Innovative Approaches: Plant-Based Polymers and Bamboo Chips as Admixtures in Mortar and Concrete Preparations

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Abstract

This review paper comprehensively analyzes the use of additives, admixtures, and natural polymers in cement-based materials to enhance performance, durability, and environmental impact. It highlights the potential of incorporating natural extracts, biopolymers, and renewable materials as eco-friendly alternatives to chemical admixtures. The study explores self-healing materials, preventive repair methods, and internal curing with super-absorbent polymers to develop durable and sustainable concrete solutions. The review identifies research gaps and areas for further investigation, emphasizing the need to optimize material combinations and understand compatibility issues. Overall, this study contributes to advancing eco-conscious construction practices and encourages the integration of innovative and sustainable materials in the building industry.

Keywords— Additives, Admixtures, Natural polymers, Sustainability, Concrete properties

I. INTRODUCTION

In recent years, the construction industry has witnessed a growing interest in exploring innovative and sustainable materials for enhancing the performance, durability, and environmental impact of cementitious materials. Researchers have extensively investigated the use of various additives, admixtures, and natural polymers in cement-based composites, with a focus on improving properties like strength, durability, and water resistance. These studies have revealed promising results, showcasing the potential of incorporating natural extracts, biopolymers, and renewable materials as environmentally friendly alternatives to traditional chemical admixtures. Additionally, the exploration of self-healing materials, preventive repair methods, and internal curing using super absorbent polymers has paved the way for more durable and eco-friendly concrete solutions. As the demand for sustainable construction practices continues to rise, the integration of these innovative materials and techniques into the building industry holds the key to creating durable and environmentally conscious structures for the future.

The scope of this review paper study is to comprehensively analyze and synthesize the existing literature on the use of additives, admixtures, and natural polymers in cement-based composites. The paper aims to highlight the diverse range of materials and their effects on concrete properties, including strength, durability, water resistance, and shrinkage. By exploring the interactions between these materials and the cement matrix, the study aims to provide valuable insights into the potential benefits and challenges of using natural and eco-friendly alternatives to chemical admixtures. Furthermore, the review paper seeks to identify research gaps and areas for further investigation, encouraging future studies to focus on optimizing material combinations, understanding compatibility issues, and exploring the long-term performance of these sustainable concrete solutions. Ultimately, this review paper aims to contribute to the advancement of durable and environmentally conscious construction materials, fostering a more sustainable and eco-friendly approach to the construction industry.

II. LITERATURE REVIEW

A. Laboratory Experiments

Chandra et al. (1998) explore the use of cactus extract from Mexico as a natural polymer in Portland cement mortar. The cactus extract enhances the mortar's plasticity, water absorption, and freeze-salt resistance. (Figure 1.) The interaction between calcium hydroxide from cement hydration and cactus extract's components, polysaccharides or proteins, leads to the formation of complexes that influence the crystallization process. Concrete painted with cactus extract also exhibits improved water resistance. Tests reveal that cactus leaves without spines produce a gluey solution containing proteins and polysaccharides, which enhances the mortar's properties. Further optimization and testing of different cactus extract concentrations and extraction times are required. Abundantly available in African countries, cactus extract presents an eco-friendly and cost-effective alternative for modern building materials, echoing ancient practices of using natural polymers for enhancing durability.

Fowler (1999) stated that over the past 25 years, polymers in concrete, such as polymer-impregnated concrete (PIC), polymer concrete (PC), and polymer-modified concrete (PMC), have garnered significant attention. PIC, known for its excellent strength and durability properties, has limited commercial applications. PC, popular since the 1970s, finds use in repair, thin overlays for floors and bridges, and precast components. PMC is primarily utilized for repair and overlays. Challenges like cost, odour, toxicity, and flammability have hindered their widespread adoption. Nevertheless, continuous advancements in materials, automated repair methods, and potential replacements for metals are expected to expand their applications. The future of concrete-polymer materials shows promise in structural, architectural, and repair applications.

