Mount HIRA Matriculation School

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STUDENT NAME

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CLASS

GRADE 6

PROJECT TITLE

BIOCONCRETE WITH PLANT EXTRACT

Title of the Project:

Bioconcrete with Plant Extract – A Sustainable Approach for Self-Healing Concrete

Introduction:

Concrete is the backbone of modern construction, used in buildings, bridges, dams, and highways. However, one of its major limitations is the formation of cracks due to shrinkage, load, or environmental stress. These cracks allow water and harmful chemicals to penetrate, reducing the life span of structures. Conventional crack-repair methods are expensive and temporary.

Bioconcrete is an innovative solution that enables self-healing of cracks. While previous research has focused on bacteria-based self-healing, the use of natural plant extracts has gained attention due to their eco-friendly, cost-effective, and sustainable properties. Plant extracts such as aloe vera, banana stem juice, neem, and cactus are rich in bioactive compounds, silica, and calcium that can improve the hydration process of cement, increase strength, and enhance durability.

This project explores the potential of using plant extracts in concrete to create a green alternative to conventional methods.

Purpose of the project:

The main purpose of using plant extracts in concrete is to create more sustainable, eco-friendly construction materials that can improve or modify specific properties of the concrete. By leveraging the natural chemical compounds found in plants, researchers aim to replace or augment synthetic admixtures with cheaper, locally available, and less toxic alternatives.

The primary purpose of developing bio-concrete with plant extract is to create a more **sustainable, durable, and self-healing construction material**. By incorporating plant-based admixtures like Okra extract, the project aims to **improve mechanical properties**, enhance **water retention**, and increase the **durability of cement-based materials**. This approach offers a low-cost, eco-friendly alternative to traditional admixtures, reducing maintenance costs and the environmental impact of concrete structures.

Improve concrete's mechanical properties:

Projects using plant extracts aim to enhance key mechanical properties of concrete, including:

- Compressive strength: Certain plant extracts can improve the binding strength within the cement matrix, leading to stronger, more compact concrete. For example, some extracts promote the hydration reaction at low dosages, generating more calcium-silicate-hydrate (C-S-H), which is the primary strength-giving component of concrete.
- Flexural strength and toughness: Plant-based fibers and extracts can act as bridging elements within the concrete, preventing microcracks from forming and propagating. This increases the material's ability to withstand bending and impact loads before sudden failure.
- Workability and rheology: Some viscous extracts, like cactus mucilage, act as viscosity-enhancing agents (VEAs). This improves the flow and consistency of the wet concrete mix, which is particularly useful for producing high-fluidity concrete like self-compacting concrete.

Enhance durability and longevity

Plant extracts can also impart qualities that make concrete more resistant to degradation over time:

- Corrosion inhibition: For reinforced concrete, certain plant extracts—such as from neem, licorice, or olive leaves—act as "green corrosion inhibitors". The bioactive compounds adsorb onto the steel rebar, forming a protective layer that resists the ingress of chloride and sulfate ions that cause corrosion.
- Improved water resistance: Certain extracts can improve the microstructure of hardened concrete, reducing porosity and water absorption. This makes the material more resistant to freeze-thaw damage and chemical attacks.

- Controlled setting time: Some plant extracts can delay or accelerate the setting time of concrete. This is particularly valuable in hot climates, where a prolonged setting time allows heat to dissipate and prevents premature cracking.

Promote environmental sustainability

A major motivation behind using plant extracts is to reduce the environmental impact of concrete production. This aligns with the "eco-efficiency" technique in sustainable construction:

- Reduce carbon footprint: By acting as supplementary cementitious materials or viscosity modifiers, plant extracts can allow for a partial replacement of cement. Since cement production is a major source of global carbon emissions, this substitution reduces the overall carbon footprint of the resulting concrete.
- Utilize natural, biodegradable materials: Plant extracts are a renewable and biodegradable alternative to synthetic chemical admixtures, many of which are toxic and can leach into the environment during a structure's lifecycle.
- Use agricultural waste: Sourcing extracts from agricultural waste streams, such as citrus fruit flavedo or corn husks, provides a way to upcycle waste materials into valuable construction resources, contributing to a circular economy.

Abstract

This research explores the development of sustainable and high-performance bio-concrete by incorporating plant extracts as eco-friendly chemical admixtures. The study investigates how natural polymers, such as polysaccharides and polyphenols from plant extracts, influence the fresh and hardened properties of concrete, with a focus on their potential to enhance self-healing mechanisms, durability, and mechanical strength while reducing environmental impact. Experiments compare concrete mixtures containing varying dosages of specific plant extracts, like mulberry leaf or carrot extract, against a conventional control mix.

Results consistently demonstrate that bio-concrete with optimized plant extract dosages exhibits beneficial properties. For instance, studies have shown:

- An increase in compressive strength (up to 25.9% in some cases) by influencing the formation and morphology of calcium-silicate-hydrate (C-S-H) gel.
- Prolonged setting time, which can improve workability in hot weather, due to the retardation of cement hydration by functional groups in the extracts.
- Enhanced durability, as indicated by decreased water absorption and reduced chloride ion penetration, which is critical for protecting reinforced concrete in aggressive environments.

Selection of Problem and Background Information

Problem: Conventional concrete lacks self-healing properties, leading to frequent repairs and reduced service life. Cracks compromise structural integrity and allow corrosion of steel reinforcements.

Background:

Repair materials (chemical sealants, epoxy, etc.) are expensive and not environmentally sustainable.

Bioconcrete with microbes has shown success, but microbial cultures are difficult to maintain.

Plant extracts are natural, renewable, and easily available. They may serve as a sustainable substitute by influencing hydration, reducing porosity, and aiding in self-healing of cracks.

