polymers. Recently the definition of biopolymer has been expanded to any polymer synthesized using natural monomers such as polylactic acid which comprises lactic acids. Biopolymers are used in cement mortar and concrete as admixtures to improve properties, as matrices in bio composites with high mechanical strength, and insulator or high-temperature retardant properties(Taib et al., 2023). Two sources of biopolymers for mortar and concrete are agro-resources extraction and biotechnology through microorganism fermentation and conventional synthesis. Extraction of natural materials or agro-resources materials produces biopolymers such as polysaccharides, cellulose, starch, chitin, chitosan, and alginates. Alginates are extracted polysaccharides from brown algae and act as a self-healing agent for crack repair in concrete without reducing the strength. Biotechnology through microorganism fermentation produces polyhydroxy alkanets(Olivia et al., 2018).

2.3 Biopolymers as additive to concrete and mortars

Performed a study related to heavy metal encapsulation in a mortar by biopolymer. The heavy metal Pb was acquired from cathode ray tube (CRT) wastes. CRT is a component of television that is considered toxic due to its high lead content. The lead content in CRT is 0-3 wt. % for the panel, 22-25 wt. % for the funnel, 30-40 wt. % for the neck and 60-85 wt. % for the solder. In the study, CRT was mixed with mortar that contains biopolymer, which is further called CRT-Biopolymer-Concrete (CBC) composite. The CRT was shattered into pieces of glassy aggregate, sand used as a replacement for silicate sand. The CRT aggregates were then submerged in a biopolymer solution. The biopolymer solution was made by mixing xanthan gum and guar gum into pure water at 0.1% concentration. For specific variations, 0.1% boric acid was also added as a crosslinking agent(Sua-iam and Makul, 2013).

Toxicity of nanoparticles depends on many factors including size, shape, chemical composition, surface area, surface charge, and others. In this study, we compared the toxicity of different sized-silver nanoparticles (AgNPs) which are being widely used in consumer products due to its unique antimicrobial activity(Park et al., 2010). Previous research has shown the potential of bio-polymers as stabilizers for concrete. Xanthan gum, derived from the fermentation of carbohydrates by the Xanthan Mona campestral bacterium, has demonstrated excellent viscoelastic properties and water retention capabilities(Sworn, 2021). Studies have indicated that the addition of xanthan gum to concrete mixtures can improve work ability, reduce segregation, and enhance the overall strength and durability of the hardened concrete.

2.4 Utilization of polysaccharides as viscosity modifying agent in self-compacting concrete

Similarly, xanthan gum possesses a high viscosity and water-thickening properties. It has shown promise in improving the flow characteristics and stability of concrete, particularly in self-compacting concrete (SCC) applications. The addition of xanthan gum has been found to enhance the workability, filling ability, and resistance to segregation of SCC mixtures. Although both xanthan gums have individually demonstrated positive on concrete, comprehensive studies comparing their performance and determining the optimal dosage are limited(Ahmed et al., 2023). This study aims to bridge this research gap and provide valuable insights into the potential application of these bio-polymers for concrete stabilization. Many biopolymers have been incorporated into concrete; some were carried by pure curiosity, such as the use of biopolymers forincreasing concrete viscosity to avoid segregation in selfcompacting concrete indicates the use of natural glues.

Too assess the most suitable matrix polymer, one must know the properties of the available polymers. Since data tend to be widely scattered over many sources and are very scarce compared to conventional polymers, it is the purpose of this article to give an overview of the most relevant properties of a range of biodegradable polymers. An overview such as the one given here may provide a useful guide in establishing the best compromise between conflicting property demands. Data are presented mostly as ranges (in tables) as well as in graphs for quick comparison reasons. One specific application (thermoplastic with flax as reinforcement) is also studied(Van de Velde and Kiekens, 2002).

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In turn, the Chinese used bio-admixtures such as proteins, egg whites, fish oils or blood to modify the mortar used during the construction of the Great Wall(Paris et al., 2005)Taking the construction industry into account, currently, biopolymers are most often used to modify the properties of concrete and dry-mix mortars. Contemporary concrete does not exist without polymer modifications, including polymer-based chemical admixtures, which influence many of the characteristics of concrete, such as rheology, strength, and durability. The global annual concrete production exceeds 10,000 million tonnes, making the share of chemical admixtures, including biopolymers, very high. It is predicted that the demand for concrete and bio-admixtures will extensively increase shortly due to the intensive growth of the construction industry in many developing countries(Pacheco-Torgal and Jalali, 2012).

2.5 Bio-based admixtures for concrete

Bio-based admixtures (BBAs) are emerging as a promising class of additives for concrete, offering a more sustainable and environmentally friendly alternative to conventional chemical admixtures. Derived from various natural or biological sources, including plants, animals, and microorganisms, BBAs have shown potential in enhancing the performance characteristics of concrete in several key areas. This review article provides an in-depth exploration of BBAs, beginning with a detailed classification of the different types of BBAs based on their source material and production methods. It then delves into the various characterization techniques used to assess the properties and performance of BBAs, providing insights into their impact on the workability, strength, durability, and rheology of concrete(Malathy et al., 2020)

The admixtures were added to the cement paste in the amount of 0.5 and 1 wt. % about the amount of cement. The lowest compressive strength was obtained for the sample with the addition of lignin alone. The results were slightly lower than the reference values obtained for pure paste without admixtures. With the increase in the amount of lignin in the composite, the value of compressive strength decreased, which is probably related to a greater aeration of the cement paste. Similar relationships have been reported by other researchers for lignosulfonates, hence the maximum amount of admixtures in cement composites is usually up to 0.5 wt. % concerning cement(Yahia et al., 2016) In improving flow ability and workability, lignin and its derivatives can have dispersive functions and can be applied as carriers for a variety of active ingredients. Such materials should be characterized by good solubility and release characteristics. Kraft lignin, for example, is well soluble in aqueous alkaline solutions and certain mixtures of organic solvents such as aqueous solutions of acetone or tetrahydrofuran, while lignosulfonates are soluble in aqueous solutions over a wide pH range2022simple.

The introduction of active substances onto/into lignin and their derivatives usually occurs through entrapment, encapsulation, and adsorption processes. These processes are most often used in medicine and biotechnology, e.g., to introduce certain drugs, enzymes, or pesticides. In technical applications, such solutions are still very limited(Zhou et al., 2009). It is well known that the main role of silica is to increase the compressive strength of cement composite. The increase in strength is related to the reaction of the silica with the calcium hydroxide produced during the hydration of the silicate phases of cement clinker. This results in the creation of an additional calcium silicate hydrate (CSH) phase which seals the cement paste Microbial biopolymers, produced by the fermentation of sugars by microorganisms have been applied in various geotechnical engineering applications such as hydraulic barriers, contaminant adsorption, and for improvement of strength (Ayeldeen et al., 2017)The application of different additives has become widespread so that you can barely find a concrete mix without any additives.

In general, using admixtures in concrete improves its workability, accelerating or retarding setting time, controlling the development of concrete strength, and enhancing durability during the deterioration process. However, the usage of admixture is not a remedy for poor-quality of concrete due to the use of incorrect mix proportion, poor workmanship in concrete mixing, and the problems caused by low-quality raw materials selection (Alsadey, 2012). Cement concrete has been widely used as the primary construction material because of its easy workability, high durability, and fire resistance. However, it has low tensile strength and is susceptible to cracking and structural deterioration due to external forces, chemical reactions, and volume changes(Nienaber et al., 2013).

Recently, increasing maintenance costs due to the increase in the number of aged concrete structures have generated interest in improving the durability and safety of concrete structures. In this regard, several studies have revealed that admixtures and functional polymer materials are useful for improving the performance of mortar or concrete(Kujawa et al., 2021). Polymeric materials are useful due to their flexibility, reusability, and toughness nature. These biopolymers can be amalgamated with various kinds of natural and synthetic materials to synthesize polymeric composites(Aggarwal et al., 2020a). Such composite materials have comparable properties to oil-based polymers. Biopolymers also play an essential role in the drug and pharmaceutical industry. These can be utilized for industrial purposes, for instance, to regenerate damage, and medication administration in addition to regenerative medicine to achieve low immunogenicity, and high pharmacological activity. Several biopolymers are described in this article.

There are various mechanisms to produce biopolymers. There are diverse forms of biopolymers that originate from microbes, animals, and plants. Biopolymers play a significant role in the chemical and pharmaceutical industries. These are extensively used in medical equipment, cosmetics, confectionery, wastewater treatments, food additives, textiles, and bio-sensing applications(Aggarwal et al., 2020b).

The use of polysaccharides as building blocks in the development of nano-sized drug delivery systems is rapidly growing. This can be attributed to the outstanding virtues of polysaccharides such as biocompatibility, biodegradability, low toxicity, and low cost. In addition, the variety of physicochemical properties and the ease of chemical modifications enable the preparation of a wide array of nanoparticles. This tutorial review describes the properties of common polysaccharides, the main mechanisms for polysaccharide based-nanoparticles preparation, and provides examples from the conceptual design towards pre-clinical and clinical applications(Mizrahy and Peer, 2012).

Gum is the common term for hydrocolloidal gels-polysaccharides that have an affinity for water and exhibit binding properties with water and other organic/inorganic materials. Traditionally, gums have been derived from a wide variety of plants. Chemically gums are carbohydrate polymers or polysaccharides (however, gelatin is a protein). Polysaccharides are present in all life forms. They have several unique chemical and physical properties. They serve as a structural material to the plant kingdom, as energy reserves, adhesives, and also information-transfer agents. Microbial polysaccharides are composed of regular repeating units of simple sugars like glucose, mannose, fructose, etc. These polysaccharides are sometimes termed slime or exon-polysaccharides(Palaniraj and Jayaraman, 2011)Xanthan gum (XG) and gelatin B (GB) interact synergistically in aqueous solution (0.2% XG, 1.0% GB (wt/vol)) and form gels with an elastic modulus G0 almost 30 times superior to a pure 0.2% XG solution.

Proteins and polysaccharides are two types of natural biopolymers commonly used in various applications such as in food and cosmetic industries, biomedical engineering, etc. Processed food systems usually contain both proteins and polysaccharides performing complementary nutritional, structural and textural functions(Tolstoguzov, 1995).

Concrete is a composite material made up of inert materials of varying sizes, which are bound together by a binding medium. Concrete contains coarse aggregate in addition to cement, water, air, and fine aggregate. The cement, water, and air combine to form a paste that binds the aggregates together. Thus, the strength of concrete is dependent on the strength of the aggregate matrix bond The entire mass of the concrete is deposited or placed in a plastic state and almost immediately begins to develop strength (harden), a process which, under proper curing conditions, may continue for years. Because concrete is initially in a plastic state; it lends itself to all kinds of construction, regardless of size or shape (Allen and Iano, 2019).

Biopolymers naturally occur as polymeric biomolecules and treasure lots of potential applications as food packaging materials, thin wraps, tissue-engineering materials and much more. Furthermore, naturally synthesized biopolymers are non-toxic and are easily biodegradable. The biopolymers extracted from the waste biomass/by-products from industry can be reused in many of the potential applications(Saha and Sarkar, 2023). The production and extraction of biopolymers from wastes necessitate the need for more sustainable approaches. In addition, the re-entry of biopolymers and their composites into the human supply chain should be in such a way that they do not disturb the natural biodiversity or create an imbalance in nature. Besides, effective use of waste can ensure a sustainable approach to support the circular economy of the region (Kalia and Pielichowski, 2018)

Biopolymers are polymeric compounds generated from biological sources and known as biopolymers. They've been studied because of their renewability, abundance, biodegradability, and other unique qualities like high adsorption capacities and ease of functionalization. For a variety of industrial uses, including sorption polysaccharides, in particular, Because of their large molecular weight, cellulose, chitin, and chitosan are important biopolymers. There's a lot of it, it's widely distributed, and it's cheap to make. This chapter provides an overview of material characterization, common processing methods, and a review of properties(Leznoff et al., 1989).In recent years, there has been a surge of interest in using biopolymer materials as natural possibilities for various biological applications. The current trend is a significant indication that it focuses on the theme of "green chemistry" or "green world," namely, a sustainable environment that is achieved by using materials and processes that are biocompatible, biodegradable, renewable, inexpensive, and efficient. The benefits of biopolymers in the biomedical field have been thoroughly demonstrated.

Biobased polymers for industrial applications, their end fate, and most importantly, origin and key aspects enabling soil biodegradation. The physicochemical properties of biobased synthetic and natural polymers and the primary factors governing degradation are explored. Current and future biobased systems. It discusses the end-fate of biopolymers in soil and the impact of residues on soil health. A limited number of studies examine side effects (e.g., microbial toxicity) from soil biodegradation of composites and biopolymers. Currently, available standards for biodegradation and composting have been described with limitations and scope for improvements. Finally, design considerations and implications for sustainable polymers used, under consideration, and to beconsidered(Mtibe et al., 2021).