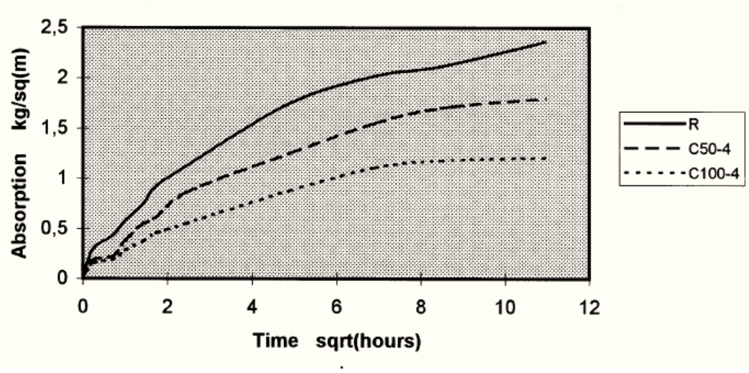

Figure 1. Water absorption of the mortar prisms mixed with cactus extract. (Modified after Chandra et al. 1998)

Hanehara and Yamada (1999) found that chemical admixtures play a crucial role in enhancing the properties of concrete, allowing for the realization of high-performance concrete with superior strength, fluidity, and self-compactibility. However, the interaction between cement and chemical admixtures can lead to incompatibilities, resulting in issues like stiffening and slump loss. This study investigates the interaction between various chemical admixtures and different types of cement, such as lignin sulfonate, naphthalene sulfonate, melamine sulfonate, amino sulfonate, and polycarboxylate, focusing on their impact on cement hydration. The authors discuss the compatibility of polycarboxylate superplasticizers with different types of cement, considering the influence of alkaline sulfates in cement. Researchers continuously strive to develop new admixtures to meet the demand for higher concrete properties, necessitating collaboration across disciplines to maximize the potential of cement and admixture for efficient concrete technologies.

Gemert et al. (2004) The pursuit of durable and sustainable construction materials has led to significant advancements in both cement concrete and concrete-polymer composites. The combination of classical building materials and polymers creates synergic effects, enhancing the performance and applications of these materials. The International ICPIC Congress serves as a platform for practitioners and scientists in the construction industry to discuss and present new trends and developments in concrete-polymer composites. The use of polymers in construction is steadily increasing, offering opportunities for innovation and improved sustainability. Polymers are no longer seen as mere replacements but essential components in the production of composite and sustainable building materials, contributing to the development of durable constructions and effective restoration techniques. This paper highlights the synergies between polymers and cement concrete, paving the way for a more sustainable construction industry.

Sebaibi et al. (2004) investigated the influence of lime proportions and characteristics, especially viscosity, on the properties of a cement-lime mortar. Different types of lime, including calcium and magnesium hydroxides, industrial slaked limes with diverse physicomechanical characteristics, and hydrated dolomite, were substituted for cement in varying proportions. Water was added to achieve consistent mortar consistency, equivalent to that of a normal mortar, with a sand-to-cement ratio of 3 and a water-to-cement ratio of 0.5. Results indicate that the viscosity of the cement-lime paste is more influenced by the morphology of the lime rather than its chemical composition. The study reveals that the substitution of cement for lime requires a higher water percentage during mortar production, and lime hydrated under pressure behaves differently from calcium and magnesium hydroxides. The findings highlight the importance of understanding lime characteristics for optimizing cement-lime mortar properties and behaviour.

Gemert et al. (2005) found that the development of durable and sustainable construction materials is driven by advancements in both cement concrete and concrete-polymer composites. These two worlds complement each other, recognizing the synergetic effects achieved through the combination of traditional building materials and polymers. Improved understanding of material behaviour, especially in the field of admixtures, has led to the creation of high-performance mineral and modified mineral concretes, mortars, and grouts. The International ICPIC Congress serves as a platform for practitioners and scientists to discuss new trends and developments in concrete-polymer composites, with a particular emphasis on the construction industry. The use of polymers in construction is growing steadily, offering opportunities for innovation and improved sustainability. Polymers have become a vital component in producing composite and sustainable building materials, enabling the development of new, durable constructions, as well as effective restoration and retrofitting techniques.

Togero (2006) investigates the leaching of hazardous substances from additives and admixtures commonly used in concrete. The research explores time-dependent leaching in metal-containing concretes with different cement types, including ordinary Portland cement (OPC), fly ash, and slag. The results show uniform leaching patterns, and the diffusion test spanning 1,700 days indicates a substantial decline in metal release. The proposed alternative availability test provides data for modelling leaching during concrete's service life. Additionally, the study examines the leaching of toxic substances like thiocyanate, resin acids, and nonylphenol ethoxylate from concrete with admixtures. The research highlights the leaching behaviour of different substances, their solubility, and their binding to the cement matrix.