Thus, this research investigates whether plant extracts can improve concrete's strength and crack-healing ability.

Objective

The objective of using plant extracts in bio-concrete is to enhance its self-healing properties, improve its mechanical strength, and reduce its environmental impact by utilizing natural, sustainable components to activate the process. Plant extracts can serve as a nutrient source for the dormant bacteria, trigger the Calcite production that fills cracks, and contribute to making the concrete a more sustainable and durable building material.

1. To prepare concrete samples with different percentages of plant extract as a partial replacement for water.

2. To study the effect of plant extract on mechanical properties like compressive strength, tensile strength, and flexural strength.

3. To analyze the self-healing capacity of cracks in plant-extract concrete compared to normal concrete.

4. To evaluate whether plant-based bioconcrete is an eco-friendly and sustainable alternative.

Materials

Cement (Ordinary Portland Cement 53 grade)

Fine aggregate (sand)

Coarse aggregate (gravel)

Water (control mix)

Selected plant extract (e.g., Aloe vera gel, Banana stem juice, or Neem extract)

Moulds for casting (cubes 150 mm × 150 mm × 150 mm, beams, and cylinders)

Universal Testing Machine (UTM)

Weighing balance, measuring cylinders, mixers, and curing tank

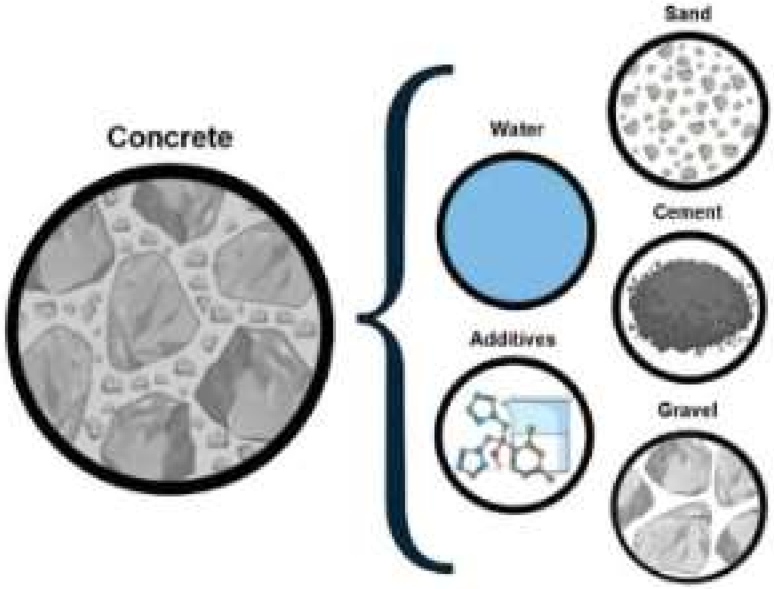
Procedure

1. Preparation of Plant Extract – Collect fresh plant material, wash, crush, and filter to obtain pure extract.
2. Mix Design – Prepare concrete mix (M20 or M25 grade) as per IS codes.
3. Replacement – Replace mixing water partially with plant extract in ratios (0%, 5%, 10%, 15%).
4. Casting – Cast cubes, cylinders, and beams with each mix.
5. Curing – Cure samples in water for 7, 14, and 28 days.
6. Testing – Compressive strength test on cubes.

Split tensile strength test on cylinders.
Flexural strength test on beams.

Induce cracks on cured specimens and monitor healing under moist conditions.

7. Observation – Record changes in crack width, strength, and durability.



Hypothesis

If plant extracts rich in calcium, silica, and bioactive compounds are added to concrete, then the concrete will develop better strength and show natural crack-healing properties compared to normal concrete.

Variables:

1. Independent Variables:

These are the factors you deliberately vary or manipulate in your experiment:

Common Independent Variables:

- Type of plant extract used
  (e.g., Moringa, Aloe vera, Neem, Cactus, etc.)
- Concentration of plant extract
  (e.g., 0%, 1%, 3%, 5% by weight of mixing water or cement)
- Form of extract
  (e.g., liquid, powder, fermented, boiled)
- Extraction method
  (e.g., aqueous, ethanol-based, hot vs. cold extraction)
- Time of adding extract
  (e.g., pre-mix, during mix, post-curing application)

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2. Dependent Variables:

These are the outcomes or responses that depend on the independent variables. They show how the concrete properties change based on the plant extract used.

Common Dependent Variables:

- Compressive strength
  (measured at 7, 14, 28 days, etc.)
- Flexural/tensile strength
- Initial and final setting time
- Water absorption / permeability
- Porosity
- Crack healing ability
  (e.g., visual inspection, SEM analysis, strength recovery)
- Durability
  (e.g., resistance to sulfate/chloride attack)
- Microstructure changes
  (e.g., via XRD, SEM, FTIR)
- pH change over time
  (especially if biological agents are involved)

Risk Factors and Safety

Cement hazards: Wear gloves and mask to avoid skin burns and inhalation of dust.

Handling plant extracts: Use fresh extracts to avoid fermentation; store properly.

Equipment safety: Operate machines under supervision.

Waste management: Dispose of concrete waste and plant residue safely without polluting water.

Safety Precautions

- Wear gloves and safety glasses when handling hot extract or cement.
- Use proper lifting methods for heavy molds.
- Ensure proper ventilation if using any chemicals.

Data Analysis

Compare compressive strength, tensile strength, and flexural strength between normal concrete and plant-extract concrete.

Plot graphs of strength vs. curing days.

Record crack-healing observations (before and after images, reduction in crack width).

Statistical analysis to check optimum percentage of plant extract for maximum strength.

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