2.6 Biobased Natural and Chemically Synthesized Polymers in Industrial Applications

Biopolymers play a pivotal role in pharmaceutical industries. The biopolymers could be employed for, the administration of medicine as well as regenerative medicine to reach minimal immunogenicity and maximum pharmacological expressivity in a treated individual. Based on their properties biopolymers were exclusively used in medical devices, cosmeceuticals, and confectionaries, it is also used as additives in food industries, bio-sensors, textile industries, and wastewater treatment plants. Ecological support is of utmost concern nowadays due to the ever-expanding ramifications over the planet by the usage of plastic as packaging material, causing scientists and researchers to focus on biodegradable biopolymer utilization. The miscibility-structural-property relation between every biopolymer must be focused on to improve the environment. Specific biopolymers are designed for the betterment of agrarian and commoners of society. Advanced structural modifications, properties of biopolymers, and applications of biopolymers to achieve a greener environment(Tanase and Spiridon, 2014).

Earth buildings are still a common type of residence for one-third of the world's population. However, these buildings are not durable or resistant to earthquakes and floods, and this amplifies their potential harm to humans. Earthen construction without soil binders (e.g., cement) is known to result in poor strength and durability performance of earth buildings. Failure to use construction binders is related to the imbalance in binder prices in different countries. In particular, the price of cement in Africa, Middle East, and Southwest Asia countries is extremely high relative to the global trend of consumer goods and accounts for the limited usage of cement in those regions. Moreover, environmental concerns regarding cement usage have recently risen due to high CO2 emissions.

Meanwhile, biopolymers have been introduced as an alternative binder for soil strengthening. Previous studies and feasibility attempts in this area show that the mechanical properties (i.e., compressive strength) of biopolymer mixed soil blocks (i.e., both 1% xanthan gum and 1% gallon gum) satisfied the international criteria for binders used in earthen structures. Economic and market analyses have demonstrated that the biopolymer binder has high potential as a self-sufficient local construction binder for earth buildings where the usage of ordinary cement is restricted schroeder2016signals. When mixing concrete with a natural polymer the result revealed a synergistic impact on the characteristics and functionality of the concrete structure.

2.7 The Mechanical Properties, Shrinkage Properties, and Durability of Concrete

Five concrete mixes were designed to achieve the study objective. For certain concrete mixes, admixtures such as a natural polymer (chitosan), and chemical (superplasticizer) were added with 0.05% by weight of the cement content. Those admixtures were added to study their behavior on the characteristics of the concrete mixes, and then compare test results with control concrete mixes. Also, the purpose of the experiment was expanded to study the impact of adding the admixtures to fibrous concrete, as this fibrous concrete faces interlocking due to steel fiber's presence in the fresh concrete mixture. The results indicated that concrete-embedded chitosan exhibited significant enhancement in the mechanical properties. Further, the surface shape of concrete was characterized by the presence of chitosan crystallites which spread and fled the spaces in the chitosan structure(Bezerra, 2016).

These biopolymers are used to enhance concrete's mechanical, physical, and durability properties. This study focuses on a critical analysis of previously published experimental studies on numerous types of biopolymer composites in concrete and mortar, and its impact on the fresh and hardened properties of biopolymer concrete and mortar. In this study, the physical and mechanical characteristics of the biopolymer concrete/mortar are examined, along with their fresh performance. This paper examines a research project that was started to enhance the fundamental comprehension of this material and to supply the information necessary for its widespread application. Consequently, a comparison of traditional concrete, polymer concrete, and biopolymer concrete along with resins and fibers in various quantities has been made. The mechanical characteristics, benefits, and applications of resin-based biopolymer concrete are discussed in this review paper. This paper discusses the use of different bio resins and bio fillers in concrete and mortar, which will be helpful for future research on the topic of biopolymer concrete(Aher et al., 2023).

At room temperature, the starch is poorly soluble in water, however, when mixed with sand and water at the optimum ratio, the mixture forms a viscous liquid with self-compacting behavior. The resulting densely-packed aggregates are one of the reasons for the material's high compressive strength after backing. During heating, the starch molecules dissolve partially and form a gel, which glues the sand grains together and hardens when dried out. Next to the mixing ratio of sand, starch, and water, the strength of the hardened concrete depends on the grain size distribution of the aggregate sand, as well as the heating procedure and time.

2.8 Use of natural biopolymers for improved mortar and concrete properties of cemenets

Natural biopolymers from plants and natural sources have been used with construction materials during the historic and prehistoric periods world over and many of these structures are even today rare in good shape confirming the durability of these structures which used natural biopolymers, vegetables, selected plant & fruit extracts. These natural biopolymers are organic materials available from selected plants, seeds, and fruit extracts which are chemically carbohydrates, proteins, oils, and fats and their derived and hydrolyzed products, plant latexes, gums starch and natural carboxylic acids/esters and their salts, and even blood (animal), milk and eggs, which had properties similar to the present day synthetic admixtures in terms of reducing the water content of the binding materials, which accelerates the hardening processes of the binders providing water retentively, render ability and compaction desirable to produce a durable compacted hardened structure as desired to bind the stones and aggregates used in this historic and prehistoric structures(van Paassen and Kulshreshtha, 2017).

These natural biopolymeric additives/admixtures improve the properties of construction material formulations (i.e. mortars, plasters mixes used) in fresh (green) as well as in hardened state and also improve the resistance of the structures to the deterioration processes in nature thereby enhancing the durability of the structures, these bio polymeric additions also exhibited biocidal and insecticidal properties leading to resistance of the constructed structure to bio-corrosion as well as termite resistance(Losini et al., 2021). The paper attempts to review the different types of available natural biopolymers and the effects of these additions on the fresh and hardened properties of Mortar and Concrete. The paper further discusses the experimental data generated at the author's laboratory as a part of exploratory work carried out, on the use of natural polymers and its impact on the properties of Cements, mortars, and concretes in terms of increased early strengths, Air entraining effect, better Adhesiveness, Anti microbiological agent(Plank, 2004), improvement in plasticity & workability of the mortars and concrete, comparing the results of the natural biopolymeric additions with the commercially available additives/ admixtures used to induce similar properties in mortar and concrete.

Biopolymers were already used as admixtures in construction materials in ancient times. The first reports regarding the use of vegetable oils in lime mortars appeared in the works of Vitruvius. The Romans also used other bio-admixtures, such as dried blood to aerate building materials or proteins as gypsum binding regulators(Ślosarczyk et al., 2020). In turn, the Chinese used bio-admixtures such as proteins, egg whites, fish oils or blood to modify the mortar used during the construction of the Great Wall. The durability of the buildings founded at that time, some of which have survived to this day, indicates the validity of the use of biopolymers in the present-day technology of construction materials. This is also important because of the increased search for biodegradable materials from natural sources as an alternative to polymers traditionally synthesized from petroleum products(George et al., 2020).

Although the production of bio-admixtures is still relatively low compared to petroleum-based ones, the use of bio-admixtures is expected to soon increase significantly. This is related to the global trend of sustainable development and the dissipation of natural resources. It is also of ecological importance, related to the need to look for biodegradable materials that will not be a problem or an ecological threat, which is currently occurring due to the large amount of plastic-based materials being released into the environment (Alnehia et al., 2022)

2.9 Oxidized Natural Biopolymer for Enhanced Surface, Physical and Mechanical Properties of Glass Ionomer Luting Cement

On laboratory investigation aimed to synthesize and characterize micron-sized Gum Arabic (GA) powder and incorporate it in commercially available formulation for enhanced physical and mechanical properties of GIC composite(Khan et al., 2023). Oxidation of GA was performed and GA-reinforced GIC in 0.5, 1.0, 2.0, 4.0 & 8.0 wt. % formulations were prepared in disc-shaped using two commercially available GIC luting materials. While the control groups of both materials were prepared as such. The effect of reinforcement was evaluated in terms of Nano hardness, elastic modulus, diametric tensile strength (DTS), compressive strength (CS), water solubility, and sorption.

Two-way ANOVA and post hoc tests were used to analyze data for statistical significance (p0.05)Kumar and Sangi (2014). FTIR spectrum confirmed the formation of acid groups in the backbone of the polysaccharide chain of GA while XRD peaks confirmed the crystallinity of oxidized GA. The experimental group with 0.5 wt. % GA in GIC enhanced the Nano hardness while 0.5 wt.% and 1.0 wt.% GA in GIC increased the elastic modulus compared to the control. The CS of 0.5 wt. % GA in GIC and DTS of 0.5 wt. % and 1.0 wt. % GA in GIC demonstrated elevation. In contrast, the water solubility and sorption of all the experimental groups increased compared to the control groups. The incorporation of lower weight ratios of oxidized GA powder in GIC formulation helps enhance the mechanical properties with a slight increase in water solubility and sorption parameters.

The addition of micron-sized oxidized GA in GIC formulation is promising and needs further research for improved performance of GIC luting composition. Starch acts as a natural polymer that has been obtained from Wheat, Tapioca, and Corn. Corn starch has been investigated as a biopolymer and has been added to concrete in different percentages (0%, 0.5%, 1%, and 1.5%) by cement weight and the study shows the effect of using starch on some properties of concrete in the fresh state (slum and fresh density) and at hardened state (compressive strength, splitting tensile strength and flexural strength) at 28 days. The mix proportion was(1:2.3:2.3) (cement: sand: gravel) respectively and at constant w/c equal to 0.47. The results indicate that the optimum percentage of starch addition was 0.5%, so it showed an increase by 50% in compressive strength and splitting tensile strength; while the increases in flexural strength were 26%. Slump showed a 25% increase and fresh density showed a 2.5% increase at 0.5% addition of starch. (Abbas and Mohsen, 2020)

Biopolymers, such as water hyacinth fiber, banana fiber, and eggshell powder, can improve the thermal insulation properties of concrete. Adding these biopolymers to concrete can increase its physical-mechanical-thermal properties, including compressive strength, water absorption, and tensile strength For example, adding 0.05 wt.% eggshell powder into concrete can significantly increase its compressive strength and reduce water absorption, making it a good insulation material Additionally, composites based on modified plant raw materials and oregano polymer binders, such as polyurethane, can provide heat-insulating properties to the material. These composites have appropriate coefficients of thermal conductivity and density, with lower thermal conductivity compared to other binders Therefore, the use of biopolymers in concrete can enhance its thermal insulation capacity, making it suitable for applications in the construction sector(Krishnasamy et al., 2021)

Natural bio-based polymers are inherently found in various proteins (such as collagen) and nucleic acids. The latest breakthrough expected in the plastics industry is to make plastics more biodegradable while maintaining strength and durability that compete with ordinary plastics Xanthan gum is a hetero-polysaccharide formed by the strains of Xanthomas spp. It is a naturally found polysaccharide molecule of high molecular weight mainly formed by various fermentation processes. Its extraordinary rheological properties make it a very useful stabilizing agent for water-based systems. It has enormous applications ranging from the food industry to oil drilling(Joseph et al., 2023). It is typically used in the food industry in salad coverings, sauces, milk products, gravies, sweets, and low-calorie foods in general. Xanthan gum is also used in making cleansers, varnishes, polishes, and in agricultural flow tables. This chapter describes the extraction procedure of xanthan gum from microbes, factors affecting production, and application in different sectors.

Admixtures are majorly classified into minerals and chemicals. Mineral admixtures are also known as Secondary Cementitious Materials (SCMs). SCMs include fly ash, limestone, shale, calcined clay, pozzolana, and many others. These are often added in large amounts to the concrete to improve the workability conditions of fresh concrete; improve its resistance to sulfates attack, alkali-aggregate expansion, and thermal cracking; and reduce the cement content in the mixture(Gupta and Chaudhary, 2022). Chemical admixtures are often applied in very small amounts to improve the quality of concrete during transportation, mixing, curing, or placement. More specifically, they are tasked with air-entraining, plasticizing concrete mixtures, reducing water requirements, and in control of the setting time. Some special admixtures are designed to control shrinkage and inhibit alkali-silica reaction or corrosion. According to ASTM C494 and AASHTO M194, chemical admixtures fall into 8 types according to their physical and general requirement; water-reducing (Type A), retarding (Type B), accelerating (Type C), water-reducing and retarding (Type D), water reducing and accelerating (Type E), water reducing, high range (Type F), water reducing, high range, and retarding admixture (Type G), and specific performance admixtures (Type S)(Plank et al., 2015).

Carbon molecular sieve (CMS) membranes are generally prepared by the pyrolysis or carbonization of appropriate polymer precursor membranes under a vacuum or inert atmosphere. The chemical composition of CMS membrane usually contains ¿80% carbon elements and a small amount of other elements, such as H, O, N, etc. (Salleh et al., 2011). Due to their inorganic nature and high rigidity, CMS membranes possess excellent thermal and chemical stability. Acacia gum is a natural agricultural resource from the gum belt region of Africa, i.e., countries geographically ranging from east to west: from Sudan, Somalia, Eritrea, and Ethiopia to Chad, Central African Republic, Mali, Niger, and farther west up to Nigeria, Senegal, and even Mauritania (Mohammed, 2011). Economically speaking, acacia gum mainly comes from Sudan, Chad, and Nigeria(Kim et al., 2021). In Sudan, the most important non-wood forest products are gum Arabic, which exudates from Acacia Senegal and is locally known as hash, or hard gum, and Acacia seyal, which is known as lathe, or friable gum. Both species spread naturally in the central belt of the low-rainfall savannah, where they exist in pure or mixed stands, in the clay plains in the East, and in the sandy soils in the West (Mäki-Petäjä et al., 2012).

