MARATHA VIDYA PRASARAK SAMAJ'S

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## DEPARTMENT OF CIVIL ENGINEERING

# SANRACHANA

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***Department Vision:***

*To be the leading department providing quality education to develop competent Civil Engineers, Entrepreneurs, and innovators to serve the nation.*

***Department Mission:***

*M1- To provide quality technical education.*

*M2- To prepare competent students for employment.*

*M3–To focus on developing values and professional skills.*

***Program Educational Objectives:***

*1. To ensure that graduates will have a mastery of fundamental knowledge, problem solving skills, engineering experimental abilities, and design capabilities necessary for entering civil engineering career and/or graduate school.*

*2. To incorporate verbal and written communication skills necessary for successful professional practice.*

*3. Demonstrate knowledge of management principles and engineering techniques for effective project management.*

*4. To prepare graduates to deal with ethical and professional issues, taking into account the broader societal implications of civil engineer.*

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# 1. Bacterial Concrete: Pioneering Sustainability in Construction

**Ritesh Deore, Yuvraj Pagar, Suraj Bhadane, Pranav Karve (BE Civil)**
**Dr. A. P. Shelorkar, Associate Professor, Mr. S. M. Waysal, Assistant Professor**

## Introduction

Concrete is the backbone of modern infrastructure, forming the basis of roads, bridges, buildings, and various other structures. However, the durability of concrete is not without its challenges; over time, cracks can develop due to various factors, necessitating costly repairs. Traditional methods of concrete repair often entail the use of materials that are resource-intensive and environmentally harmful. In response to this issue, the construction industry is turning to innovative and sustainable solutions, and one of the most promising of these solutions is bacterial concrete, also known as self-healing concrete. Bacterial concrete is a technology that relies on the metabolic activities of certain calcium-producing bacteria to autonomously repair cracks in concrete structures. In this article, we will embark on a comprehensive journey into the world of bacterial concrete, delving into its composition, mechanisms, applications, and environmental benefits. We will also discuss the challenges faced by this technology and the exciting opportunities it offers for the future of sustainable construction.

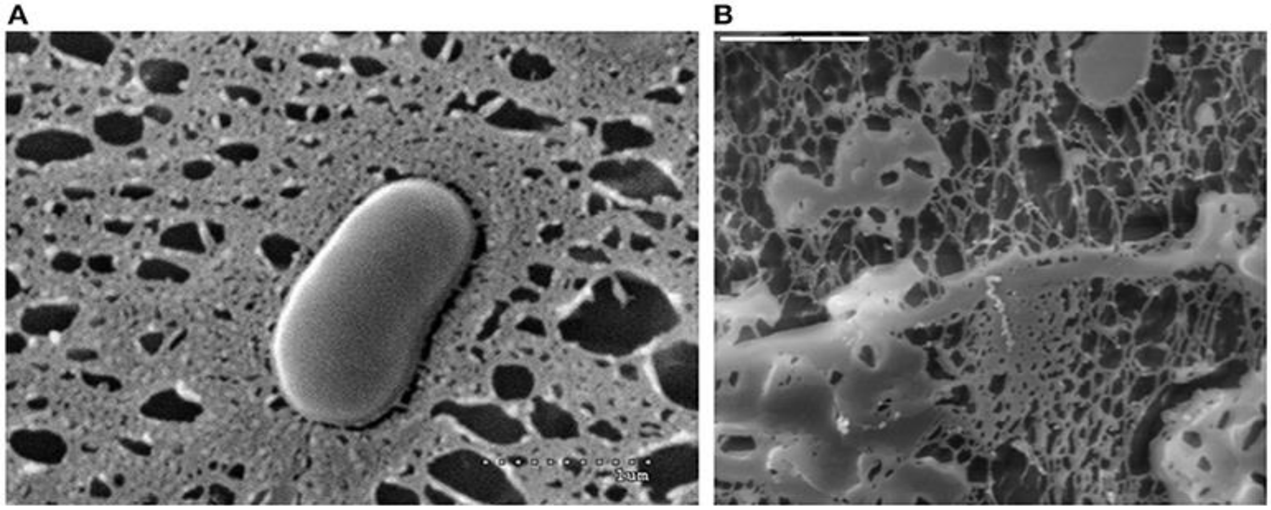
## The Composition of Bacterial Concrete

### The Concrete Matrix

At its core, bacterial concrete maintains the essential elements of traditional concrete, including cement, aggregates, and water. The concrete matrix is the backbone of any concrete structure, providing it with structural integrity and support. It is within this matrix that the magic of bacterial concrete takes place, as it serves as the protective environment for the calcium-producing bacteria.