Dwivedi et al. (2008) This study investigates the impact of admixtures, black gram pulse (BGP), and sulfonated naphthalene-based superplasticizer (SP), on the hydration of Portland cement. The research employs non-evaporable water content determinations, calorimetric methods, Mössbauer spectroscopy, and atomic force microscopy to analyze the hydration characteristics. Both BGP and SP are found to adsorb onto cement and its hydration products, resulting in the retardation of cement hydration and the formation of nanosized hydration products. BGP shows superior retardation compared to SP at the same concentration (2.0 wt. (%)), with Mössbauer spectral parameters revealing different extents of adsorption (Figure 2). The eco-friendly and cost-effective nature of BGP suggests its potential as a viable retarder; however, further investigations are required before its widespread use as an admixture.

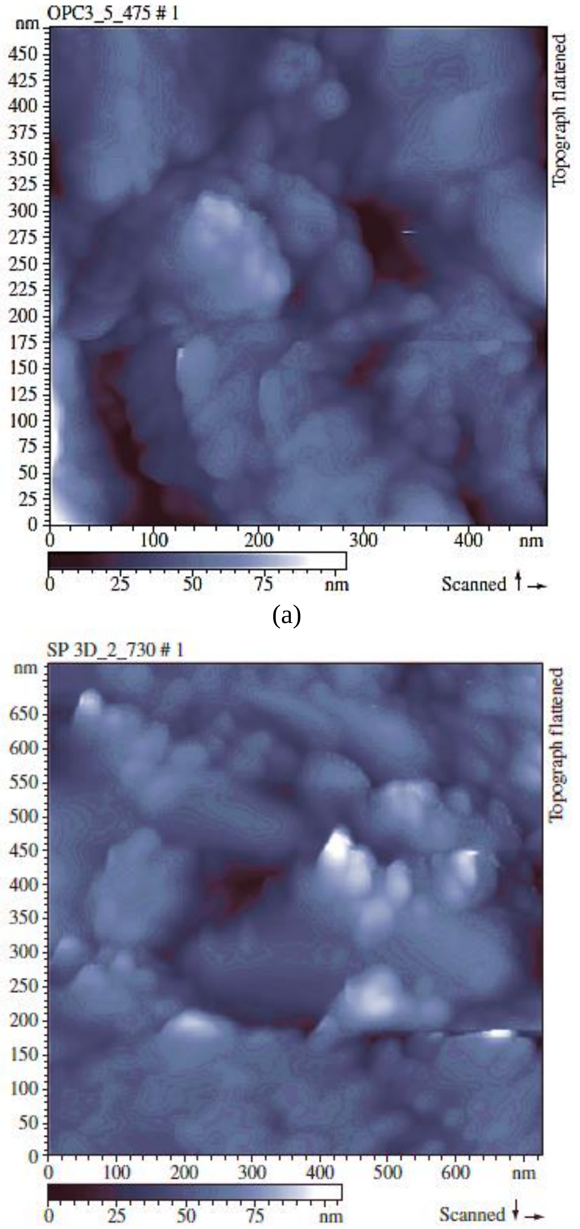

Figure 2. Atomic Force Microscopy pictures of a) OPC hydrated for 3 days and b) OPC hydrated for 3 days in the presence of 2.0 wt. (%) SP. (Modified after Dwivedi et al. 2008)

Knapen and Gemert (2009) investigate the effect of water-soluble polymers on cement hydration reactions and the microstructure of cement mortars. The presence of small amounts (1% of the cement mass) of water-soluble polymers initially retards the hydration reactions, but after 90 days, it leads to a higher degree of hydration due to improved cement particle dispersion in the mixing water. The addition of certain polymers, such as MC, affects the morphology of Ca(OH)2 crystals, creating a layered deposition with polymer bridges between crystals, resulting in better interparticle bonding and a stronger microstructure. Furthermore, water-soluble polymers enhance the internal cohesion of the bulk cement paste, leading to reduced crack formation. These findings highlight the potential benefits of using water-soluble polymers for improving cement mortar properties.