2.10 Acacia Seyal distribution

In general, there are two main varieties of A. seyal: variety seyal and variety fistula. Variety seyal is found in both western and eastern Africa and also on the Arabian Peninsula, while variety fistula is found in the eastern parts of Africa; this indicates that variety seyal is native to northern tropical Africa and Egypt the distribution of A. seyal varieties concerning rainfall. However, seyal trees are naturally grown in Sudan as long as there has been no reforestation done by humans (Saidur et al., 2011).

Harvesting of Ethiopian natural gum is done manually by labor-intensive traditional methods of tapping. Tapping and collecting of frankincense and Arabic gum are carried out around mid-September up to June during the offset of the dry season. Tapping is done by shaving of very thin, 2 mm deep and 4-8 mm wide, external circular layer of the bark starting at 0.5 from the base of the stem using hand tools. Once the first tapping is done, the second will take place after 30-40 days. The tapping process usually continues for up to 4 months. Ethiopia natural gum is purified and packed in new bags made of cotton cloth ready for export. Natural gum is exported overseas by air. Local traders use bags made from synthetic materials for packing to be sold in the local market.

Aggregate

Aggregates can be of many types based on the different parameters. These parameters can be shape, size, strength, etc. Based on the size of the aggregates, they can broadly be classified as fine aggregate and coarse aggregate.

Fine aggregate: This is the aggregate for which its size ranges between 4.75 mm to 0.075 mm. These are also called sand. These are the natural particles that the mining process can generate. It consists of the particles of the crushed stone or the sandy material.

Coarse aggregate: These aggregates have a size of more than 4.75 mm. These aggregates are used in the construction of concrete structures. Such aggregates

Figure 2.1: Acacia tree

include river gravel and stone particles made from rock stratum.

Advantages of Aggregate in Concrete structures:

Aggregate in civil engineering is hard structures made from the disintegration of rocks. It can be used in the designing of concrete structures and other structures. It is a durable and high-strength material. It has many advantages in the construction of concrete structures. Here are some advantages based on various aggregate properties in concrete structures.

• Aggregates provide more strength to the concrete.

• The use of aggregates in concrete structures increases the compactness of the structures.

• The use of aggregate reduces the quantity of cement in the concrete mix.

• It also reduces the water requirement in the concrete mix.

• It reduces the shrinkage of concrete in the dry mix.

• It reduces the voids in the concrete.

Cement:

Cement serves as a crucial binding agent in construction, playing a fundamental role in solidifying, reinforcing, and adhering to various materials to merge them into a cohesive structure. It is typically integral to the construction process as it is used not in isolation but to bind fine aggregate (such as sand) and coarse aggregate (like gravel) together. When combined with fine aggregate, cement creates mortar used in masonry work, while its mixture with both fine and coarse aggregate forms concrete(Martínez et al., 2016). Concrete stands out as one of the most widely employed construction materials worldwide, second only to water in terms of usage. Construction cements are predominantly inorganic, commonly derived from lime or calcium silicate, and are classified as non-hydraulic or hydraulic based on their ability to set in the presence of water.

Water

Water is an integral part of construction. If the water quality is not maintained, the building gets damaged easily and it can be easily visible. Water is important in every step of construction. Cement concrete is the backbone of construction. Water plays a major role in cement concrete production. Water governs the hydration of cement, strength, workability, and overall durability of concrete. The durability of concrete is one of the important properties of sustainable concrete. Curing has a major role in developing microstructure. Water used in construction and curing should be free from salts and solid particles. Potable tap water is generally used in making concrete(Niemczynowicz, 1999). Water is used in many activities in the construction process. The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acids, oils, salt, sugar, organic materials, vegetable growth, and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6. It has been observed that certain common impurities in water affect the quality of mortar or concrete. Many times despite using best material i.e. cement, coarse sand, coarse aggregate, etc. in cement concrete, the required results are not achieved. Most Engineers/Contractors think that there is something wrong with cement, but they do not consider the quality of water being used.

Construction product manufacturers use water in a wide variety of ways throughout their manufacturing processes. Water can serve as a lubricant, a cleaning agent, a sealant, a heat transfer medium, a solvent, an air pollution control medium, and an array of other uses depending on the materials and products being produced. Different uses of water for construction industry purposes may also have different requirements for water quality (purity, dissolved materials content) and quantity(Groover, 2010).

2.11 Admixtures

Admixtures are those ingredients in concrete other than Portland cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures can be classified by function as follows:

Air-entraining admixtures: are used to purposely introduce and stabilize microscopic air bubbles in concrete. Air entrainment will dramatically improve the durability of concrete exposed to cycles of freezing and thawing. Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers. Air-entrained concrete contains minute air bubbles that are distributed uniformly throughout the cement paste. Entrained air can be produced in concrete by use of an air-entraining cement, by introduction of an air entraining admixture, or by a combination of both methods. An air-entraining cement is a Portland cement within air-entraining addition inter ground with the clinker during manufacture. An air-entraining admixture, on the other hand, is added directly to the concrete materials either before or during mixing(Manyara, 2019).

Water-reducing admixtures: are used to reduce the quantity of mixing water required to produce concrete of a certain slump, reducethe water-cement ratio, reduce cement content, or increase slump. Typical water reducers reduce the water content by approximately 5% to 10%. Adding a water-reducing admixture to concrete without reducing the water content can produce a mixture with a higher slump. The rate of slump loss, however, is not reduced and in most cases is increased. Rapid slump loss results in reduced workability and less time to place concrete. An increase in strength is generally obtained with water-reducing admixtures as the water-cement ratio is reduced. For concretes of equal cement content, air content, and slump, the 28-day strength of water-reduced concrete containing a water reducer can be 10% to 25% greater than concrete without the admixture. One example of water–reducing admixture is Lignosulfonate-based admixtures are the largest admixtures used, by volume, in the construction industry, typically used in dosages of 0.1–0.3% by weight of cement in concrete.

Plasticizers: often called superplasticizers are essentially high- range water reducers meeting ASTM C 1017; these admixtures are added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction while remaining essentially free of excessive bleeding or segregation.

Accelerating admixtures also known as accelerators, are substances used in concrete mixtures to decrease the setting time of concrete and speed up the early strength development. They are particularly useful in cold weather conditions or projects that require rapid setting, such as repairs on highways or bridges. There are different types of accelerating admixtures available in the market, but the most common ones include calcium chloride, calcium format, and triethanolamine. These admixtures work by increasing the rate of hydration of cement, which leads to faster setting and early strength gain. When using accelerating admixtures, it's important to follow the manufacturer's instructions regarding the dosage and application. Excessive use of accelerators can lead to rapid setting, which may result in reduced workability and potential cracking. It's also essential to test the admixture with the specific materials and conditions of your project to ensure compatibility and desired results(Dorn et al., 2022).

Retarding admixtures: are used to delay the rate of setting of concrete. High temperatures of fresh concrete (30°C [86°F]) are often the cause of an increased rate of hardening that makes placing and finishing difficult. One of the most practical methods of counteracting this effect is to reduce the temperature of the concrete by cooling the mixing water and/or the aggregates. Retarders do not decrease the initial temperature of concrete. The bleeding rate and bleeding capacity of concrete are increased with retarders. Retarding admixtures are useful in extending the setting time of concrete, but they are often also used in attempts to decrease slump loss and extend workability, especially prior to placement at elevated temperatures(Alsadey, 2013).

Hydration-control admixtures:Hydration-controllingg admixtures became available in the late 1980s. They consist of a two-part chemical system: (1) a stabilizer or retarder that essentially stops the hydration of cementing materials, and (2) an activator that reestablishes normal hydration and setting when added to the stabilized concrete. The stabilizer can suspend hydration for 72 hours and the activator is added to the mixture just before the concrete is used. These admixtures make it possible to reuse concrete returned in a ready-mix truck by suspending the setting overnight. The admixture is also useful in maintaining concrete in a stabilized non-hardened state during long hauls. The concrete is reactivated when it arrives at the project(Jakob et al., 2023).

Corrosion inhibitors: are used in concrete for parking structures, marine structures, and bridges where chloride salts are present. The chlorides can cause corrosion of steel reinforcement in concret.Ferrous oxide and ferric oxide form on the surface of reinforcing steel in concrete. Ferrous oxide, though stable in concrete's alkaline environment, reacts with chlorides to form complexes that move away from the steel to form rust. The chloride ions continue to attack the steel until the passivating oxide layer is destroyed. Corrosion-inhibiting admixtures chemically arrest the corrosion reaction. Commercially available corrosion inhibitors include calcium nitrite, sodium nitrite, dimethyl ethanolamine, amines, phosphates, and ester amines. Anodic inhibitors, such as nitrites, block the corrosion reaction of the chloride-ions by chemically reinforcing and stabilizing the passive protective film on the steel; this ferric oxide film is created by the high pH environment in concrete(Kadhim et al., 2021).

Shrinkage reducers: introduced in the 1980s, have potential uses in bridge decks, critical floor slabs, and buildings where cracks and curling must be minimized for durability or aesthetic reasons. Propylene glycol and polyoxyethylene alkyl ether have been used as shrink Unmodified carbon black substantially reduces air content(Contescu and Burchell, 2005). Most carbon black for coloring concrete contains an admixture to offset this effect onthe air. Before a coloring admixture is used on a project, it should be tested for colorfastness in sunlight and autoclaving, chemical stability in cement, and effects on concrete properties. Calcium chloride should not be used with pigments to avoid color distortions. Pigments should conform to ASTM C 979.

Alkali-silica reactivity inhibitors: Chemical admixtures to control alkali-silica reactivity (alkali-aggregate expansion) were introduced in the 1990s.Lithium nitrate, lithium carbonate, lithium hydroxide, lithium aluminum silicate (decrepitated spodumene), and barium salts have shown reductions in alkali-silica reaction (ASR) in laboratory tests (Thomas and Stokes 1999 and AASHTO 2001). Some of these materials have potential for use as an additive to cement (Giada 1996). There is little long-term field experience available on the effectiveness of these materials(Kon et al., 2012).

Coloring admixtures: Natural and synthetic materials are used to color concrete for aesthetic and safety reasons.Red concrete is used around buried electrical or gas lines as a warning to anyone neartheses facilities**?**shah2014chemical. Yellow concrete safety curbs are used in paving applications. Generally, the amount of pigments used in concrete should not exceed 10% by weight of the cement. Pigments used in amounts less than 6% generally do not affect concrete properties.

Biopolymers, which are renewable, sustainable, and biodegradable, show significant promise as admixtures in mortar and concrete mixes. Studies indicate that incorporating chitosan, xanthan gum, and guar gum as admixtures enhances the properties of mortars designed to encapsulate heavy metals(Ding, 2008).

Chitosan helps counteract the negative effects of heavy metal encapsulation on properties like workability, setting time, and compressive strength. The interaction between xanthan gum, guar gum (combined with boric acid), and the mortar matrix system increases compressive strength by up to 30% while reducing heavy metal leaching to minimal levels. Lignosulphonate, acting as a plasticizer, enhances the workability of fresh mortar, whereas the inclusion of cellulose ethers improves water retention in fresh mortar significantly. In conclusion, the use of biopolymers undeniably enhances the physical properties and reduces the leaching characteristics of mortar and concrete.(Abdel-Maksoud et al., 2023)

2.12 Research gaps:

Identifying research gaps is crucial for guiding future studies and contributing to advancing knowledge in a specific field. When considering the investigation of the potential of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete performance, here are some potential research gaps that could be explored, Lack of Comprehensive Studies, Long-Term Durability Studies, Optimal Dosage and Mix Design, Environmental Impact Assessment, Compatibility with Other Materials, Practical Applications and Field Studies, Standardization and Guidelines. By addressing these research gaps, future studies can enhance the understanding of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete performance and contribute valuable insights to sustainable construction practices and materials development.

Exploring the literature concerning the use of different gums as natural bio-polymers in concrete unveils several notable research gaps: Limited long-term studies hinder a thorough understanding of the durability and performance of gum-enhanced concrete over extended periods. The absence of standardized testing procedures presents challenges in comparing results across studies, potentially undermining the consistency and credibility of research outcomes. The underlying mechanisms dictating the interplay between gums and cementitious materials, as well as their influence on concrete properties, are still inadequately elucidated.

3

MATERIALS AND METHODS

3.1 Introduction

The literature review in Chapter 2 explores different research studies and identifies gaps in investigating the potential of Ethiopian gum (xanthan gum) as a natural bio-polymer for enhancing concrete performance. Chapter 1 establishes the research objectives for the study based on these identified research gaps. This chapter details the research methodology employed to achieve the study's goals and provides an overview of the materials and methods utilized, the research design, materials utilized, test parameters, specimen preparation, and the experimental work conducted to fulfill the research objectives.

As a preliminary to the investigation of the laboratory on material engineering concrete properties, the behavior of the cement, aggregate, sand, and water as it is used in the study is carried out first. All these properties were evaluated using six data points per measured quantity with Ethiopian gum powder. The stability of concrete is an important aspect of construction, structural integrity, and durability. As a result, there is an interest in exploring natural bio-polymers as alternative admixtures or additive agents.

Ethiopian gum (xanthan gum) is a polysaccharide as a natural product that is extracted from the Acacia tree produced by the fermentation of primarily Lacto-bacillus plant arum campsites bacterium. It possesses unique rheological proper-ties, such as high viscosity and thin behavior, for modifying the flow ability and durability of concrete. Additionally, I hope Ethiopian gum is biodegradable and non-toxic, aligning with the principles of sustainable construction. This research aims to investigate the potential of Ethiopian gum as a natural biopolymer in concrete. The study will focus on evaluating its impact on the rheological behavior, hydration, mechanical properties, and long-term performance of concrete. The chapter emphasizes the research methodology, materials utilized, experimental procedures, and the analytical approach that will guide the investigation.