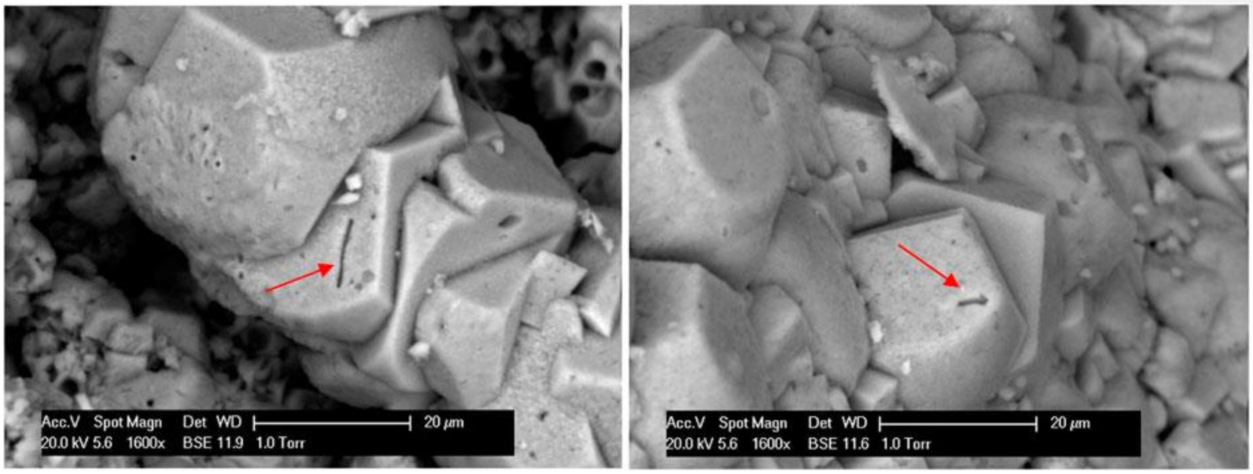
### Calcium-Producing Bacteria

The key component that sets bacterial concrete apart is the inclusion of calcium-producing bacteria. Typically, bacteria from the Bacillus or Sporosarcina genera are employed for this purpose. These bacteria are capable of forming calcium carbonate (CaCO3) as part of their metabolic activities. When a crack forms in the concrete, these bacteria play a pivotal role in sealing the breach, preventing further deterioration.



### Nutrient Medium

For the bacteria to thrive and engage in their self-healing process, a nutrient medium is introduced into the concrete mix. This medium acts as a source of nutrients, including calcium lactate, which serves as the precursor to calcium carbonate production. Calcium lactate provides the necessary calcium ions for the bacteria to perform their repair work when a crack emerges.



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The self-healing process in bacterial concrete is a fascinating and highly effective one. It unfolds in three essential steps:

### Activation

Bacterial concrete holds its secrets until a crack forms in the structure. As soon as this breach emerges, it provides a pathway for moisture and air to enter. Prior to this, the bacteria remain dormant within the concrete matrix.

### Bacterial Metabolism

Upon contact with water, the previously dormant bacteria come to life, initiating their metabolic activities. They feed on the calcium lactate present in the nutrient medium, and as they do so, they produce calcium carbonate as a byproduct. This calcium carbonate forms within the crack, effectively sealing it.

### Crack Sealing

As the calcium carbonate accumulates within the crack, it acts as a natural sealant. It reinforces the concrete structure, preventing further propagation of the crack and inhibiting the penetration of moisture and harmful substances. This process not only restores the structural integrity of the concrete but also ensures that the crack is sealed in an eco-friendly and sustainable manner.

