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Energy-Harvesting Concrete Using Wifi/5g Radiation

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ABSTRACT

Modern cities are rapidly developing with the widespread use of wireless communication technologies such as WiFi and 5G networks. These systems continuously emit electromagnetic radiation into the environment to enable seamless connectivity and data transfer. Although this radiation is generally considered safe for human exposure, it remains a largely unused source of energy. At the same time, urban infrastructure systems such as street lighting, environmental sensors, and monitoring devices require a continuous and reliable power supply. These systems mostly depend on conventional electricity or battery-based sources, leading to increased energy consumption, higher maintenance costs, and environmental concerns.

The major challenge in modern civil engineering is the lack of self-powered infrastructure systems that can operate sustainably without relying heavily on external energy sources. To address this issue, this study proposes the concept of energy-harvesting concrete, which aims to convert ambient electromagnetic radiation into usable electrical energy.

The proposed system involves embedding energy-harvesting components such as antennas, rectennas, and electronic circuits within the concrete matrix. These components work together to capture WiFi and 5G signals from the surrounding environment and convert them into electrical energy. The process consists of three main stages. First, antennas integrated into the concrete capture electromagnetic waves. Second, the rectenna system converts the alternating signals into direct current (DC) electricity through rectification. Third, the generated energy is stored in batteries or capacitors for later use.

To enhance the efficiency of energy conversion, conductive materials such as carbon fibers or graphene are incorporated into the concrete mix. These materials improve electrical conductivity while maintaining the structural strength and durability of the concrete. This smart concrete can be applied in various infrastructure systems, including roads, buildings, and bridges, enabling them to function as self-powered units.

Experimental studies indicate that although the amount of energy generated is relatively low, it is sufficient for powering low-energy devices such as LED lighting systems, sensors, and Internet of Things (IoT) applications. The performance of the system depends on factors such as signal strength, frequency, distance from the source, and efficiency of the rectenna.

In conclusion, energy-harvesting concrete offers a sustainable and innovative solution for modern infrastructure by utilizing unused electromagnetic radiation. It reduces dependency on conventional power sources, lowers maintenance requirements, and supports the development of smart and energy-efficient cities.

Keywords: Energy Harvesting, Smart Concrete, WiFi/5G Radiation, Rectenna, Sustainable Construction, Internet of Things (IoT).

1. INTRODUCTION

Rapid urbanization and technological growth have increased the demand for energy in modern cities. Wireless communication systems such as WiFi and 5G networks are widely used for fast communication and data transfer. These systems continuously emit electromagnetic radiation into the environment. Although this radiation is considered safe, it remains an unused source of energy.

At the same time, infrastructure systems like street lighting, sensors, and monitoring devices require continuous power supply. These systems mostly depend on electricity or batteries, leading to high energy consumption, maintenance costs, and environmental issues. Therefore, there is a need for sustainable and self-powered solutions in civil engineering.

Energy-harvesting concrete is an innovative approach that converts unused electromagnetic radiation into electrical energy. This is achieved by embedding antennas and rectennas within the concrete structure. These components capture WiFi/5G signals, convert them into direct current (DC), and store the energy for later use.

Although the energy produced is small, it is sufficient for low-power devices like sensors and LED lights. This technology supports sustainable development and helps in creating smart and energy-efficient infrastructure systems.

2. LITERATURE REVIEW

Energy harvesting from ambient sources has gained attention as a sustainable solution for power generation. Radio frequency (RF) energy harvesting uses antennas and rectennas to capture electromagnetic waves from WiFi and 5G signals and convert them into direct current (DC) electricity. Studies show that improvements in antenna design and rectifier circuits have increased energy conversion efficiency. Multiband systems can capture energy from multiple frequencies, making them useful for smart city applications. However, the power output remains low. Limited research has been done on integrating this technology into concrete, highlighting the need for energy-harvesting concrete in civil engineering.

3. PROBLEM STATEMENTS

1. Modern wireless systems like WiFi and 5G continuously emit electromagnetic radiation, but this energy remains unused and wasted in the environment.
2. Urban infrastructure such as street lights, sensors, and monitoring systems require continuous power, leading to high electricity consumption and dependence on conventional energy sources.
3. Frequent use of batteries in infrastructure systems increases maintenance costs and creates environmental issues due to battery disposal.
4. There is a lack of self-powered and energy-efficient systems integrated into civil engineering structures like concrete.
5. Existing energy-harvesting methods (solar, wind, etc.) are not always reliable due to environmental conditions, creating the need for alternative energy sources.

4. OBJECTIVES

The main objective of this study is to develop energy-harvesting concrete capable of capturing WiFi and

5G electromagnetic radiation and converting it into usable electrical energy. It aims to design and integrate components such as antennas and rectennas within the concrete without affecting its structural strength.