3.2 Material

Samples of Ethiopian gum from acacia trees in Ethiopia to guarantee variations in purity and quality. These samples are expected to conform to established ACI standards and specifications governing the behavior of natural biopolymer gums in construction applications.

All preparation of materials depends on the ACI Education Bulletin, ASTM C78, and (AASHTO M 194). Or ASTM C 494, and (EBS).

Materials which are used in this research are:

- Aggregates: utilized in this study consist of crushed particles with a maximum size of 25 mm. A sieve analysis was conducted to tailor the aggregates according to Ethiopian standards, guarantee the specific type of aggregate required, and verify that it adheres to the experiment's specified criteria.

- Cement: Portland-Pozzolana Cement (PPC) or CEM 32.5R is the one that is commonly used in Ethiopia for concrete production, therefor PPC is a suitable type of cement. PPC, which uses natural and industrial waste, helps reduce environmental contamination, making it an eco-friendly option that aligns. Its high resistance to sulfate attacks makes it a top choice for projects such as dams, foundations, and marine structures. Despite initially lower strength than OPC, PPC's gradual strength development through proper curing proves advantageous. Furthermore, its cost-effectiveness and superior toughness compared to OPC make it an ideal material for masonry, plastering, and mass concreting applications.

- Water: water free from impurities in laboratory rooms.

- Sand: Choose sand for an experimental investigation that complies with the necessary standards and meets the requirements for research papers.

- Ethiopian gums (xanthan gm): from acacia tree.

Apparatus

Equipment used in research includes a mixer, a 15cm*15cm*15cm cubical mold for beam testing, a 10cm*10cm*50cm cubical mold for beam testing, a vibration apparatus, a spatula, a slump tests apparatus, a compressive strength testing machine, a flexural strength testing machine, Fourier transform infrared spectroscopy (FTIR) machines, and diffracted X-rays (XRD) machines.

To mix the proportions of standard aggregate, cement, water, sand, and Ethiopian gum based on the application and performance requirements of the concrete. We decided on the dosage of Ethiopian gum to mix with water. Indicated the specific objectives of our research paper. And to determine and combine the aggregate, cement, water, sand, and Ethiopian gum (xanthan gum) to determine the compaction strength, flexural strength, and water absorption proportions.

3.3 Research Approach and Design

This particular research is structured as an experimental study. The objective of these experimental designs was to ascertain the optimal dosage of Ethiopian gum as an admixture for cement in C-25 grade concrete while assessing the impact of these admixtures on concrete workability, compressive strength, flexural strength, and water retention. To analyze the influence of these admixtures on concrete behavior, the following factors were designated as fixed and variable parameters in the study. Cement types, dosage of Ethiopian gum admixture, and water content were identified as variable parameters. Conversely, the sizes of fine and coarse aggregates were set as fixed parameters, alongside the specified quantity of cement.

Proportioning concrete involves carefully selecting appropriate components and establishing their respective ratios to create concrete that meets specific criteria for workability, strength, and durability on concrete production.

ACI 301-99, 1999 concrete mix design procedure was used to C-25 Concrete Mix Design that can achieve the desired workability and provides an average adequate compressive strength. According to ACI, average compressive strength must equal or exceed the required average compressive strength the required average compressive strength f_{cr} was calculated for the specified class of concrete by one of the following:

$f_{c_r} = f_{ck}$ + 7 MPa when the specified compressive strength is less than 21 Mpa.
f_{c_r} = f_{ck} + 8.5MPa when specified compressive strength is between 21 to 35Mpa.

f_{c_r} = $1.1 f_{c_k}$ + 5 MPa when specified compressive strength is greater than 35 Mpa

So, the Target mean strength for C-25 grade concrete is calculated by using f_{c_r} = f_{c-k} + 8.5MPa Therefore 33.5N/mm2.

materiale	Volume(lit)
water	173.53kg/m3
cement	358kg/m3
Coarse aggregate=1029.5+51.4752	1080.975kg/m3
Fine aggregate=813.5-56.945	756.55kg/m3

Ingredient	Coarse aggregate	Fine aggregate	cement
Quantities/m3	1080.975/358	756.55/358	358/358
Ratio	3	2	1

3.4 Research Methods frame work

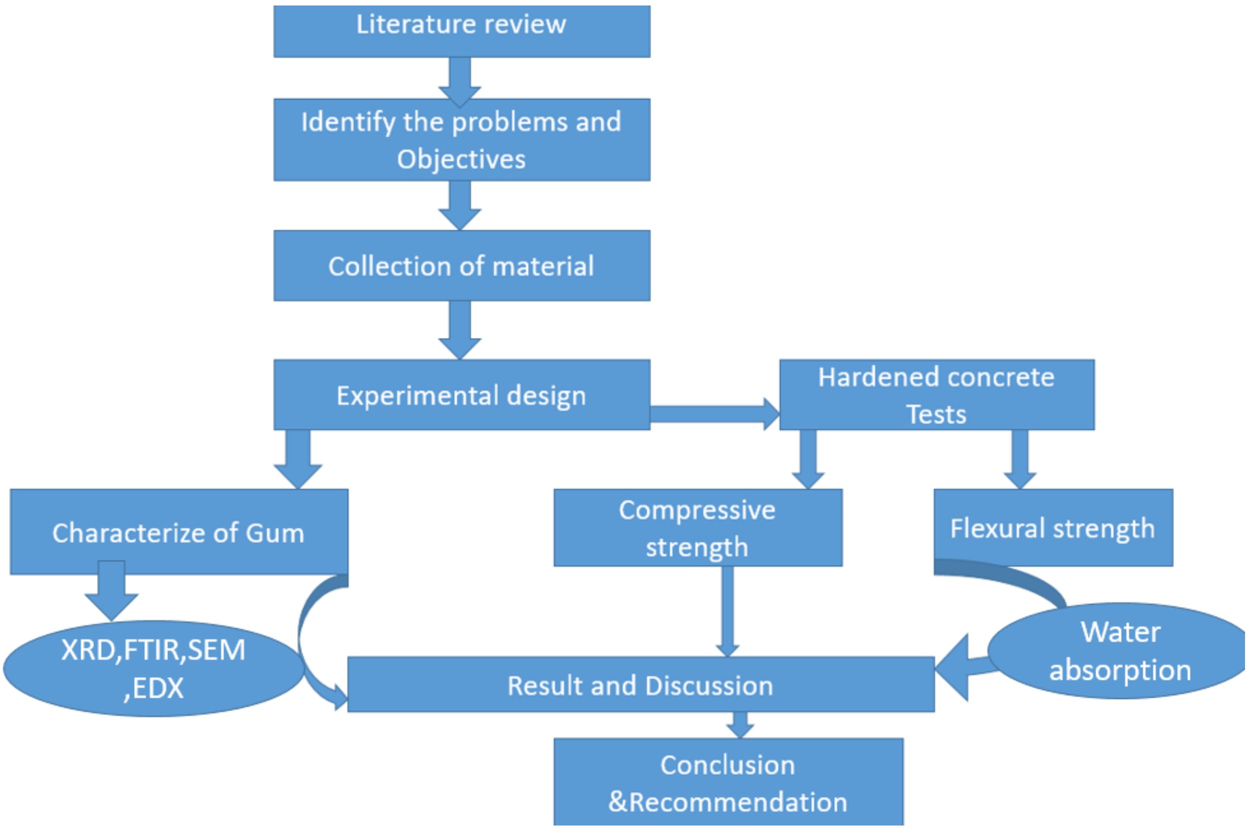


Figure 3.1: Work Methodology Flow Chart

3.4.1 Experimental Design:

Following the engineering definition of experimental design, a fitting approach was selected to address engineering problem-solving, employing principles and methods to facilitate the comparison of the impacts of varying concentrations of Ethiopian gum on concrete properties. In line with the characteristics of natural biopolymers, an Ethiopian gum powder solution will be created in deionized water with concentrations ranging from 0.1% (1000 mg/L) to 0.5% (5000 mg/L) utilizing Ethiopian gum (xanthan gum) powder.

3.4.2 Sample Preparation:

The collected samples underwent a series of tests to evaluate their engineering properties and to analyze the dispersion of the concrete mix. Initially, assessments were carried out on the concrete samples, after which Ethiopian gum, a natural biopolymer, was introduced at concentrations ranging from 0.1% (1000 mg/L) to 0.5% (5000 mg/L)from(Sulaiman et al., 2022) by dry weight of Ethiopian gum powder to the water. The samples were meticulously mixed and exposed to different curing periods, including 7 and 28 days in a moist environment for 24 hours. Following this, a specific number of specimens, comprising 6 experimental and 1 control for each, were removed from molds, designated, and submerged in clean, fresh water just before the testing procedures commenced.

The concrete mix proportions, which encompass Ethiopian gum (xanthan gum), aggregates, and the water-to-cement ratio, are established by industry standards. Ethiopian gum (xanthan gum) can be integrated into distinct concrete mixtures at different concentrations.

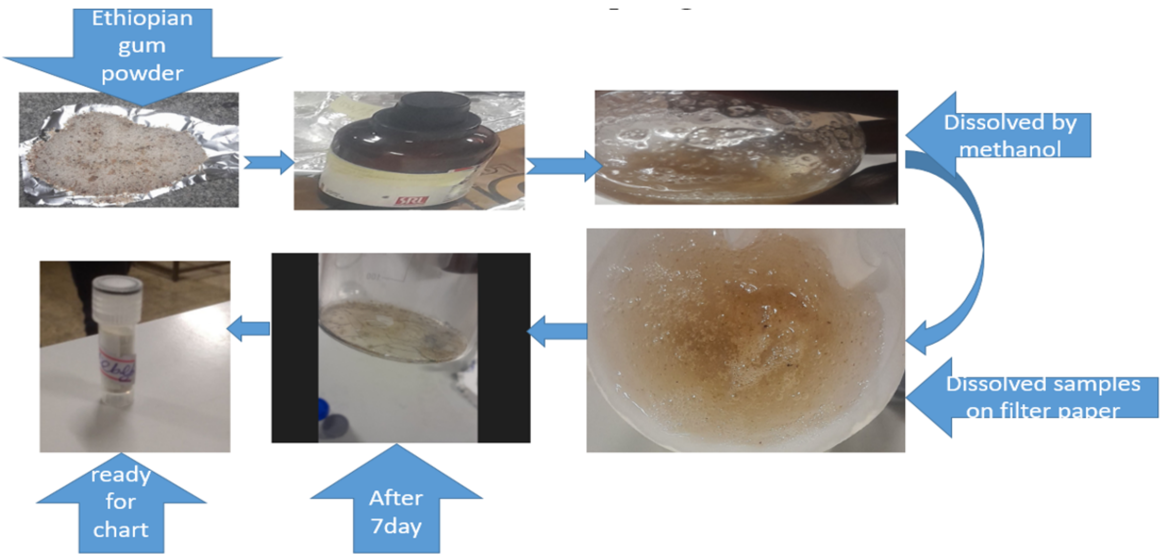


Figure 3.2: Sample Preparation

3.4.3 Testing and Measurements:

The workability of the concrete was evaluated using a slump test following ASTM C 143 standards for Portland pozzolana cement (PPC) on fresh concrete specimens containing Ethiopian gum at concentrations of 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%(Sulaiman et al., 2022). The slump test involved utilizing a cone with specific dimensions (height of 300 mm, bottom diameter of 200 mm, top diameter of 100 mm). Initially, the cone was filled with freshly mixed concrete, and a tamping rod was inserted vertically, conducting 25 raises and lowers for each of the three layers. After removing any excess concrete from the top of the cone, the cone was gently lifted from the concrete sample. The difference in height between the original cone and the compacted concrete was measured, with consistent 5 cm slump values observed across all tested concrete mixtures.

Figure 3.3: slump test

3.4.4 Curing of the Concrete cube samples

Proper curing allows the concrete to achieve its intended strength. Curing helps the concrete to fully hydrate and form strong bonds between the cement particles, resulting in a more durable and resilient structure.The concrete cubes underwent curing by being immersed in water within a curing tank for 7 and 28 days at a consistent temperature of 26c0 to facilitate the curing process until the specified testing age was attained.

a) 

b) 

Figure 3.4: Curing cube and flexural beam

3.4.5 Hardened Concrete Tests

The compressive strength of concrete samples was assessed using standard testing methodologies like ASTMC39 to investigate the influence of Ethiopian gum (xanthan gum) on strength enhancement. After this, a compressive strength examination was conducted to identify the optimal dosage of a water-reducing agent that delivers the highest early strength across different cement brands. For C-25 grade concrete, Ethiopian gum was blended at varying proportions of 0.1% (1000mg/l), 0.2% (2000mg/l), 0.3% (3000mg/l), 0.4% (4000mg/l), and 0.5% (5000mg/l) from (Sulaiman et al., 2022)when combined with water before mixing with cement. Concrete samples were meticulously prepared for evaluation at 7 days and 28 days to gauge the early potential compressive strength. Cubic specimens measuring 15cm * 15cm * 15cm were crafted following the guidelines outlined in AASHTO M 194 standards for producing and curing concrete test specimens within the laboratory setting.

