

Review on the Effect of Aloe Vera and Neem Extracts on the Strength and Durability of Eco-Friendly Concrete

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Abstract

Eco-friendly concrete has gained significant attention due to the growing need for sustainable construction materials that reduce environmental impact while maintaining structural performance. This study investigates the combined effect of aloe vera extract and neem extract as natural bio-admixtures on the strength and durability characteristics of eco-friendly concrete. Aloe-vera and neem extracts are cost effective, biodegradable, and readily available plant-based materials with potential water reducing, binding, and antimicrobial properties. The primary objective of this review is to evaluate the effect of aloe vera and neem extracts on fresh, mechanical, and durability properties of concrete. Concrete mixes incorporating ordinary Portland cement with partial replacement by supplementary cementitious materials are prepared, with aloe vera and neem extracts added in different proportions up to 10% by weight of mixing water. The performance of the modified concrete is assessed through workability tests and compressive strength tests at 7 and 28 days. Durability aspects such as water absorption, permeability, and resistance to chemical attack are also examined, indicate that the inclusion of aloe vera and neem extracts improves workability and enhances hydration characteristics at optimum dosages

Key Words: Aloe-vera, neem, workability, compression test, flexural strength.

1.INTRODUCTION

Concrete remains the most widely used engineered material in infrastructure owing to its exceptional compressive strength, structural adaptability, and cost-effectiveness. Its primary constituents cement, fine aggregate, coarse aggregate, and water form a composite material whose performance can be tailored through the use of admixtures. These admixtures influence fresh properties such as workability and setting time, as well as long-term performance including strength and durability. However, the environmental footprint of conventional concrete is substantial, especially due to the high energy demand and CO₂ emissions associated with Ordinary Portland Cement (OPC) production, which accounts for a significant share of global greenhouse gas emissions. This environmental concern has motivated research into sustainable additives and low-carbon cementitious systems to mitigate ecological impacts and improve resource efficiency.

Natural admixtures such as aloe vera have gained particular attention for their multifunctional properties in concrete technology. Aloe vera gel contains complex polysaccharides, organic acids, and minerals, which contribute to enhanced

workability, water retention, and potentially hydration control when used as a bio-admixture. Experimental investigations have demonstrated that aloe vera gel can improve workability and mechanical characteristics; for instance, concrete mixed with aloe vera gel showed enhanced flexural strength at 28 days when optimal dosages were used (Oshim et.al). Similarly, researches reported improved compressive strength, tensile strength, and water absorption characteristics with specific proportions of aloe vera gel acting as a self-curing agent, highlighting its potential as a sustainable alternative to conventional admixtures (M.Tadesse). Other concrete research has also shown increased compressive strength and reduced permeability in mixtures containing plant mucilage including aloe vera (Evelyn Katherine Barco-Tocto et.al).

In parallel, neem a widely distributed tropical tree with well-documented medicinal and antimicrobial qualities, has been explored for its utility in concrete both as a natural corrosion inhibitor and as a functional additive affecting mechanical behaviour. Neem leaf extract has been studied as a corrosion-inhibiting agent for steel reinforcement in concrete exposed to chloride environments, where it preserved concrete integrity without adversely affecting mechanical properties (B. Valdez-Salas et.al). Beyond corrosion inhibition, research utilizing neem seed powder and neem extract in concrete mixtures has reported beneficial influences on compressive strength and durability indices, suggesting that neem derivatives could serve dual roles in eco-friendly admixture systems (R. Dharmaraj et.al). Experimental investigations also indicate that neem extract may contribute to crack healing and improved durability when used as an indigenous additive for self-healing concrete applications (P. Nimitha et.al).

2. ALOE VERA-MODIFIED CONCRETE

2.1 Material Properties

Aloe-vera fibres are eco-friendly materials that possess several beneficial properties, including low density, light weight, low cost, high tensile strength, and resistance to water and fire (C. Arulmani et al.). The 28-day compressive strength and split tensile strength of concrete were found to be higher than those of conventional concrete when aloe vera resin and 1% jute fibre were used (B. Muhi Malini et al. and Shanmugavel T. et.al). By use of plant derived products in construction may reduce the emission of this embodied energy and at the same time strength of this concrete is also maintained by use of jute fibre, aloe-vera which are added in the proportion of 0.5%, 1%, 1.5%, 2% to the weight of cement and quantity of water (V. Anujayasree et.al). Aloe-vera mucilage is a sticky gel taken from the leaves of the aloe vera plant and is considered a useful admixture in concrete.