Applications of Bacterial Concrete

The potential applications of bacterial concrete are vast and promising. It can be effectively used in the construction of various types of structures, each benefiting from its self-healing properties. Some of the most prominent applications include:

### Infrastructure

Bacterial concrete is particularly well-suited for the construction of critical infrastructure, such as bridges, tunnels, and highways. By increasing the durability of these structures, bacterial concrete can significantly reduce maintenance costs and extend their service life.

### Residential and Commercial Buildings

In residential and commercial construction, bacterial concrete offers a sustainable solution to the common problem of cracks and degradation in concrete structures. The implementation of bacterial concrete can enhance the longevity of buildings, reduce repair costs, and ensure a longer service life.

### Marine Structures

Structures exposed to harsh marine environments, such as seawalls, docks, and offshore platforms, are highly susceptible to damage due to the corrosive nature of saltwater. Bacterial concrete's ability to self-heal cracks and prevent further deterioration makes it an ideal choice for these applications.

## Environmental Benefits of Bacterial Concrete

The adoption of bacterial concrete offers numerous environmental benefits, aligning with the global shift towards sustainable construction practices:

### Reduced Carbon Footprint

By extending the life of concrete structures and reducing the need for frequent repairs and replacements, bacterial concrete has the potential to significantly decrease the carbon footprint associated with the construction industry. Traditional concrete repair methods often involve energy-intensive processes and the use of materials that contribute to greenhouse gas emissions. Bacterial concrete helps mitigate these environmental impacts.

### Sustainable Building Practices

Bacterial concrete is a prime example of sustainable building practices. It promotes resource efficiency, reduces waste, and minimizes the negative environmental effects associated with traditional construction methods. As such, it aligns with global efforts to promote sustainable and eco-friendly construction techniques.

## Challenges and Future Prospects

As with any emerging technology, bacterial concrete faces its own set of challenges and opportunities.

### Bacterial Survival and Activation

Ensuring the long-term survival and activation of bacteria within concrete remains a challenge. Environmental factors, as well as the specific composition of the concrete mix, can influence the performance of the bacteria. Continued research is needed to optimize these conditions.

### Scale-Up and Cost

The commercial-scale production of bacterial concrete and the cost-effectiveness of integrating bacteria into construction materials are areas that require further investigation. Currently, the production of bacterial concrete remains more expensive than traditional concrete, but ongoing research may yield cost-saving strategies.

### Standards and Regulations

To facilitate the widespread adoption of bacterial concrete, standards and regulations for its use in construction must be established. This will ensure the safe and reliable implementation of this innovative technology.

## Conclusion

Bacterial concrete represents a groundbreaking and sustainable approach to improving the longevity and durability of concrete structures. By harnessing the metabolic abilities of calcium-producing bacteria, this technology has the potential to revolutionize the construction industry. It not only reduces maintenance costs but also contributes to environmental sustainability, aligning with global efforts to reduce the carbon footprint of construction. Bacterial concrete, while still in its infancy, holds great promise. As research continues to address existing challenges, this innovative solution has the potential to play a vital role in the construction industry's journey toward a more sustainable and environmentally responsible future.

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## 2. Concrete 3D printing

**Pallavi Chaudhari, Arjun Singh (BE Civil)**

**Introduction:**

in this new era of automation technology, we need to develop our concrete world along new ideas. in this era world is running towards new infrastructure with less construction time and errors. one of the best ideologies is concrete 3d printing technology in which automation technology is used in constructure technology. William. Urschel invent the world’s first concrete 3d printer. this technology is one of the famous acceptable technologies in all over the world. the Asia pacific region is rapidly growing market for concrete 3d printing technology. the countries like China and Japan are investing heavily in this technology. Europe and north America are also interesting adoption of concrete 3d printing technology in construction industry. in global, 3d concrete printing market was valued at usd 310 million in 2020 and is projected to reach usd 40.652 billion by 2028. concrete 3d printing technology allows for the creation of complex and customized structure with less waste and faster production times than tradition construction method