After preparation, the specimens were labeled for identification purposes and stored in a controlled laboratory environment for a day as per AASHTO M 194 or ASTM C 494, ASTM C 136 standards concerning the compressive strength examination of cubic concrete specimens. Subsequently, compressive strength tests were executed on the concrete samples featuring Ethiopian gum at both the 7-day and 28-day marks. On the testing days, a compression apparatus was utilized to apply compressive stress at a rate of 0.1Mpa/sec until specimen failure, with the maximum load attained during the test duly recorded. The compressive strength formula for any material involves calculating the load applied at the point of failure against the cross-sectional area of the subjected face.

Compressive strength: concrete samples are tested for compressive strength using standard methods, such as ASTMC39, to assess the enhancement provided by Ethiopian gum (xanthan gum).

The compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which the load was applied.

Compressive Strength = Load / Cross-sectional Area

Figure 3.5: compressive strength

The failure type is satisfactory concrete failures [Abebe Dineku]

Figure 3.6: concrete failures

Flexural strength: like ASTMC78, measure the ability of Ethiopian gum (xanthan gum)–inforced concrete to resist bending forces for both beam and columns. The flexural strength test was conducted following the ASTMC78 standard procedure. To initiate the test, a concrete specimen was prepared as a beam with standard dimensions of 10cm*10cm*50cm according to the metric system for beam testing. The specimen was positioned on two supporting rollers, and a load was applied at the midpoint of the beam. This load was incrementally increased until the specimen either deformed or reached a predetermined limit of bending. The applied load on the specimen was continuously monitored throughout the test until the concrete beam cracked or broke. Once the beam reached its limit and cracked, the testing machine was stopped, and the maximum load applied to the specimen was recorded. The flexural strength of the specimen was then computed using the designated formula provided in the ASTMC78 standard. The formula for calculating the flexural strength of concrete following the ASTM C78 standard test method is as follows.

Flexural Strength = PL/BD2(Mandal et al., 2016)

Where:

Flexural Strength =is the measured maximum bending stress at failure MPa.

P =is the maximum applied load during the flexural test Newton.

L= is the span length between the supports mm.

B= is the width of the test specimen mm.

D= is the depth of the test specimen mm.

Figure 3.7: Flexural Strength Test

3.4.6 Water Absorption Test:

To assess water absorption, a crucial factor in determining concrete's permeability and potential durability concerns, concrete samples are weighed both before and after undergoing water immersion. The variance in weight provides valuable information. The standardized test method ASTM C1585/C1585M involves measuring the weight of the concrete before and after immersion to quantify water absorption during the testing period, aiding in the evaluation of concrete's permeability and durability. This process includes submerging the specimen in water and monitoring its weight periodically until a consistent mass is achieved. To assess the compatibility of Ethiopian gum (xanthan gum) with other admixtures or additives, various common methods can be employed. Solubility techniques are often utilized to evaluate the compatibility of different components in the concrete mixture. To assess compatibility, the solubility of Ethiopian gum (Xanthan gum) and other admixtures in the selected solvent or medium should be examined. This involves observing whether both substances dissolve thoroughly or encounter any problems like aggregation or incomplete dispersion. Uniform dispersion of both substances signals their compatibility.

The formula calculates the percentage of water absorbed:

%Absorption=(final weight-initial weight)/(initial weight) 100

Water absorption
4000mg/l (for compressive strength)

mass(kg)	Before immersed	After immersed	difference	%water absorption
M1	7.72	7.56	0.14	1.81
M2	7.51	7.59	0.08	1.07
M3	7.49	7.54	0.05	0.67

Water absorption
4000mg/l (for flexural strength)

mass(kg)	Before immersed	After immersed	difference	%water absorption
M1	11.45	11.89	0.44	3.84
M2	11.75	12.21	0.47	3.96
M3	11.81	12.31	0.50	4.23

3.4.7 Rheological Analysis:

Rheological measurements are conducted to analyze the behavior of Ethiopian gum, specifically Xanthan gum, and other admixtures individually. Parameters such as viscosity, shear thinning, and viscoelastic properties are carefully evaluated.

Any significant deviations from the anticipated behavior may indicate potential compatibility issues. Conducting comprehensive literature reviews is essential to ensure that the final product adheres to the necessary specifications. Following this, the evaluation process should extend to subjecting Ethiopian gum (Xanthan gum) and the other admixtures to various stress conditions, including temperature fluctuations, freeze-thaw cycles, and a range of diverse tests. Monitoring any changes in viscosity, stability, or physical characteristics under these conditions is crucial.

Figure 3.8: Ethiopian gum on filter paper

3.4.8 Microstructural Analysis:

Fourier transform infrared spectroscopy (FTIR) machines are widely used to analyze the chemical composition of Ethiopian gum (xanthan gum). They can provide information about the functional groups present in Ethiopian gum (xanthan gum). This technique can help identify specific bonds and molecular structures. By using FTIR, we can determine the chemical composition, groups of structural elements, and characteristics of Ethiopian gum (xanthan gum). By measuring the angles and intensities of the diffracted X-rays, can determine the spacing between planes of atoms in the crystal lattice, the types of atoms present, and the rheology properties of Ethiopian gum (xanthan gum).

Figure 3.9: ready for XRD, and FTIR

The above Chapter focuses on the methodology and material focusing on carrying out experimental research. The methods used were developed with the intent of ensuring the validity and reliability of the study results. A comprehensive explanation of the research materials is provided in this chapter's preface. These included a variety of equipment and materials needed for my research collecting and analyzing data. Along with those steps taken to assure data accuracy and quality, the sources of the data were briefly described. The results will be thoroughly presented and discussed in the next chapter 4.

4

RESULTS AND DISCUSSION

4.1 Introduction

Ethiopian gum (xanthan gum) can effectively act as a water reducer in concrete. It contains polysaccharides and other compounds that interact with water molecules, reducing the water demand of the concrete mix. Additionally, Ethiopian gum has been found to have plasticizing effects, improving the workability and flow characteristics of the concrete.

4.2 To Characterization and Evaluation of Ethiopian gum (xanthan gum) for its rheological properties and compatibility with other admixtures.

We can identify the functional groups within a sample using FTIR analysis, allowing us to pinpoint specific chemical bonds and structural groups in Ethiopian gum (xanthan gum). The results of this analysis reveal the chemical and functional groups. At the same time, XRD's diffraction pattern suggests that despite the lack of an orderly arrangement of atoms or molecules in an amorphous structure, chemical nomenclature provides valuable insights. By measuring the angles and intensities of diffracted X-rays, we can typically determine the atomic plane spacing in crystal lattices; however, in amorphous samples, this information is not ascertainable as the types of atoms present cannot be determined. Consequently, the amorphous nature of the structure leads to an absence of consistent spacing between atomic planes, the result is in the below table and figure.

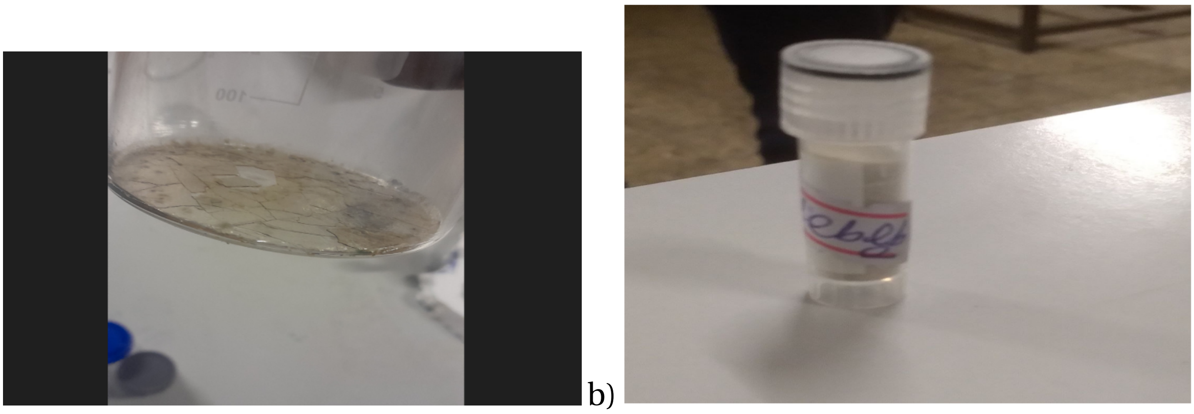


Figure 4.1: a, sample after 7 days and b, samples read for XRD, and FTIR

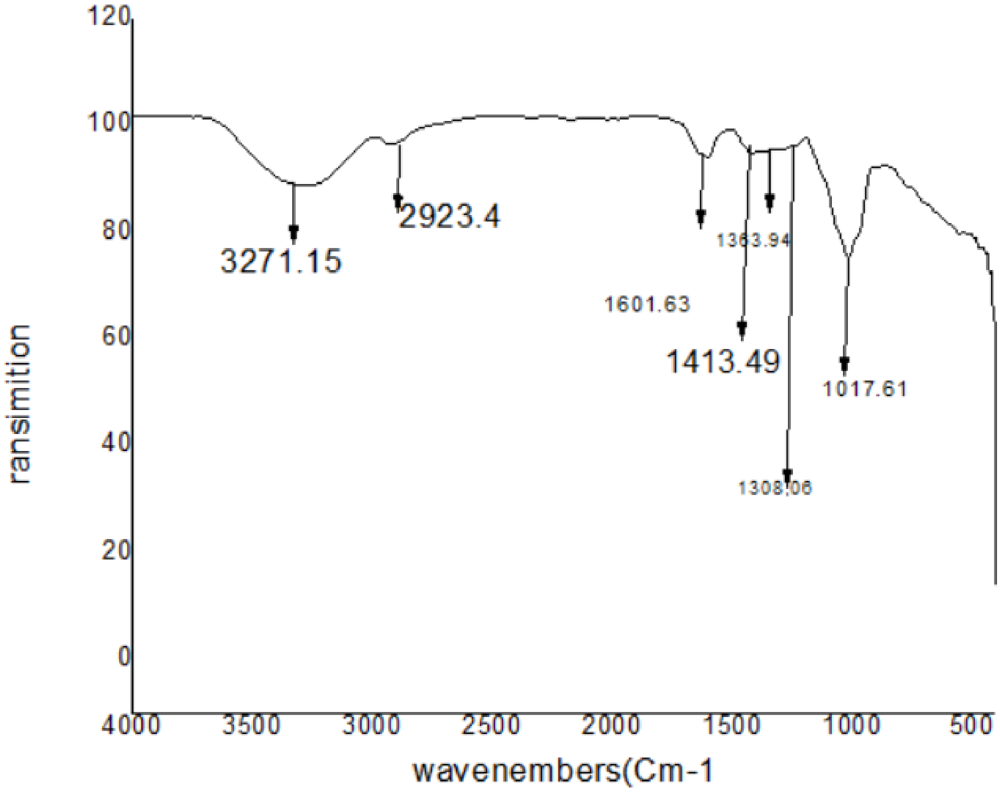


Figure 4.2: FTIR result

Frequency, cm^{-1}	samples	bond	Functional group
3500-3200 (s, w)	3271.15	O-H stretch H-bonded	Alcohols, phenols
3000-2850 (m)	2923.40	C-H stretch	alkanes
1600-1585 (m)	1601.63	C-C stretch (in -ring)	aromatic
1370-1350 (m)	1363.94	C-H rock	alkanes
1335-1250 (s)	1308.08	C-N stretch	Aromatic amines
1320-1000 (s)	1017.61	C-O stretch	Alcohols, carboxylic acid, ethers

Figure 4.3: From my graph result identifies the chemical bond and functional groups.

- Chemical Structure: Ethiopian gum (xanthan gum) is composed of repeating units of glucose, mannose, and glucuronic acid. These units are linked together to form a linear polysaccharide chain with literature reviews and laboratory results.
- Molecular Weight: Ethiopian gum (xanthan gum) has a high molecular weight, compared to water. The molecular weight affects its viscosity and solution behavior.
- Solubility: Ethiopian gum (xanthan gum) is soluble in cold or hot water, forming highly viscous solutions.

A set of characteristics of peaks appearing at 3271.15 cm–1, 2923.40 cm–1,1601.63 cm–1, and 1017.61 cm–1 are due to different functional groups present in the Ethiopian gum namely, O-H stretching vibration, C-H stretching vibrate with C-C stretch in ring in-plane bending vibration respectively. The stretching C-O vibrations at 1017.61 cm–1 and the stretching C-H rock at 1363.94cm–1 vibrations from C-N at 1308.08cm–1stretch vibration. were among the Ethiopian gum distinctive peaks group at 2923.4 cm–1, and O–H stretching vibrations are responsible for the peak at 3271.15cm–1. Similar results are observed Obtaining consistent, ”the bio-admixture incorporating cassava starch-Xanthan gum was utilized with cement mortar for building applications by Paramathmeka Selvakumar and Vidhya Kumarasamy ”

Energy-dispersive X-ray Spectroscopy (EDX) result

The EDX result helps in quality assessment by quantifying the elemental composition of the material. It provides valuable information for characterizing the material’s properties and performance.