Aloe-vera is a plant that grows well in dry and semi-dry areas and has been widely used around the world for medicinal and cosmetic purposes. Studies show that adding aloe vera mucilage to concrete can improve workability, increase compressive strength, help reduce corrosion of steel, and also aid in producing porous concrete. However, the influence of aloe vera mucilage on the flow behaviour (rheology) and its ability to reduce water content in green self-compacting concrete made with LC3 is still not clearly understood. A dosage of 2.5% aloe vera mucilage resulted in a noticeable improvement in compressive strength for both ordinary Portland cement and LC3 concrete samples. In general, aloe vera mucilage performed similarly to a commercial plasticizer, as both reduced yield stress and increased slump flow (Andrew Nyabuto Onderi et.al). Aloe-vera extract inhibited the corrosion of zinc in 2 M HCl solution and the inhibition efficiency increased with increasing concentration of the extract but decreased with increasing temperature (Olusegun K.Abiola). The aloe-vera leaf has a bark covering its entire surface. Beneath the bark is a thin vascular layer in the form of a yellow gel. Inside is a white pulp (Eshun). Aloe-vera gel acts as an effective, eco-friendly (green) corrosion inhibitor for mild steel in acidic environments 1 M HCl (Singh et.al). Aloe-vera gel contains over 70% saccharides and polysaccharides (Femenia et.al). Aloe vera is composed of several high molecular weight heterocyclic compounds (Avwiri et.al).

2.2 Effect of aloe vera on strength and durability of concrete

The increasing demand for sustainable construction materials has directed research towards the utilization of natural and biodegradable additives in concrete to reduce environmental impact while maintaining or enhancing structural performance. Among various plant-based materials, Aloe Vera gel and neem-based additives have emerged as promising alternatives due to their availability, eco-friendliness, and beneficial chemical composition. Several studies have examined their influence on workability, strength development, self-curing ability, and durability of concrete.

The influence of aloe vera gel as a natural admixture on the flexural strength of concrete using mix ratios of 1:1.5:3 and 1:3:5 with a constant water–cement ratio of 0.6. AVG was incorporated at levels ranging from 0.5% to 5% by weight of cement, and both fresh and hardened properties were evaluated at curing ages of 7, 21, and 28 days. The results indicated that aloe vera gel improved workability and flexural strength, with the optimum performance observed at 2% AVG at 28 days. A mathematical prediction model developed using Ibearugbulem's regression method was validated using the Student's T-test, proving its reliability. The study concluded that aloe vera gel can effectively enhance flexural strength while contributing to sustainable concrete production (Oshim et.al).

The effect of aloe vera gel on the compressive strength of concrete and developed a regression-based predictive model. Concrete specimens were prepared using two mix ratios with AVG content varying from 0.5% to 5%, and a total of 264 cubes were tested up to 28 days. The study showed that Aloe Vera gel significantly improved workability and compressive strength, particularly in the richer mix. The optimum compressive strength was achieved at 2% aloe vera gel, beyond which strength gains diminished. The predictive model demonstrated

high accuracy at a 95% confidence level, confirming Aloe Vera gel as a reliable eco-friendly admixture (Onwuka et.al)

An experimental investigation on aloe vera gel as a self-curing agent in C-30 grade concrete. Aloe-vera gel was added in proportions ranging from 0% to 3% by weight of cement, and concrete properties such as workability, compressive strength, split tensile strength, flexural strength, water absorption, drying shrinkage, and setting time were evaluated. The results showed that aloe vera gel enhanced internal curing by retaining moisture, thereby improving hydration and strength development. An optimum dosage of 2% aloe vera gel was found to provide balanced performance in terms of strength and durability. Although slight increases in drying shrinkage and setting time were observed, they remained within permissible limits, highlighting the suitability of aloe vera gel as a sustainable self-curing agent (Meron Tadesse).

The application of aloe vera gel as a natural water-reducing admixture in concrete. Aloe-vera gel was incorporated in proportions up to 2.5%, and fresh and hardened properties were analysed. The study reported a significant enhancement in workability, with up to a 57% increase in slump, while compressive strength increased by approximately 10% at higher aloe vera gel contents.

The research emphasized that aloe vera gel improves ease of placement and compaction without compromising strength, making it a cost-effective and eco-friendly alternative to chemical plasticizers (Fareed Ahmed Memon et.al.)

The broader development of non-conventional and sustainable concrete systems, highlighting the importance of alternative materials such as aloe vera to overcome the inherent tensile weakness and environmental drawbacks of conventional concrete. The study emphasized that natural additives and fibers can enhance tensile performance and durability while reducing dependence on synthetic materials. The work supports the integration of aloe vera-based additives in eco-friendly concrete applications (A.S. Shalini et.al.)

The combined effect of aloe perfoliate gel and sisal fibers on the strength and corrosion resistance of concrete. Using M20 grade concrete, various combinations of aloe gel and sisal fibers were tested to identify the optimal mix. The results revealed that the combination of 1% aloe gel and 2.5% sisal fibers produced maximum tensile strength, flexural strength, and durability. The study highlighted the synergistic action of natural fibers and plant-based gels in improving crack resistance, bonding characteristics, and corrosion resistance of concrete (Jayaraman Ariyagounder et.al)

3. NEEM EXTRACT–MODIFIED CONCRETE

3.1 Material Properties

Neem is a widely recognized medicinal plant in India and nearby regions, known for its diverse applications in medical science and its wide range of biological properties. It has been traditionally used in Ayurvedic, Unani, Homeopathic, and Siddha systems of medicine, as well as in skin and hair care treatments, and has gained importance in modern medicine (Nidhi Rahul Kunjar & Anupama Shrivastav). The extract from neem leaves has attracted particular attention due to the collective corrosion protection results proposed for different metals exposed over critical corrosion conditions. It is important to mention that the neem tree is easy to cultivate since

it has a rapid growth rate in different climates and can be easily harvested in accordance with a sustainable scheme (Valdez-Salas et.al).