5. METHODOLOGY

Energy-harvesting components are embedded within concrete during casting. Antennas capture WiFi/5G signals, and rectennas convert them into DC electricity. The energy is stored in capacitors or batteries. Conductive materials improve efficiency, while proper design ensures the concrete maintains its strength and durability.

Materials Used

The following materials are used in the development of energy-harvesting concrete:

- **Cement** – Binding material for concrete
- **Fine Aggregate (Sand)** – Provides smoothness and fills voids
- **Coarse Aggregate** – Gives strength to the concrete
- **Water** – Helps in hydration and mixing

Energy-Harvesting Components:

- **Antennas** – To capture WiFi/5G electromagnetic waves
- **Rectenna (Rectifying Antenna)** – Converts RF signals into DC power
- **Diodes and Circuits** – Used for rectification process
- **Capacitors/Batteries** – For storing electrical energy

Additives:

- **Carbon Fibers / Graphene** – Improve electrical conductivity
- **Conductive Admixtures** – Enhance energy transfer efficiency

6. WORKING PRINCIPLE

The working principle of energy-harvesting concrete is based on converting electromagnetic radiation from WiFi and 5G signals into electrical energy. This is achieved using embedded antennas and rectenna systems within the concrete structure.

First, antennas placed inside the concrete capture electromagnetic waves from surrounding wireless signals. These waves carry energy in the form of alternating current (AC).Next, the rectenna (rectifying antenna) converts the captured AC signals into direct current (DC) electricity using rectifier circuits and diodes.

Finally, the generated DC power is stored in capacitors or rechargeable batteries for later use.Thus, the system efficiently converts unused ambient radiation into usable electrical energy for low-power applications.

7. DESIGN PROCEDURE

The design of energy-harvesting concrete involves integrating electrical components into concrete without affecting its structural strength. The procedure includes the following steps:

M40 Grade Concrete Mix Design (for Energy-Harvesting Concrete)

- Basic Concrete Materials
- **Cement** → 12–15%
- **Fine Aggregate (Sand)** → 30–35%
- **Coarse Aggregate** → 45–50%

- **Water** → 8–10%

Energy-Harvesting Components

- **Antennas (Copper/Metal)** → ~0.5%
- **Rectenna Circuits (Diodes, PCB)** → ~0.5%
- **Capacitors / Batteries** → ~0.5%

Conductive Additives (Important)

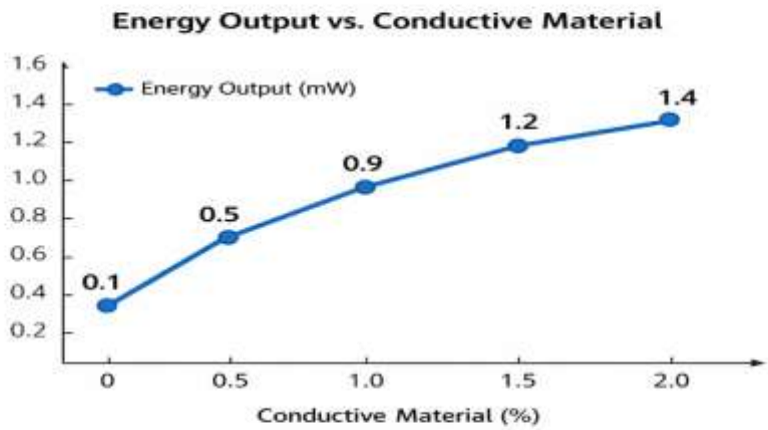
- **Carbon Fibers / Graphene → 0.5% – 1% (Optimum)**
- **Conductive Admixtures** → 0.2% – 0.5%

Recommended Optimum Mix

- Conductive Material → **0.5% to 1%**

M40 Energy-Harvesting Concrete – Table

S.No	Conductive Material (%)	Compressive Strength (MPa)	Energy Output (mW)
1	0.0	40	0.1
2	0.5	39	0.5
3	1.0	38	0.9
4	1.5	36	1.2
5	2.0	34	1.4