Table 4.1: Energy-dispersive X-ray Spectroscopy

Code	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	Wgt
D-G-001	0.60	0.16	0.22	1.28	0.42	$<$0.01	0.50	0.02	$<$0.01	$<$0.01	2.5kg

The data you provided represents the elemental composition of a material, possibly concrete, in terms of various oxides (SiO2, Al2O3, Fe2O3, CaO, MgO, Na2O, K2O, MnO, P2O5, and TiO2).

Rheological Properties.

Ethiopian gum, also known as xanthan gum, showcases pseudo-plastic behavior characterized by its viscosity increasing as the shear rate decreases. This unique property is highly sought after in numerous applications as it facilitates effortless pouring and spreading. Additionally, Ethiopian gum displays shear-thinning behavior, enabling easy pumping and application. Once the shear force is removed, it regains its viscosity, ensuring stability and consistency in the concrete structure’s various processes.

Thickening Agent: Ethiopian gum, commonly referred to as xanthan gum, serves as a popular thickener renowned for its capability to enhance the viscosity of aqueous solutions. By creating a network structure that effectively entangles water molecules, it elevates the thickness and enhances the texture of concrete structures.

Stabilizer: Ethiopian gum plays a critical role as a stabilizer by delivering a consistent and homogeneous viscosity to suspensions. It prevents the separation of phases and settling of solid particles within liquid systems, thereby enhancing the stability of concrete performance is increases.

Enhanced Pump ability: Ethiopian gum, known as xanthan gum, exhibits shear-thinning behavior, allowing for improved pump ability and easier handling of viscous solutions. Ethiopian gum, also known as gum acacia or gum Arabic, generally exhibits good resistance to various weather conditions. It is known to be stable and resistant to degradation when exposed to moderate fluctuations in temperature, humidity, and sunlight. Ethiopian gum can withstand mild weather conditions such as normal sunlight, moderate temperature changes, and regular humidity levels without significant degradation or loss of properties. Therefore the rheological properties of Ethiopian gum (xanthan gum) are more comfortable for concrete structures.

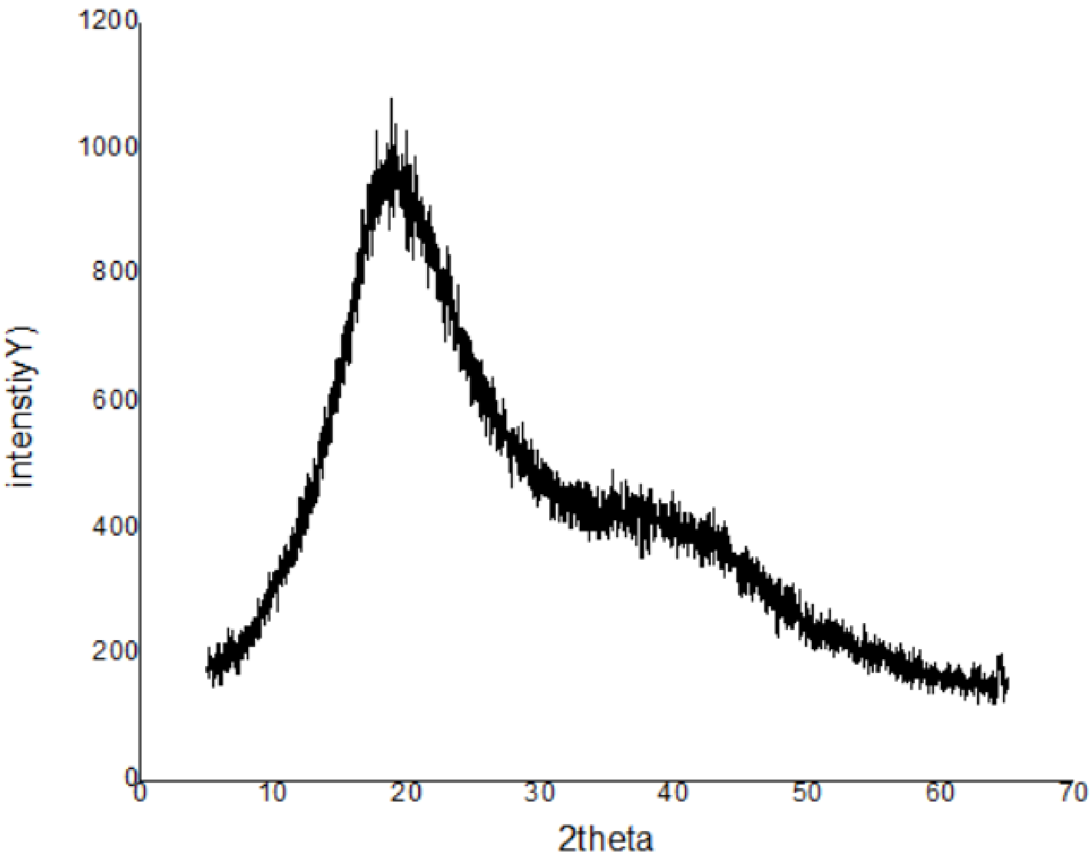


Figure 4.4: XRD graph.

XRD spectra of powdered gum revealed that the Acacia tree gum has an amorphousands crystalline nature. However, the area corresponding to crystalline peaks is tiny compared to the amorphous area and hence will not make much difference in the overall crystallinity.

XRD form of Ethiopian gum displayed a sharp peak at 18.76° with a strong diffraction signal, and three other peaks around the area 17.9°, 19.5°, and 20° appearing at amorphous regions representing natural biopolymers and typically it is not a C-type crystallinity and there is no crystallite in the samples.

$(C_3H_6)_n$: This notation suggests a repeating unit or monomer in a polymer. In this case, it indicates that the polymer consists of repeating units of C3H6 a which is the chemical formula for propylene. The ”n” represents the number of repeating units, which can vary and determine the size of the polymer chain.

Polypropylene (Pp): is a widely used thermoplastic polymer that is derived from the monomer propylene (C3H6). It is a versatile material with a wide range of applications due to its excellent combination of properties, including high chemical resistance, low density, good mechanical strength, and high melting point.

Therefore Polypropylene (PP) fibers are widely utilized for reinforcing concrete structures, aiming to enhance toughness, impact resistance, and crack control. Introducing PP fibers into concrete mixtures mitigates plastic shrinkage cracking, boosts durability, and elevates the overall performance of the concrete. The incorporation of PP can effectively manage thermal cracking from temperature variations, restrict crack development during the plastic stage, and improve post-cracking behavior. This reinforcement technique proves especially beneficial in scenarios necessitating increased toughness and crack resistance, such as in industrial floors, pavements, shotcrete applications, and precast elements. Integrating Polypropylene (PP) fibers into concrete structures is a feasible and advantageous approach to bolster their mechanical properties and longevity. The chemical composition of Ethiopian gum consists of glucose, mannose, and glucuronic acid, because of that chemical composition we attached the concrete structures.

Understanding Ethiopian gum interacts with cement is pivotal in assessing its influence on key properties such as workability, strength, and durability of the concrete. Exploring the interactions of Ethiopian gum with companion additives like superplasticizers, accelerators, retarders, or fibers can provide valuable insights into the synergies or possible conflicts that may arise among these components. This compatibility investigation holds significance in ensuring that admixtures collaborate efficiently to achieve the desired concrete characteristics without compromising overall quality or performance. The behavior of Ethiopian gum's internal polysaccharides and glycoproteins is likely aligned with water-reducing admixtures, potentially offering a suitable substitute for lignosulfonate.

4.2.1 Synthesis and Optic Analysis Ethiopian gum (xanthan gums)

By Using FTIR and XRD results more effective values on the functional groups' structure are more acceptable with laboratory results. FTIR can provide information about the functional groups present in Ethiopian gum by measuring the absorption of infrared radiation by the sample. This technique helps identify specific bonds and molecular structures, and X-ray diffraction patterns were carried out using equipment of the 2Θ operational range from $5^0 to 65^0$.

Ethiopian gum with cement, aggregate, sand, and water mixed will have better strength, workability, and durability compatibility with other admixtures. Ethiopian gum (xanthan gum) is the chemical group more on the result of laboratory and the functional group is an amine with high viscosity and bubbles increasing concentration essential for understanding the behavior and properties of solutions. It affects factors such as reaction rates, and solubility, and the amount is better than other water-reducing and retarded admixtures, Compatibility with lignosulfonates and my result will compete with"Boeriu et al. in 2004" "identified align with findings from previous studies on lignins, technical lignins, and lignosulfonates conducted by the FTIR spectra of all lignosulfonates samples exhibit a consistent pattern, characterized by a broad peak between 3600-3300 cm-1 attributable to hydroxyl groups present in phenolic and carboxylic acids. Additionally, various bands of different intensities are observed in the fingerprint region spanning from 1900 to 800 cm-1.

Notable features in this region include peaks at 1770 cm-1 (indicative of aromatic acetoxy groups), 1715 and 1630 cm-1 (representing unconjugated carbonyl-carboxyl stretching), 1600 to 1500 cm-1 (corresponding to C=C skeletal vibrations), 1470-1460 cm-1 (reflecting C-H deformation coupled with aromatic ring vibrations), 1260 cm-1 (representing C=O stretching), 1230-1215 cm-1 (indicating C-C, C-O, and C=O stretching), 1140 cm-1 (suggesting C-H in-plane deformation), 1050 cm-1 (associated with a complex vibration linked to C-O, C-C stretching, and COH bending in polysaccharides), as well as peaks at 840 and 810 cm-1 (indicating C-H out-of-plane deformations). Moreover, the band between 620-660 cm-1 is attributed to sulfonic groups (S-O stretching vibration), resulting from the interaction of sodium sulfite with the secondary OH groups of the aliphatic side chains in lignins. Interestingly, changes in the intensity of several bands are observed post-formation of Fe complexes, signaling structural modifications in the molecules due to metal addition. Notably, bands at 2940, 2830, 1715, 1470, 1500, and 1050 cm-1 consistently exhibit reduced intensity upon complexation with Fe (Fe2+ or Fe3+), suggesting alterations in CH stretching, carbonyl and carboxyl stretching, CH deformation, aromatic ring vibrations, C=C aromatic skeletal vibrations, and vibrations related to C-O, C-C, and C-OH in polysaccharides occurs". can be used in a wide range of applications.

But in this research result the chemical Name(mineral Name)=polypropylene,00-057-1845($(C_3H_6)_n$), Therefore, the molecular mass of C_3H_6 is 42 grams/mol. This means that one molecule of propene has a mass of 42 atomic mass units Poly (propene), also known as polypropylene, is a versatile thermoplastic polymer used in a wide range of applications. It is a synthetic resin that belongs to the polyolefin family and is derived from propylene monomers. Polypropylene is known for its strength, durability, and resistance to chemicals and heat. In the context of concrete mixers, polypropylene can be used as a replacement for water in certain applications. This is because polypropylene can absorb and retain water, which can help to improve the workability and strength of concrete.

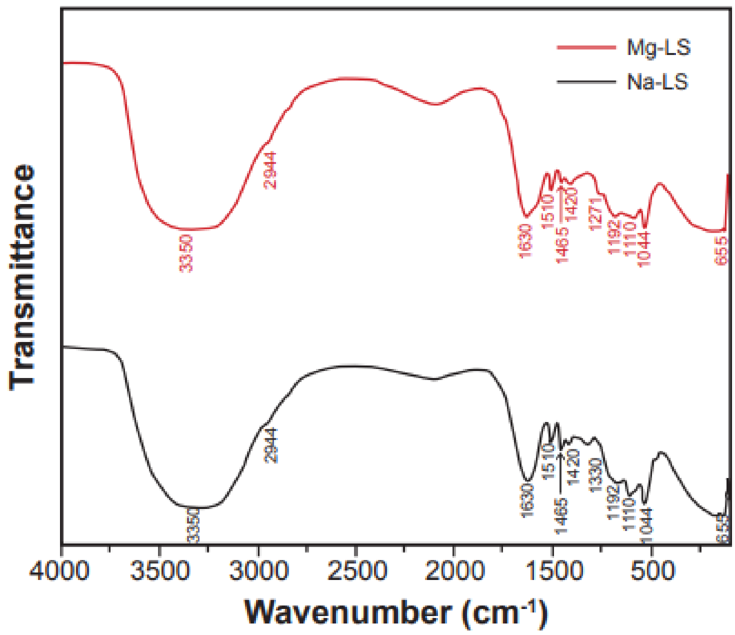


Figure 2: FTIR spectra of sodium lignosulfonate (Na-LS, black line) and magnesium lignosulfonate (Mg-LS, red line).

Figure 4.5: FTIR sodium lignosulfonate and magnesium lignosulfonate

However, it's important to note that polypropylene is not a direct substitute for water in concrete mixers and should only be used in specific applications where its properties are beneficial. The use of polypropylene in concrete mixers requires careful consideration and may require adjustments in water content to the concrete mix design to ensure optimal performance and structural integrity. Therefore the Molecular weight of Propylene [C_3H_6] is greater than the Molecular weight of Water [H_2O], on the other hand, the boiling point of water is 100C^O and the propylene is 120-132C^O that means the void space on concrete occupied by propylene by different literature review papers and the melting point of propylene is160C^O and water will be $0C^0$. Therefore when water is evaporated from concrete structures by different temperature changes the space will be occupied by Ethiopisn gum (propylene). Polypropylene (PP) is a widely used thermoplastic polymer that is derived from the monomer propylene (C_3H_6). It is a versatile material with a wide range of applications due to its excellent combination of properties, including high chemical resistance, low density, good mechanical strength, and high melting point.