Abdulrahman and Ismail (2011) address the environmentally harmful nature of existing chloride corrosion inhibitors for steel-reinforced concrete. To find sustainable alternatives, the study explores the hydrophobic green plant extract inhibitor derived from Bambusa arundinacea. Compared to calcium nitrite, Bambusa arundinacea showed superior performance in passivating chloride-induced corrosion in concrete. Results revealed higher concrete resistivity, chloride binding, and polarization resistance. Bambusa arundinacea emerges as a promising and versatile substitute for nitrite-based corrosion inhibitors, contributing to more durable and eco-friendly concrete structures. The research highlights the direct use of impedance data for corrosion assessment and confirms Bambusa arundinacea's effectiveness as a mixed-type corrosion inhibitor in fresh concrete.

Bezerra (2016) The chapter focuses on biopolymers with superplasticizer properties for concrete and concludes that using biopolymers in combination yields optimized concrete properties. With traditional polymer sources depleting, biopolymers, which are virtually inexhaustible, will play a crucial role in the future. They estimated that oil will last approximately 41 more years, allowing for a short window of using petroleum-based superplasticizers. However, the availability of biopolymers remains uncertain due to their partial recycling nature, which relies on the sustainable practices of Homo sapiens, the only species capable of influencing the planet's renewal. The research emphasizes the significance of embracing eco-friendly and renewable alternatives like biopolymers to ensure the sustainable development of construction materials and technologies.

Jonkers et al. (2016) highlight the importance of durability in construction materials and structures and emphasize the need for designs that meet intended service life with minimal maintenance and repair. The study explores the use of biotechnological approaches, specifically bacteria-based systems, to improve the durability and sustainability of concrete repair. Two different metabolic pathways involving bacteria are discussed, with a focus on the precipitation of calcium carbonate for concrete improvement without producing environmentally harmful by-products. Successful application of bacteria-based repair systems in reducing water permeability and sealing cracks in parking decks is presented. Promising results indicate the potential for biotechnological mortars to enhance durability in concrete repair. Combining biotechnology with concrete technology offers new possibilities for creating durable and sustainable construction materials, ultimately lowering environmental impacts and saving costs in civil engineering projects.

Shen et al (2016) conducted an experimental study focused on the effect of internal curing (IC) using super absorbent polymers (SAPs) on the early-age autogenous shrinkage (AS) of high-performance concrete (HPC). The research aimed to investigate the relationship between AS and the amount of IC water provided by SAP. The results showed that SAP effectively mitigated AS, but the early-age expansion of internally cured concrete increased with higher amounts of IC water. The ultimate AS at 28 days decreased with increasing IC water, and a model to estimate AS considering early-age expansion and IC water was proposed. The IC efficiency of SAP decreased with higher IC water amounts. Further research is needed to understand the optimal amount of SAP for enhancing cracking resistance in internally cured concrete with SAP.

Thong et al. (2016) Polyvinyl alcohol (PVA) has been widely used in the building industry for about 90 years, finding applications as a modifier, aggregate surface pre-treatment agent, and fibre reinforcement in cement-based composite materials. This review paper discusses the physical properties of PVA and its effects on the engineering properties of cement-based composites. Overall, researchers have found that the inclusion of PVA in cement-based materials has positive effects on their engineering properties, leading to better adhesion between the paste and aggregates and reduced thickness of the interfacial transition zone (ITZ). However, there have been some conflicting reports, warranting further research for future development in the building industry.

Barrera et al (2017) This special issue compiles recent research on construction technologies and new construction materials with a focus on eco-friendly and sustainable solutions. Investigations include the use of by-products in cement matrices, recycled materials in concrete pavement, and the effects of carbon nanotubes in cementitious composites. The durability of composites in aggressive environments, self-healing efficiency, and the properties of mineral aggregates are also explored. Studies on fibre-reinforced concrete and metal utilization in construction provide valuable insights. Additionally, research on cement-based materials with combination mineral admixtures and spalling resistance in lightweight aggregate concrete at high temperatures is presented. The issue concludes with examinations of plant-produced asphalt concrete mixtures and coloured aggregate use in architectural mortar applications.