concrete 3d printing is the technology in which concrete layers are laid one over the other using an automated robotic system. the system consists of a pump and extruder along with a print head. the entire printing process is streamlined with the help of software integrating the machine & material parameters. the 3d concrete printing process typically involves the use of a robotic arm or gantry system, which moves the printer nozzle along a pre-programmed path to deposit the concrete layer by layer. the printer uses a specially formulated concrete mixture that has been optimized for printing, which may include additives to improve the material's properties, such as strength and durability. the applications of 3d concrete printing are diverse and include the production of architectural elements, building components, bridges, and even entire houses. in recent years, the technology has gained traction in the construction industry, with several companies and research organizations investing in research and development to improve the technology and explore its potential applications.

**special features of 3d printing system are**

1. design freedom
2. construction efficiency
3. labor safety
4. no requirement of formwork
5. automations

**top companies in concrete 3d printing market**

1. foster + partners limited
2. sika
3. tvasta manufacturing solutions
4. xtreee
5. heidelberg cement
6. monolite uk
7. apis cor
8. carillion plc
9. kier group plc
10. lafargeholcim ltd

11. winsun, cybe construction
12. skanska ab,
13. balfour beatty plc

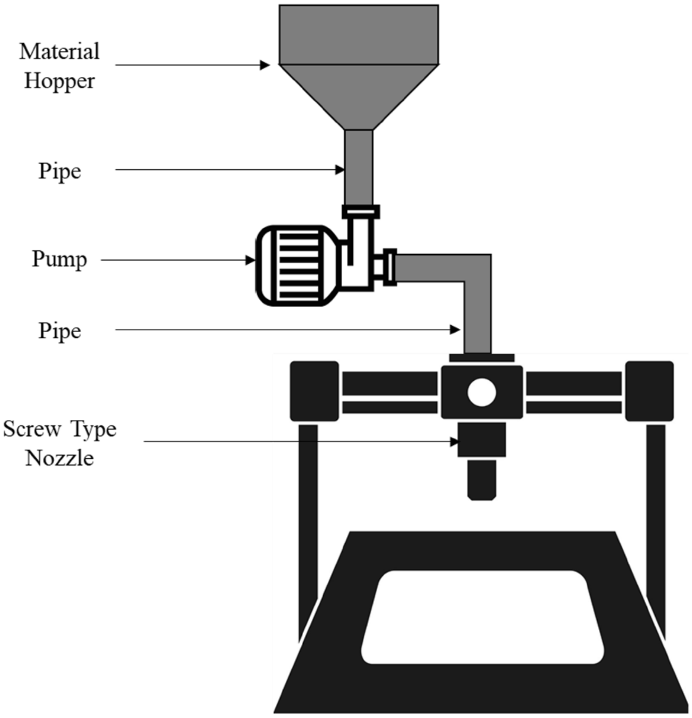

fig 1 structural components of concrete 3d printer

Despite its potential, there are several challenges that the 3d concrete printing technology faces. some of the significant challenges are:

**material properties**
**scalability**
**cost**
**standardization**
safety and regulatory challenges
**complexity of design**

**Opportunities:**

The 3d concrete printing technology offers several opportunities for businesses and individuals to innovate, improve efficiency, and create sustainable solutions in the construction industry. by embracing these opportunities, businesses and individuals can stay ahead of the competition and meet the increasing demand for sustainable construction practices.

**case study:**

### Bengaluru’s 3d-printed marvel

The 3d-printed post office in Bengaluru stands as a beacon of innovation. completed in a mere 43 days, two days ahead of its deadline, this structure spans over 1,021 square feet. constructed by Larsen and toubro with technical guidance from iit madras, the project exemplifies the efficiency and precision of 3d printing in construction. the choice of 3d printing technology for this project was driven by its cost-saving potential and the ability to deliver quality at speed.

### Cost-effective solutions

Furthermore, the use of 3d printing technology led to substantial cost savings. The entire construction was accomplished at a cost of Rs 23 lakh, translating to a reduction of around 30-40% compared to conventional method.

### The future of 3d-printed construction

The success of the 3d-printed post office in bengaluru is a clear indicator of the vast potential 3d-printed construction holds, not just in india but globally. As urban populations swell and the demand for infrastructure grows, 3d-printed buildings offer a sustainable and efficient solution.