Sustainable harvesting practices are crucial to preserve this resource for future generations Ethiopian gum (xanthan gum) Investigation of xanthan gums compatibility with other admixtures. The resistance of freezing and thawing of concrete on chemical admixtures was primarily related to the amount and characteristics of the air-void system it entrained. The resistance increases it. Increasing air content and decreasing air void spacing factors. Improvement of resistance to freezing and thawing beyond others resulting from the entrained air would be dependent on the amount of water reduced and increase in strength.

4.3 The investigation of Mechanical properties (compressive strength and flexural strength) of concrete sample additives with varying concentrations of Ethiopian gum (xanthan gum).

Compressive strength test: this is a vital process in evaluating the impact of Ethiopian gum (xanthan gum) on concrete samples. Standard methods like ASTMC39 are commonly employed to gauge the enhancement provided by this additive. Compressive strength stands as a fundamental characteristic of concrete, reflecting its capacity to resist axial loads or forces administered along its axis. This mechanical property plays a pivotal role in assessing the quality and longevity of concrete structures. Compressive strength signifies the maximum compressive load or stress a concrete specimen can endure before failure transpires. Typically quantified in pounds per square inch (psi) or mega Pascal's (MPa), it offers crucial insights into concrete components' robustness and structural integrity.

Compressive Strength = Load / Cross-sectional Area(Moccia et al., 2021)

The maximum compressive strength of concrete at 7 days is 17.28 N/mm^2 as shown in the tables. However, the control value for C25-grade concrete is 16.76 N/mm^2. Therefore, the outcome indicates a satisfactory performance.

Table 4.2: 7 DAYS COMPRESSIVE STRENGTH

SL No.	Ethiopian gum%	MAX LOAD(kN)	STRENGTH IN N/ mm2	AV.STR.(N/mm2)
1	0.0	381	16.95	
2	0.0	369.2	16.42	16.76
3	0.0	381	16.9	
1	0.1	295	13.1	
2	0.1	299	13.28	13.25
3	0.1	301	13.37	
1	0.2	356	15.82	
2	0.2	378	16.8	16.27
3	0.2	365	16.2	
1	0.3	376	16.71	
2	0.3	369	16.4	16.5
3	0.3	370	16.4	
1	0.4	387	17.2	
2	0.4	389	17.28	17.28
3	0.4	391	17.37	
1	0.5	291	12.93	
2	0.5	289	12.84	12.67
3	0.5	276	12.26	

Table 4.3: 28 DAYS COMPRESSIVE STRENGTH

SL No.	Ethiopian gum%	MAX LOAD(KN)	STRENGTH IN N/ mm2	AV.STRENGTH
1	0.0	572	25.43	
2	0.0	554	24.63	25.15
3	0.0	571.4	25.4	
1	0.1	694	30.8	
2	0.1	718	31.9	31.2
3	0.1	695	30.9	
1	0.2	727	32.3	
2	0.2	728	32.4	32.0
3	0.2	706	31.4	
1	0.3	729	32.4	
2	0.3	707	31.4	31.9
3	0.3	716	31.8	
1	0.4	738	32.8	
2	0.4	736	32.7	32.8
3	0.4	739	32.8	
1	0.5	695	30.9	
2	0.5	703	31.2	31.1
3	0.5	706	31.4	

The concrete's maximum compressive strength is 32.8 N/mm2 in the above tables, while the control value for C25 concrete is 25.15 N/mm2. The discrepancy between the control value and lab results is 7.65 N/mm2. Consequently, utilizing Ethiopian gum at a concentration of 4000mg/liter is deemed more appropriate for the construction sector.

Flexural strength: like ASTMC78, measure the ability of Ethiopian gum (xanthan gum)-reinforced concrete to resist bending forces for both beam and columns. Flexural strength, also known as modulus of rupture, is a measure of a material's ability to resist deformation and failure when concrete to bending or flexural stresses. In the context of concrete, flexural strength indicates the maximum tensile stress that the material can withstand before failing in a bending scenario. Here is an explanation of flexural strength in concrete: Bending Stress, Tensile Zone, Cracking Behavior, and Design Considerations.

for the flexural machine is a two-point load

Flexural Strength = PL/BD2 (Mandal et al., 2016)

Where:

Flexural Strength is the measured maximum bending stress at failure MPa.

P =is the maximum applied load during the flexural test Newton.

L =is the span length between the supports mm.

B= is the width of the test specimen mm.

D =is the depth of the test specimen mm.

The maximum flexural strength of concrete at 7 days is 2.47 N/mm^2 as shown in the below tables. However, the control value for C25 grade concrete is 1.693N/mm^2 2.5 N/mm^2. Therefore, the difference will be 0.77N/mm^2 outcome indicates a satisfactory performance.

The optimized flexural strength result is 3.3 N/mm2, which falls slightly below the control value of 2.513 N/mm2 for C25 concrete, Therefore, the difference between the values will be 0.787N/outcome indicates a satisfactory performance.

Table 4.4: 7 DAYS FLEXURAL STRENGTH

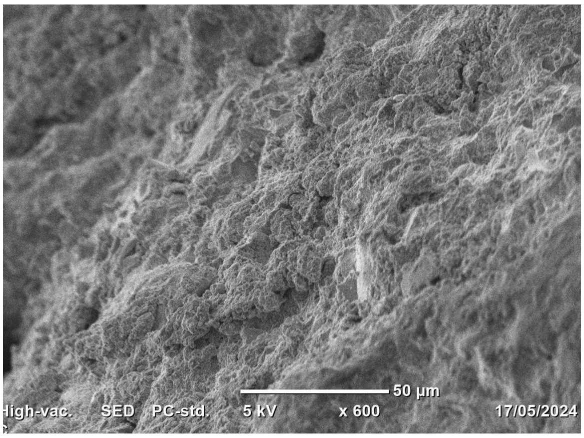
SL No.	Ethiopian gum%	MAX LOAD(KN)	STRENGTH IN N/ mm2	AV.STR.(N/mm2)
1	0.0	5.59	1.695	
2	0.0	5.418	1.642	1.693
3	0.0	5.58	1.693	
1	0.1	6.6	1.979	
2	0.1	6.52	1.975	1.95
3	0.1	6.12	1.89	
1	0.2	6.51	1.953	
2	0.2	6.51	1.953	1.96
3	0.2	6.5	1.96	
1	0.3	6.7	1.98	
2	0.3	6.56	1.95	1.98
3	0.3	6.99	2.01	
1	0.4	8.4	2.54	
2	0.4	7.9	2.381	2.47
3	0.4	7.94	2.481	
1	0.5	6.01	1.56	
2	0.5	6.03	1.65	1.63
3	0.5	6.05	1.67	

Table 4.5: 28 DAYS FLEXURAL STRENGTH

SL No.	Ethiopian gum%	MAX LOAD	STRENGTH IN N/ mm2	AV.STR.(N/mm2)
1	0.0	8.38	2.54	
2	0.0	8.118	2.46	2.513
3	0.0	8.38	2.54	
1	0.1	9.91	2.96	
2	0.1	9.92	2.975	2.8
3	0.1	8.64	2.593	
1	0.2	8.96	2.688	
2	0.2	8.76	2.67	2.6
3	0.2	8.67	2.52	
1	0.3	9.32	2.79	
2	0.3	9.01	2.65	2.7
3	0.3	9.03	2.72	
1	0.4	11.01	3.303	
2	0.4	11.05	3.316	3.3
3	0.4	10.85	3.254	
1	0.5	10.03	3.01	
2	0.5	10.08	3.026	3.0
3	0.5	10.09	3.028	

SEM enables the examination of key aspects of Ethiopian gum: Surface Morphology, Particle Size and distribution, internal structure of concrete, and interactions with admixtures. In all the above SEM image analyses we observe that the

Figure 4.6: beam bending pictures

a) 

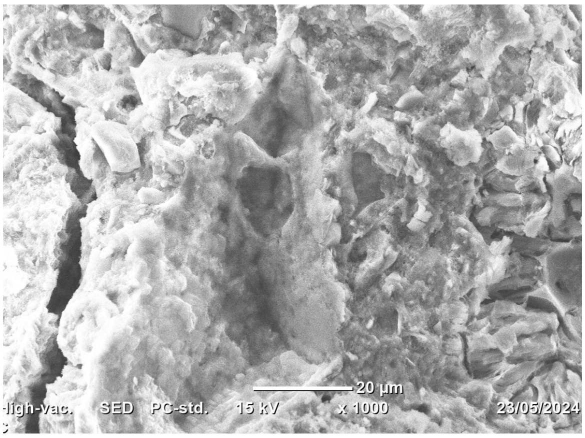
b) 

Figure 4.7: SEM image concrete with Ethiopian gum and For a)X600 b)X1000.

concrete at 28 the day has fewer voids but to the same extent and lower cracking.

Ethiopian gums are frequently utilized in concrete as water-reducing and retarding admixtures in laboratory results. They enhance workability, lower water content, and postpone setting time. These admixtures can significantly improve concrete durability by enhancing workability, reducing permeability, promoting proper hydration, and extending placement time. Gums are recognized for their elasticity and stretchability, which is similar to the flexibility required in durable concrete to withstand movement without cracking, especially in areas prone to ground settlement or seismic activity.

4.4 Evaluate the effect of different concentrations of Ethiopian gum (xanthan gum) on resistance to water absorption was determined

Understanding the concept of water absorption is crucial for concrete structures as it enables effective control of the hydration process, ensuring the desired outcomes in terms of structural stability, durability, and physical properties of the concrete structure. Therefore, incorporating Ethiopian gum into concrete can potentially provide solutions to enhance these properties further. In a laboratory study investigating the effect of various concentrations of gum samples mixed with cement, aggregate, sand, and water, we added Ethiopian gum powder in concentrations ranging from 0.1% to 0.5%. After mixing, the samples were cured for 24 hours and then submerged in water. Subsequently, we measured the mass of the cubic concrete molds and the mass of the beam.

Water absorption
4000mg/l (for compressive strength)

mass(kg)	Before immersed	After immersed	difference	%water absorption
M1	7.72	7.56	0.14	1.81
M2	7.51	7.59	0.08	1.07
M3	7.49	7.54	0.05	0.67

The above tables show that the measured values differed from the original mass, indicating the compressive strength concrete absorbed water by 1.81%.

Water absorption
4000mg/l (for flexural strength)

mass(kg)	Before immersed	After immersed	difference	%water absorption
M1	11.45	11.89	0.44	3.84
M2	11.75	12.21	0.47	3.96
M3	11.81	12.31	0.50	4.23

The above tables show that the measured values differed from the original mass, indicating that the flexural strength concrete absorbed water by 4.23%.

5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION.

When concluding an investigation into the potential of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete performance, it is essential to summarize the key findings, implications, and future directions of the study. The investigation into the utilization of Ethiopian gum, specifically Ethiopian gum, as a natural bio-polymer additive in concrete, has provided valuable insights into its potential impact on concrete performance. The addition of Ethiopian gum to concrete mixes showed promise in improving certain properties such as workability, durability, and strength. This suggests that Ethiopian gum can be a viable bio-polymer option for enhancing concrete performance. The study highlighted the significance of determining the optimal dosage of Ethiopian gum to achieve the desired effects without compromising overall concrete characteristics.

In conclusion, the investigation of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete signifies a promising avenue for innovating concrete technology toward sustainability and performance optimization. While initial results are encouraging, further studies are warranted to address remaining questions, standardization, and broader applications in the construction industry. By continuing to explore the potential of Ethiopian gum in concrete mixes, we can advance towards greener, more durable, and resource-efficient construction practices.

5.2 RECOMMENDATION.

Future research can develop into these areas to solidify the practical implications of using Ethiopian gum in real-world construction contexts. After conducting an investigation into the potential of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete performance, it is crucial to provide actionable recommendations for future research and practical applications. Here are some recommendations based on the study findings

- Conduct further optimization studies to determine the ideal dosage and mix design incorporating Ethiopian gum in concrete. Explore a range of concentrations to identify the most beneficial effects on concrete properties without compromising other performance aspects.

- Investigate the compatibility of Ethiopian gum with different types of cement, aggregates, admixtures, and supplementary materials commonly used in concrete production.

- Initiate field trials and real-world applications to validate the laboratory findings on the performance of concrete with Ethiopian gum. Observing the material's behavior in practical construction scenarios will enhance the understanding of its feasibility and benefits

- Collaborate with industry stakeholders and regulatory bodies to develop standardized testing methods, guidelines, and specifications for incorporating Ethiopian gum as a bio-polymer in concrete. Establishing clear protocols can facilitate the adoption of Ethiopian gum in the construction sector.

  By implementing these recommendations, future research endeavors can further explore the potential of Ethiopian gum (xanthan gum) as a natural bio-polymer in concrete, leading to enhanced performance, sustainability, and innovation in the construction industry. These actions can contribute to the advancement of eco-friendly materials and practices, paving the way for greener and more resilient infrastructure development.