Hazarika et al. (2017) explored the use of an aqueous extract of okra, termed bio-admixture, as a sustainable chemical admixture in cement mortar and concrete production. The bio-admixture is found to exhibit viscosity-enhancing properties, leading to shorter setting times and increased hydration rates of cement particles in the presence of the admixture. The addition of bio-admixture enhances cement hydration rates by interacting with Ca^{2+} ions in the cement paste. As a result, the compressive strengths of cement mortar and concrete containing bio-admixture are higher, and their durability under adverse conditions, such as exposure to $MgSO_4$-NaCl solution, is improved. The investigations also demonstrate that the properties of the cement composites depend on the concentrations of the bio-admixture in aqueous solution. The study concludes that the bio-admixture can serve as a low-cost and environmentally friendly viscosity-enhancing admixture, contributing to the production of sustainable cement composites with enhanced mechanical and durability properties. The research presents a promising avenue for using vegetable extracts as bio-admixtures in concrete preparation, offering potential benefits for the construction industry's sustainability and material performance.

Faque (2020) presents a critical review of the use of chemical admixtures in concrete and their environmental impact, including leaching and pollution concerns. To address these issues, the study focuses on natural materials used as eco-friendly and low-cost alternatives to chemical admixtures, examining their influence on the mechanical and durability properties of concrete. The results highlight the urgency and validity of considering natural admixtures, which are environmentally friendly and readily available from natural sources, including waste materials. The research concludes that natural admixtures can enhance concrete's mechanical and durability properties, making them viable and sustainable options for the concrete industry. This move towards natural admixtures contributes to the creation of green concrete, promoting environmentally friendly construction practices.

García-González et al. (2020) This research focuses on enhancing the sustainability and safety of cementitious structures by exploring new self-healing materials and preventive repair methods. Biodegradable biopolymers, derived from waste biomass of mixed microbial cultures during polyhydroxyalkanoates production, are used as eco-friendly consolidants and water repellents. The study evaluates the effectiveness of these biopolymers in protecting and consolidating cement mortar specimens through water absorption tests. External treatment with biopolymer products and the inclusion of biopolymers in mortar mixing water result in decreased water absorption, indicating improved durability of cementitious elements. The treatment with MMC bioproduct from glycerol demonstrated a notable reduction in permeability, and the sonicated biopolymer exhibited better-repairing effects than the non-sonicated version. Moreover, adding MMC bioproducts to cement mortars showed a positive impact on their durability, with the bioproduct's effectiveness increasing over a short period.

Paul et al. (2022) investigated the use of sugarcane juice (SCJ) as a natural admixture in cementitious materials to enhance their properties. The study found that SCJ can act as an accelerator, significantly reducing the initial setting time of cement mortar, especially at low cement-sand (c/s) and water-cement (w/c) ratios. The addition of SCJ in concrete mixes also led to improved compressive strength and splitting tensile strength, with up to 29% higher compressive strength achieved with 10% SCJ addition compared to the control mix. The effect of SCJ on setting time and mechanical strength was influenced by the dosage and mix composition. The research concluded that SCJ can be a cost-effective and eco-friendly alternative to manufactured admixtures, positively impacting the rheological, mechanical, and durability properties of cementitious materials. However, further investigation is needed to understand its full potential and behaviour under different conditions.

B. Sustainability and research on plant-based natural fibre-reinforced cement composites

The quest for sustainability and research carried out on the natural fibres reinforced cement composites extracted from plant sources continue to play an important role in attainments in green technology utilization and thus resulted in a sporadic escalation for sustainability for raw materials and high-performance materials usage made from natural resources and indirectly or directly boosted the mammoth utilization in construction material domain industry and in its subsidiaries. The natural fibres which we obtain from nature are cheaper renewable goods that can be located with large supplies around the globe. Regarding the usage and utilization of naturally Fiber Reinforced Polymer Composites, it can be seen that they find a comprehensive broad base of industry utilization because of excellent specific strength, favourable mechanical properties, environmental camaraderie character and also they are biodegradable by nature. This Natural Fiber Reinforced Polymer Composites network mapping can be found in Figure 3 [Kamarudin et al.(2022)] while natural fibres that can be obtained from wood and non-wood-based plants are broadly classified as per Figure 4.