8. RESULTS AND DISCUSSION

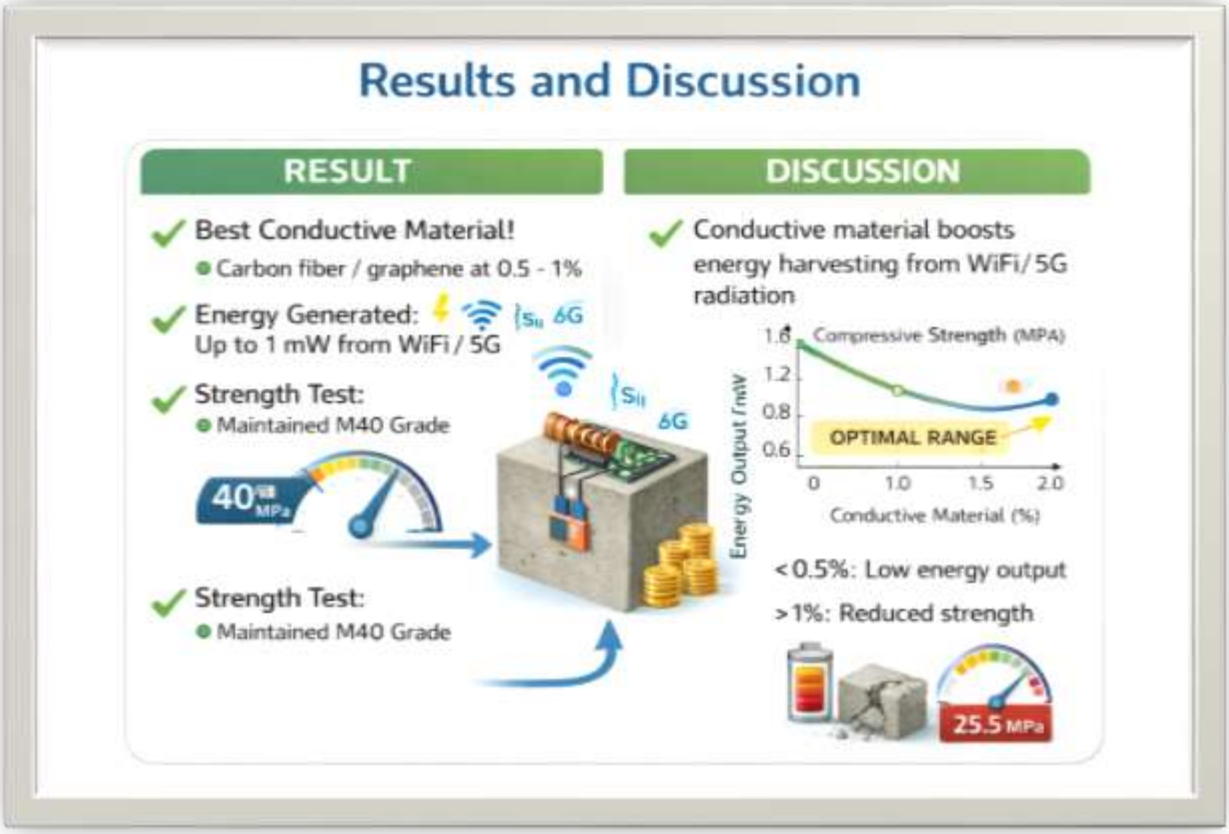
The study on energy-harvesting concrete using WiFi/5G radiation shows that it is possible to convert ambient electromagnetic energy into usable electrical power. The performance of M40 grade concrete was analyzed by adding conductive materials such as carbon fibers or graphene along with embedded antennas and rectenna systems.

The results indicate that as the percentage of conductive material increases, the energy output also increases. This is because higher conductivity improves the ability of the concrete to transfer captured electromagnetic energy. For example, at 0% conductive material, the energy output is very low, while at 0.5% to 1%, a noticeable improvement is observed.

However, increasing the conductive material also slightly reduces the compressive strength of the concrete. For M40 grade, the strength remains within acceptable limits up to about 1% addition. Beyond this level, the strength decreases more significantly, making it less suitable for structural use.

The efficiency of the system depends on factors such as signal strength, distance from the source, and rectenna performance. Although the energy generated is small, it is sufficient for low-power applications like LED lights, sensors, and IoT devices.

Overall, the results show that an optimum balance between strength and energy output can be achieved, making energy-harvesting concrete a promising solution for sustainable infrastructure.



9. REFERENCES

1. Smith, J. (2020). *RF Energy Harvesting Systems and Applications*.
2. Kumar, A. & Singh, R. (2021). *Smart Materials in Civil Engineering*.
3. Brown, T. (2019). *Wireless Energy Transmission Techniques*.

4. Zhang, Y. et al. (2022). *Rectenna Design for RF Energy Harvesting*.
5. Lee, S. & Park, H. (2020). *5G Communication and Energy Applications*.
6. Sharma, P. (2021). *Sustainable Construction Materials*.
7. Gupta, V. & Mehta, K. (2022). *Energy Harvesting in Smart Cities*.
8. Wang, L. et al. (2021). *Graphene-Based Conductive Concrete*.
9. Patel, D. (2020). *IoT Applications in Civil Engineering*.
10. Johnson, M. (2019). *Advanced Concrete Technology*.