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Appendix

CONCRETE MIX DESIGN

C-25 Concrete Mix Design

ACI 301-99, 1999 concrete mix design procedure was used to design concrete that can achieve the desired workability and provides an average adequate compressive strength. According to ACI, average compressive strength must equal or exceed the required average compressive strength the required average compressive strength f_{c_r} was calculated for the specified class of concrete by one of the following:

$f_{c_r} = f_{ck} + 7$ MPa when the specified compressive strength is less than 21 Mpa.

f_{c_r} = $f_{ck} + 8.5$ MPa when specified compressive strength is between 21 to 35Mpa.
f_{c_r} = $1.1 f_{c_k}$ + 5 MPa when specified compressive strength is greater than 35 Mpa

So, the Target mean strength for C-25 grade concrete is calculated by using f_{c_r} = f_{c-k} + 8.5MPa Therefore 33.5N/mm2

1. Slump selection

From Table 3(ACI-2111-91), maximum slump = 50 mm and minimum slump= 25mm.

2. Maximum size of aggregate selection

The maximum Nominal aggregate size of coarse aggregate was used at 25 mm

3. Estimation of mixing water and air content Slumps and Nominal Maximum Sizes of Aggregates (ACI-2111-91)

table

From the table, for non-air entrained and slump of 25-50mm, the water in 1m³ of concrete is 179 4. Water-to-cement ratio selection From ACI 211-1-81 the water-to-cement ratio is 0.5

5. Calculation of cement content For slump of 25-50mm Air =1.5 or 15% Water content=179 Kg Water/cement = 0.5 Cement content = water content / (W/C) = 179/0.5 = 358 Kg

6, Estimation of coarse aggregate content The volume of coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate (ACI-2111-91)

Table 5.1: Volume of coarse aggregate per unit of volume of concrete

Nominal maximum size of aggregate (mm)	2.40	2.60	2.80	3.00
9.5	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
19	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72
75	0.82	0.80	0.78	0.76
150	0.87	0.85	0.83	0.81

The quantity of coarse aggregate estimated from ACI 211-1-81 Table 6.3.6 for fineness modules of 2.4 and 25mm Nominal size of coarse aggregate, the table indicates the volume of Coarse aggregate to be we used is 0.71

Weight of coarse aggregate = bulk volume*Dry rodded Unit Weight of Course Aggregate =1450Kg/m3*0.71m3 = 1029.5 Kg

7. Determining the content of the mass of fine aggregate.

Known mass of ingredients

Mass of water =179kg

Mass of cement= 358 Kg

Mass of coarse aggregate= 1029.5Kg

From ACI table A.1.5.3.7.1. Mass of fresh concrete with 25mm nominal maximum aggregate size is 2380kg/m3

Mass of fine aggregate = total mass – (Mw+ Mc+ MCA)

= 2380- 1566.5

= 813.5Kg

materiale	Volume(lit)	Wt(kg)
cement	113.5	358
water	179	179
Coarse Aggregate	403.7	1029.5
Fine Aggregate	306.98	813.5
total	1000lit	2380kg

Adjustment for moisture in the aggregate.

Since the moisture level of the fine aggregate in our storage varies, we will apply a simple rule to adjust the water required.

Decrease the amount of water required by the surface moisture content of the weight of the fine aggregate.

Increase the amount of aggregate by the amount equal to the surface moisture.

Let: assume

5% of moisture absorption by coarse aggregate.

7% of moisture adsorption by fine aggregate.

The amount of water absorbed by coarse aggregate = 1029.5kg/m3 * 0.05 = 51.475 kg/m3

The amount of water supplied by fine aggregate

813.5kg/m3 * 0.07 = 56.945kg/m3

Therefore, the estimated amount of water needed for the mix is;

(179 kg/m3 + 51.475 kg/m3) – 56.945kg/m3 = 173.53kg/m3

Therefore, the estimated batch wt. for a cubic meter of concrete is;

materiale	Volume(lit)
water	173.53kg/m3
cement	358kg/m3
Coarse aggregate=1029.5+51.4752	1080.975kg/m3
Fine aggregate=813.5-56.945	756.55kg/m3

Ingredient	Coarse aggregate	Fine aggregate	cement
Quantities/m3	1080.975/358	756.55/358	358/358
Ratio	3	2	1

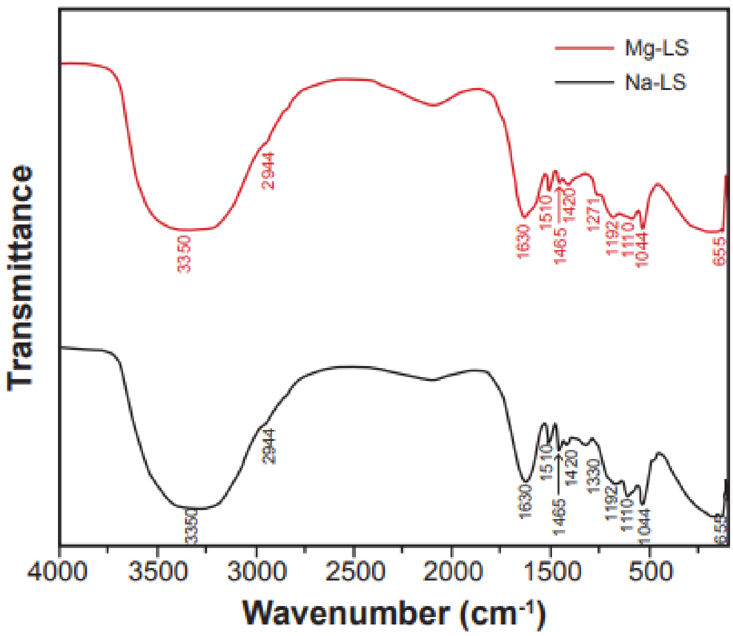

Figure 2: FTIR spectra of sodium lignosulfonate (Na-LS, black line) and magnesium lignosulfonate (Mg-LS, red line).

Figure 5.1: FTIR sodium lignosulfonate and magnesium lignosulfonate

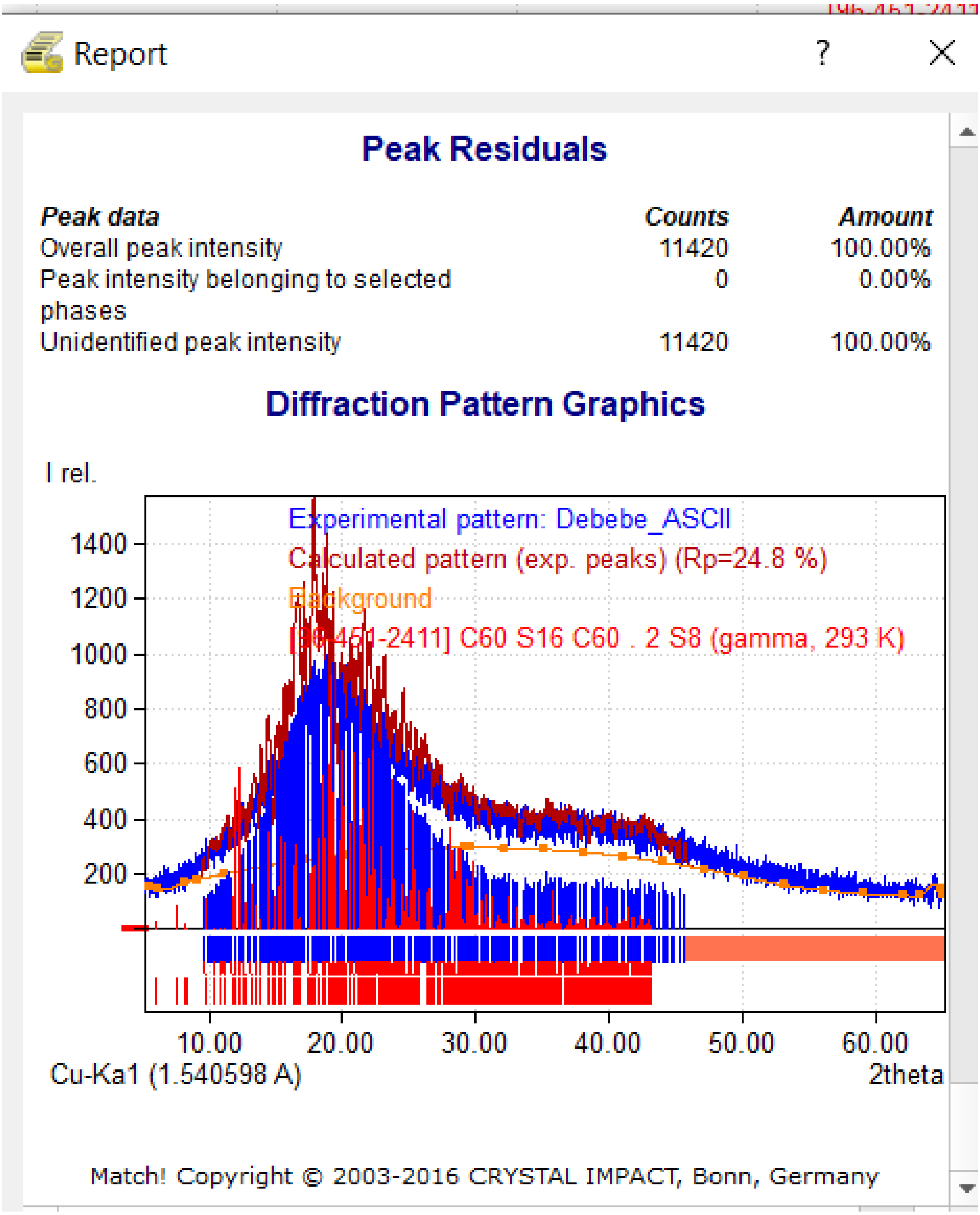

Figure 5.2: XRD by match diffraction analysis

Peak Residuals

Peak data	***Counts***	***Amount***
Overall peak intensity	11420	100.00%
Peak intensity belonging to selected phases	216	1.89%
Unidentified peak intensity	11204	98.11%

Diffraction Pattern Graphics

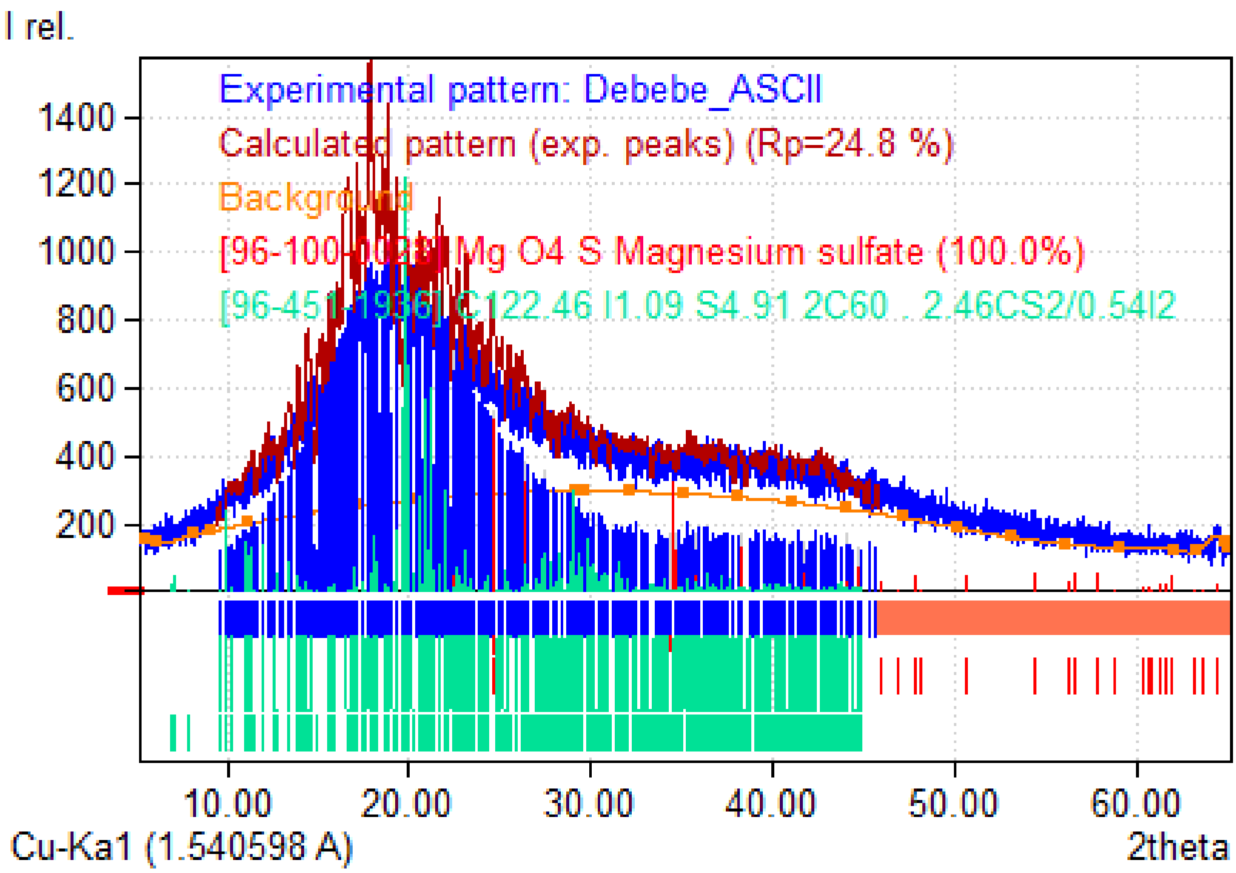

Figure 5.3: XRD by match diffraction analysis