Fig 3: Network mapping of Natural Fiber Reinforced Polymer Composites (adopted from Kamarudin et al.2022)

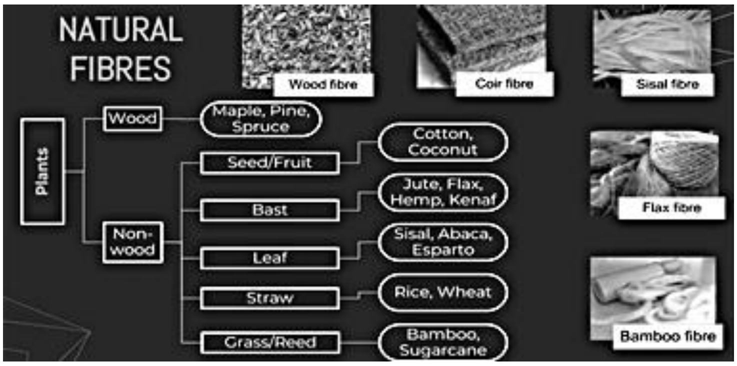

Fig 4: Natural fibres classification from wood and non-wood-based plants

Onuaguluchi and Banthia's (2016) in their research discussed natural fibre-reinforced cement composite's progress and also critically presented the several fibre types and characteristics properties and how they were affecting cement-based materials the authors put special emphasis on endurance stage settings of cement-based composites containing plant-based natural fibres. In another work, Ramesh et al.(2017) explored detailed research and presented a review paper pertaining to renewable green and sustainable materials and discussed in detail the comprehensive aspects of plant fibres which were utilized in bio-composites and which included their sourcing type, structural character, compositional nature, as well as their material and mechanical properties. Pacheco-Torgal and Jalali (2011) researched sustainable construction & cementitious building materials reinforced with vegetable fibres and presented a review paper about cementitious building materials reinforced with vegetable fibres and stressed fibre properties and traits of a matrix of the cementitious building materials reinforced with vegetable fibres. In another research paper, Torgal, and Jalali (2011) stressed the building materials based on renewable resources such as vegetable fibres and accordingly presented their research work on the utilization of natural fibres for concrete reinforcement which also included how to improve the fibre properties and suggested treatments to improve their performance utilization in the cement industry. Santos et al.(2015) presented a review highlighting the state-of-art approach and depicted the progress of processing vegetable fibres utilized in reinforcement and presented their, physiomechanical performance, the strength quality of non-conventional fibre-cement composites and also identified how the degradation of this non-conventional-vegetable-fibres-be utilized in reinforcement and thus it can be controlled and paving the way for a better sustainable housing construction arena.