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## 3. Group Technique for Order Preference by Similarity to Ideal Solution (GTOPSIS) for Risk in Public Private Partnership (PPP) Road Projects

**Mr. R. C. Patil, Assistant Professor**

With an increase in demand for infrastructure in India which actually contributes to the economic as well as the overall development, there is huge certainty for accumulation or entering the project into risk. Existing models for PPP of roads such as Built Operate and Transfer (BOT) and Hybrid Annuity (HAM) model are not the exception ones. Identification of risks on field is bit a tougher job as limitation in data availability and making the risks quantitative from qualitative becomes much more difficult because of no factors of judgment are available. There seems a way of light if some rating methodology is developed to deal with conversion so that the analysis can be done using quantitative data generated. The research adopts an integrated approach to prioritize risks using group technique for order preference by similarity to ideal solution (GTOPSIS). The analysis can help improve the understanding of implications of specific risk factors on project completion time and cost. This enables the project manager to devise a suitable strategy for risk response and mitigation.

Moreover, if risks are to be prioritized using GTOPSIS. A multi-criteria-based decision-making system called Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was developed in the 1980s. TOPSIS is a method for allocating ranks based on the importance and weights of the given factor. Weights indicate how much a particular factor should be taken into account. Impact denotes whether a certain factor has a favorable or unfavorable effect. GTOPSIS is a variation of TOPSIS with multiple decision-makers. Due to the fact that estimates offered by experts for risk analysis frequently reflect their pre-existing biase (against particular risk variables), it is crucial to have a diverse group of decision makers and to use group decision making techniques. Incorporating collective decision-making reduces this impact while performing risk analysis. Last but not least, GTOPSIS is incredibly effective, appropriate in situations when there are many attributes and choices, and useful for both subjective and objective data availability.

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## 4. Geospatial Revolution: Enhancing Reservoir Sustainability Through GIS-Based Catchment Area Treatment Strategies

**Divya Chavan, Bhuvnesh Sonawane, Sidhhant Velis, Sakshi Sangale(BE Civil)**

### Introduction:

Water scarcity is a pressing global issue, demanding innovative solutions to ensure sustainable management of water resources. Reservoirs play a pivotal role in meeting the escalating demand for freshwater, making their effective management a priority. The integration of Geographic Information System (GIS) technology has emerged as a transformative approach in optimizing reservoir performance, particularly through meticulous catchment area treatment. This article delves into the comprehensive application of GIS in assessing, analyzing, and treating catchment areas to enhance reservoir sustainability.

### Understanding Catchment Areas:

Catchment areas, also known as watersheds or drainage basins, are vital components of the hydrological cycle. They represent the geographical area from which water drains into a specific water body, such as a river or reservoir. Efficient management of catchment areas is crucial for maintaining water quality, regulating runoff, and sustaining the health of aquatic ecosystems. GIS provides a powerful platform for the holistic evaluation of catchment areas, utilizing diverse datasets to create detailed spatial representations.

### GIS Technology Overview:

GIS is a sophisticated technology that combines geographical data with analytical tools to visualize, interpret, and understand spatial patterns. It encompasses various components, including hardware, software, data, and skilled personnel. Satellite imagery, aerial surveys, and ground-based data are integrated into GIS systems, allowing for the creation of detailed maps, models, and analyses. The application of GIS in water resource management has revolutionized decision-making processes by providing accurate, real-time spatial information.

### The Role of GIS in Catchment Area Analysis:

GIS technology facilitates a multifaceted analysis of catchment areas, offering insights into topography, land use, soil composition, and hydrological patterns. Satellite imagery, with its high resolution, enables the identification of land cover changes, deforestation, and other environmental factors influencing water quality. GIS also integrates elevation data, allowing for the delineation of watershed boundaries and the identification of critical areas susceptible to soil erosion and sedimentation.