3.2 Effect of neem extract on strength and durability of concrete

The effect of neem-gum-powder as an admixture on Grade 20 concrete, adding it at 0.5%, 1.0%, 1.5%, and 2.0% by weight of cement, and found that neem gum powder increased both compressive strength (up to 23.81 N/mm² at 1.5%) and tensile strength (up to 9.52 N/mm² at 1.5%), also improving workability by acting as a plasticizer and reducing water requirement, concluding that neem gum powder can enhance concrete strength and sustainability, offering an eco-friendly alternative to commercial admixtures for concrete production (Aliyu, Y., et.al).

The effect of neem extract on concrete properties. Neem extract was used as an admixture, added at various percentages to the concrete mix. The study found that Neem extract improved the compressive strength of concrete, with optimal results at a certain dosage. The workability of concrete also showed improvement. The researchers suggest that neem extract can be a potential natural admixture for sustainable concrete production, contributing to eco-friendly construction practices (M.G.L.Annaamalai et.al).

The effect of neem gum powder on concrete properties. Neem Gum Powder was used as an admixture in concrete, improving workability and strength. The study found NGP increased compressive and tensile strength, with optimal performance at 1.5% neem gum powder. The researchers suggest neem gum powder as a sustainable alternative to commercial admixtures, promoting eco-friendly construction. Additionally, neem gum powder enhanced concrete durability and reduced water requirement, making it a promising eco-friendly option for construction projects. The study's findings support the use of natural admixtures in concrete production, contributing to more sustainable building practices (S. Raghuram et.al).

4. COMBINED ACTION OF ALOEVERA AND NEEM ON CONCRETE

The effect of aloe-vera and neem extracts on the mechanical and durability properties of concrete exposed to saline environments. A comprehensive experimental program involving compressive, tensile, and flexural strength tests, along with carbonation and corrosion assessments, was conducted. The study found that the optimal combination of 2% neem and 0.5% aloe vera significantly enhanced strength and reduced corrosion rates. The denser microstructure formed due to the presence of aloe-vera gel improved durability under aggressive environmental conditions, indicating its suitability for long-term structural applications (Evelyn Katherine Barco-Tocto et.al).

The incorporation of neem powder in concrete to enhance strength performance. Neem powder was added in proportions up to 0.5% by weight of cement, and beam specimens were tested for compressive and split tensile strength. The results indicated a continuous increase in compressive strength with increasing neem content, while split tensile strength reached an optimum value at 0.2% neem powder after 28 days. The study concluded that neem powder acts as an effective natural additive that enhances bonding and strength due to its chemical and antimicrobial properties (S. Raghuram).

An empirical study on self-curing concrete using natural additives, emphasizing the role of plant-based materials in improving internal moisture retention and hydration. The study highlighted that natural self-curing agents reduce water consumption, shrinkage cracking, and labour requirements while enhancing durability. However, the authors identified challenges related to dosage optimization and material variability, recommending further experimental research to standardize mix designs (Panneerselvam et.al).

5. CONCLUSIONS

Aloe-vera and neem extracts can be effectively used as natural, eco-friendly bio-admixtures in concrete. The incorporation of these plant-based materials offers multiple benefits in terms of workability, strength development, and durability characteristics while reducing dependence on chemical admixtures. A notable improvement in workability due to the water-retention and plasticizing properties of aloe-vera gel and neem derivatives. At optimum dosages, both materials contribute to enhanced hydration, improved particle bonding, and better compaction of concrete. The compressive, tensile, and flexural strength of concrete generally increase at optimal replacement levels, while excessive dosages may lead to marginal strength reduction. It is observed that the early-age strength development may be relatively moderate, particularly in mixes incorporating higher proportions of natural extracts, owing to delayed hydration and ongoing biochemical interactions. However, the long-term strength beyond 28 days shows significant improvement, indicating the positive influence of sustained pozzolanic and hydration processes. Improved durability performance of concrete containing Aloe-vera and neem extracts, including reduced water absorption, enhanced resistance to chemical attack, corrosion mitigation, and improved performance under aggressive environments such as saline exposure. The combined use of aloe-vera and neem demonstrates a synergistic effect, resulting in denser microstructure and superior long-term performance compared to individual usage. Overall, aloe-vera and neem extracts present a sustainable and cost-effective alternative for developing eco-friendly concrete, contributing significantly to green construction practices.

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