C. Sustainability and research on Concrete using Bamboo Fibre as a Partial Replacement for Course Aggregate in Concrete

Concrete continues to hold a high place in demand for the civil constructional arena because it is having a lesser cost, and is fire& heat-resistant with a large ratio of availableness but it has a big disadvantage having a much lesser value of tensile strength characteristics. The construction barons and architects continue to utilize steel to reinforce the concrete. But steel is not easy to make and being a costly choice the world has now turned its eyes to a plant source Bamboo. Bamboo is available in plenty in nature and can be grown easily and it has a big advantage being very strong in both compressive and tensile force resistance. Numerous research studies about concrete using bamboo fibre have been presented in the last few decades and here we present some innovative experimental works carried out. Pandey and Singh (2017) presented experimental research on bamboo fibres being mixed in concrete and tried to measure the flexural and compressive stresses for the bamboo-reinforced concrete(both single and double reinforced beams) versus plain concrete bars beams. They found very encouraging results and the test beams showed an increase in strength and their value became double in fifty days of tests. In another study, Dudhatra et al. (2017) presented their research on bamboo-reinforced concrete by calculating the physical and mechanical properties which included flexural and compressive stresses as well. The results showed a reduction of slump value of self-compacting bamboo for a larger percentage of bamboo being considered and the authors concluded on the 56th day of experiments by showing that when they choose an increase in bamboo content pieces by 5% the test results depicted a decrease of the flexural strength of the concrete up to 15% to 20%. Bhowmik et al.(2017) put forward their research on Bambusa Balcooa species splint as an innovative reinforcing material for constructional concrete and brickwork beam manufacture. The authors utilized Bambusa Balcooa species splint beams using different percentages of bamboo reinforcement and evaluated the UTS (ultimate tensile strength) and found it out to be 288 MPa, and it showed a promising 4.9 times increase by utilizing Bambusa Balcooa species. Manimaran et al.(2017) presented a laboratory research evaluation and investigation on the strength traits involving quarry dust and bamboo incorporated into M40 concrete. The percentage of bamboo incorporated into M40 concrete according to volume basis was 0, 5%, 10%, 15%, 20%, and 25% which acted as a replacement for coarse aggregate utilized in industrial concrete. The final results depicted by the authors chose 15 % of bamboo replacement in M 40 concrete because with this value it remarkably showed an increase in flexural strength, compressive strength, split tensile strength and durable nature when compared to normal concrete. Sevalia et al.(2013)) presented experimental research and tried to evaluate the feasibility and utilization of Bamboo as reinforcement in concrete structures and beams without any formal treatment and stirrups of bamboo. The results were encouraging for the practical viewpoint of elasticity. In another work related to bamboo as reinforcement in concrete, Kute and Wakchaure (2013) presented experimental research on the Dendrocalamus strictus bamboo variety being utilized as concrete reinforcement with or without nodes. These Dendrocalamus strictus bamboo varieties were experimentally tested for change in dimension water absorption rate, tensile and bond strength in M20 concrete considering 20 different treatments. The authors also drew a comparison of the bond strength of TMT steel, mild steel and of untreated bamboo with that of bamboo having different low-cost treatments as well primarily for reduction of water absorption which resulted in enhancement of the bond strength of bamboo utilized in concrete.

III. CRITICAL REVIEW

The literature review reveals that the use of various additives and admixtures in concrete can significantly influence its properties, durability, and environmental impact. Chemical admixtures, such as polymers and superplasticizers, play a vital role in enhancing concrete performance and sustainability. Meanwhile, incorporating natural materials, like sugarcane juice or biopolymers, can mitigate early-age cracking and improve concrete properties. Moreover, internal curing using super absorbent polymers (SAPs) shows promise in reducing autogenous shrinkage and enhancing concrete's overall performance. Furthermore, the investigation of leaching behaviour in concrete with different additives and admixtures highlights the importance of understanding the environmental impact of such materials during their service life. This comprehensive literature review emphasizes the significance of using innovative and sustainable materials to develop a durable and environmentally-friendly concrete solution.

Further, this presented literature review has revealed the relationship of several natures of the mechanical, and physical behaviour of cementitious building materials which were considered as reinforced with vegetable fibres. The authors feel more clarifications and research are required in relation to the delaying effect of fibre inclusion and how the alkaline degradation can be tackled since it has not been understood yet the chemical interactions that occur considering the cement matrix and the natural fibres. Optimisation of improvement of natural fibre utilized in cement matrix compatibility needs to be worked and so also durability of fibre properties when subjected to toxic environment. The goal will be to control quality methods which are the need of the hour to ensure minimal variations in the properties of natural fibres. Also, we need to stress research on durability issues involving concrete structures reinforced with bamboo fibres because they have a promising field aiming towards sustainable construction. The mechanical performance of Long bamboo fibres reinforcement needs to be worked upon and so also we need to calculate the durability issues when these Long bamboo fibres are immersed in a cement matrix, Nevertheless, we can say that this literature review paper touched innovative and sustainable materials and is the first step towards the development of the sustainable future. It is meaningful to emphasize experimental studies which consider the practical applications of long and short Bamboo to be mixed in concrete. For practical application of the structure with bamboo, it seems to be important to consider the following conditions: 1) the criticality of designing the structure with long and short bamboo strips, 2) Combinations of materials which is being utilized (the concrete strength and type of bamboo being the major emphasis), 3) Workability of bamboo and Construction aspects and last but not the least 4) optimization of the durability-issues of bamboo when mixed in cement mortar and concrete.