**Hydrological Modeling:**

One of the key strengths of GIS lies in its ability to perform hydrological modeling, simulating the movement and distribution of water within a catchment area. This involves the creation of Digital Elevation Models (DEMs) to represent the terrain, enabling the calculation of flow paths, drainage networks, and watershed characteristics. Advanced GIS software allows for the development of hydrological models that simulate rainfall-runoff processes, aiding in the prediction of water flow, sediment transport, and potential areas of erosion.

**Identification of Vulnerable Areas:**

GIS-based analyses empower water resource professionals to identify vulnerable areas within catchment zones. By overlaying data layers related to land use, soil types, and slope, GIS can pinpoint locations susceptible to erosion, sedimentation, and nutrient runoff. This information is crucial for devising targeted catchment area treatment strategies, such as afforestation, soil conservation, and erosion control measures.

**Afforestation Initiatives:**

GIS assists in strategic planning for afforestation initiatives within catchment areas. By analyzing land cover data and identifying areas with minimal vegetation, GIS helps prioritize locations for tree planting programs. Afforestation not only stabilizes soil and reduces erosion but also enhances water retention, mitigating the risk of flash floods and regulating streamflow. GIS aids in selecting tree species suitable for specific environmental conditions, ensuring the success of afforestation projects.

**Erosion Control Measures:**

Understanding the dynamics of soil erosion is paramount in catchment area treatment. GIS facilitates the identification of erosion-prone areas through slope analysis, allowing for the implementation of targeted erosion control measures. Techniques such as contour plowing, cover cropping, and terracing can be precisely applied based on GIS-derived information. Monitoring the effectiveness of these measures is also streamlined through GIS, enabling adaptive management strategies.

**Sustainable Land-Use Planning:**

GIS contributes significantly to sustainable land-use planning within catchment areas. By integrating land cover, land use, and soil quality data, GIS aids in developing land-use plans that balance human activities with ecological integrity. Zoning strategies can be implemented to restrict certain activities in sensitive areas, preserving natural habitats and minimizing the impact of urbanization on water resources.

**Water Quality Monitoring:**

GIS plays a crucial role in ongoing water quality monitoring. By incorporating data from various sources, including remote sensing, field measurements, and laboratory analyses, GIS allows for the creation of spatially explicit water quality maps. These maps enable the identification of pollution sources, tracking the movement of contaminants, and assessing the overall health of reservoirs. Real-time monitoring can be achieved through sensor networks, providing instant updates on water quality parameters.

### Integration of Remote Sensing Data:

Remote sensing, a complementary technology to GIS, contributes valuable data for catchment area analysis. Satellites equipped with sensors capture high-resolution imagery, enabling the monitoring of land cover changes, vegetation health, and the impact of human activities. GIS integrates remote sensing data seamlessly, providing a comprehensive understanding of catchment dynamics and facilitating informed decision-making.

### Case Studies:

Several successful implementations of GIS-based catchment area treatment strategies have demonstrated the efficacy of this approach. Case studies from around the world showcase the diverse applications of GIS in reservoir management. For instance, in the Upper Yangtze River Basin in China, GIS was instrumental in identifying critical erosion-prone areas and implementing soil conservation measures, leading to improved water quality and reduced sedimentation in the Three Gorges Reservoir.

### Challenges and Future Directions:

While GIS has proven invaluable in catchment area treatment, challenges persist. Data availability, accuracy, and interoperability remain issues that need addressing. Additionally, capacity building and training are essential for ensuring that water resource professionals can harness GIS tools effectively. The integration of emerging technologies, such as Artificial Intelligence (AI) and Machine Learning (ML), holds promise for enhancing the predictive capabilities of GIS models and improving decision support systems in reservoir management.

### Conclusion:

The application of GIS in catchment area treatment for reservoirs marks a significant leap forward in water resource management. By providing a comprehensive understanding of spatial dynamics, GIS enables the development and implementation of targeted strategies to enhance water quality, mitigate erosion, and promote sustainable land use. As water scarcity becomes an increasingly urgent global concern, the fusion of GIS technology with catchment area treatment strategies emerges as a vital approach to ensure the long-term sustainability of reservoirs and the ecosystems they support. Embracing this geospatial revolution is not just a technological leap; it is a commitment to securing the future of our most precious resource - water.