IV. SAMPLE PREPARATION

The methodology recommended for the investigation of the use of bamboo chips and bio-admixture in cement mortar preparation can be outlined as follows:

1. Collection of Materials:
   - (i) White cement sample.
   - (ii) Normal river sand for sieve analysis.
   - (iii) Locally available 10 mm–20 mm crushed aggregates for coarse aggregates test as per IS: 2386-1963.
   - (iv) Bamboo chips pass through a 4.75 mm sieve.
   - (v) Vegetable extract, such as Okra, for the bio-polymer.
   - (vi) Normal tap water for most operations.

2. Preparation of Samples:
   - 2.1. Preparation of Normal Cement Mortar.
     - (i) Mix cement and sand in a dry state.
     - (ii) Add the required water and mix thoroughly.
   - 2.2. Surface Treatment of Bamboo Chips:
     - (i) Soak bamboo chips in water to remove dust and debris.
     - (ii) Immerse the chips in a certain percentage of NaOH solution for 24 hours for leaching alkalis.
   - 2.3. Preparation of Cement Mortar with Bamboo Chips:
     - (i) Mix fine sand and cement thoroughly.
     - (ii) Add pre-treated bamboo chips and mix them with different ratios.
   - 2.4. Extraction of Bio-Polymers:
     - (i) Collect vegetables, e.g., Okra, and cut them into small pieces.
     - (ii) Mix vegetable pieces with water in a predefined ratio.
     - (iii) Stir the mix thoroughly and allow it to stand for an hour.
     - (iv) Filter the extract using 300 μm and 150 μm sieves to remove any vegetable bits.
   - 2.5. Preparation of Polymer Coated Bamboo Chips:
     - (i) Treat bamboo chips with the prepared polymer to reduce moisture absorption.
   - 2.6. Mixing of Polymer Coated Bamboo Chips to the Cement Mortar:
     - (i) Mix the freshly prepared polymer-coated bamboo chips with the normal cement mortar in a certain percentage.

3. Determination of Properties:
   - 3.1. Determination of Free State Properties of Cement Composite:
     - (i) Determine the consistency of prepared specimens using Vicat's apparatus by varying the mixing liquid percentage.
   - 3.2. Determination of Hardened State Property:
     - (i) Cast mortar cubes in wooden moulds and allow them to harden for at least 24 hours.
     - (ii) Determine the compressive strength of cubes at 3, 7, and 28 days using a universal testing machine as per IS 516-1959.
   - 3.3. Evaluation of Cement Hydration Reaction:
     - (i) Mix cement with distilled water or bio-admixture and stir at room temperature.
     - (ii) Measure the conductance and Ca^{2+} ion concentration in the simulated cement pore solution at different time intervals.
     - (iii) Study the hydration of cement pastes with and without the presence of the bio-admixture using the paste hydration method.
     - (iv) Record FTIR spectra of hydrated samples using an FTIR spectrophotometer in the range of 400–4000 cm^{-1}.

The above methodology aligns with international standards and outlines the process of collecting materials, preparing samples, and determining the properties of cement composites with bamboo chips and bio-admixture. This standard methodology will guide the research investigation and provide essential data to evaluate the impact of using bamboo chips and bio-admixture as sustainable alternatives in cement-based materials.

V. CONCLUSION

In conclusion, the literature review highlights the significant impact of various additives and admixtures on concrete properties, durability, and environmental sustainability. Chemical admixtures, such as polymers and superplasticizers, play a crucial role in enhancing concrete performance. Additionally, incorporating natural materials, such as sugarcane juice or biopolymers, shows promise in mitigating early-age cracking and improving concrete characteristics. Moreover, internal curing using super absorbent polymers (SAPs) demonstrates the potential in reducing autogenous shrinkage and enhancing overall concrete performance. The investigation of leaching behaviour in concrete with different additives emphasizes the importance of understanding the environmental implications of these materials during their service life. Moving forward, the research emphasizes the need for further investigations to explore the mechanical behaviour of cementitious building materials reinforced with vegetable fibers, especially regarding fibre degradation and cement-fibre interactions. The comprehensive literature study sets the stage for future developments and practical applications, particularly in utilizing bamboo as a reinforcing material in concrete structures. The outlined methodology offers a standardized approach for investigating the use of bamboo chips and bio-admixture in cement mortar, paving the way for more sustainable and environmentally friendly concrete solutions. By embracing innovative and sustainable materials, the construction industry can progress towards creating durable and eco-conscious structures, ultimately contributing to a more sustainable built environment.

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