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Smart Bricks Curing System using IoT

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Abstract

The existing curing method for bricks lacks in precision and efficiency, resulting in inferior strength and durability in the finished product. Traditional procedures may result in over- or under-curing, causing cracks and decreased structural integrity. Furthermore, manual monitoring and intervention are labor-intensive and prone to human mistake. A smart bricks curing system designed specifically for concrete bricks is critical for obtaining optimal strength and durability. This technology seeks to reduce cracks that threaten the longevity of concrete by maintaining precise moisture levels during the hydration process. The research's central feature is the implementation of sensors that continuously monitor moisture and temperature levels within the bricks.

Keywords: Automatic Curing System, Concrete Bricks, Moisture Content, Temperature Monitoring, IoT-based Wireless Networks, Water Management

1. Introduction

Curing is essential for concrete bricks to reach the required strength. The process of curing involves subjecting concrete bricks to ambient temperature and humidity levels that induce the cement's constituent materials to solidify. Maintaining the appropriate temperature and moisture during the strengthening period is known as curing. Curing of Smart bricks system has been developed to reduce water waste, as the curing process wastes a lot of water

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[8]. Unwanted moisture content causes fractures by warming the interior. Since there is no way to regulate how much water is used, water waste is an issue. On the other hand, a lot of water and unskilled workers can sometimes make the curing process difficult [9]. With the advancement of various sensors, automation has proliferated. Automation has simplified production and management while lowering the need for human intervention [11, 12]. The use of various sensor systems for monitoring and regulating various operations is boosting automation in civil engineering [10]. The purpose of the smart brick curing system is to build an automated curing mechanism that will provide water for curing based on the temperature and moisture content of the bricks [7]. Without the need for human assistance, a moisture sensor determines the bricks' moisture level. Whenever moisture content decreases in the structure the sensors will automatically turn the pumping motor ON [13]. When moisture content reaches the required level the motor will OFF automatically. This smart brick curing system needs sensors, a 0.25 horsepower motor, an Arduino Nano microcontroller, a humidity and temperature sensor, an IoT Wi-Fi module, a solar panel, a PCB, and other components. Based on the bricks moisture content, the Arduino Nano is configured to gather input signals [14,15].

2. Literature Review

[1] G. Singh proposed a smart concrete curing system to address water scarcity in construction. Their system utilizes moisture sensors to regulate water supply based on concrete moisture levels and ambient temperature, connected to the internet through Wi-Fi for remote monitoring. Data on moisture levels and pump status are transmitted to the cloud for access through a mobile app, offering efficient and controlled curing while conserving water resources. Results demonstrate that concrete strength achieved with the smart curing system surpasses that of traditional immersion curing methods.

[2] Neerej and Abraham Sudharson Ponraj proposed an automatic curing system for concrete structures, aiming to maintain optimal moisture and temperature levels using sensors. Water is supplied only when sensor values drop below threshold levels, minimizing water wastage. The system utilizes wireless networks for reliable communication between field sensors and controllers, reducing human interaction and enhancing flexibility in water management.

[3] S. Yang reviews various types of sensors used for monitoring the health and performance of concrete structures. This includes strain gauges for measuring strain caused by loads or environmental factors, accelerometers for detecting acceleration due to external forces like earthquakes, and piezoelectric sensors for converting mechanical stress into electrical signals. Additionally, fiber optic sensors are highlighted for their sensitivity and durability in harsh environments, while ground-penetrating radar (GPR) is discussed as a non-destructive testing method for evaluating the internal condition of concrete structures. Overall, Yang emphasizes the utilization of these sensors in ensuring the safety, durability, and longevity of concrete structures.

[4] L. Chen developed a system for compact embedded wireless sensor-based monitoring of concrete curing. Their system utilizes sensors capable of measuring parameters like temperature, humidity, and strength development in real-time. By employing wireless connectivity, they eliminated the need for physical wires, simplifying installation and reducing costs. Through continuous monitoring of key parameters like temperature and humidity during the curing process, engineers can ensure optimal conditions for concrete strength development and durability.

[5] F. J. A. Molina, introduced a new curing technique called "drip curing" in 2017. This method involves a controlled dripping system that delivers water to the surface of freshly poured concrete at regular intervals, aiming to maintain optimal moisture levels for proper hydration and strength development. The system includes emitters connected to a water source and a control system regulating flow rate and timing. Automation adjusts water delivery based on factors like temperature, humidity.

[6] R. K. Gupta have developed a "Water-saving irrigation automatic agricultural controller under Vishvakarma Yojana." This project focuses on promoting innovation and technological advancements in agriculture, particularly emphasizing water conservation in irrigation practices. It incorporates various technologies such as sensors, actuators, and automation systems to optimize water usage in irrigation. The controller likely features soil moisture sensors to find watering needs, automated valves or drip irrigation systems for precise water delivery, and remote monitoring and control capabilities for farmers. The ultimate aim is to enhance water efficiency in agriculture, reduce wastage, and increase crop yield, in line with the broader objectives of the Vishvakarma Yojana.

3. Proposed System

The goal of the proposed system is to address the critical issue of water wastage during bricks curing by implementing a smart bricks curing system. Currently, the lack of monitoring and control over water usage in the curing process contributes to unnecessary water wastage, exacerbating concerns over water scarcity. As global populations continue to grow, the demand for water is expected to surpass available supply, highlighting the urgent need for more efficient water management practices. Traditionally, water is provided for bricks curing without adequate monitoring of moisture levels within the structure. This often results in overwatering, where excess water is not absorbed by the bricks and ultimately goes to waste. To mitigate this inefficiency, a system is required to observe the water requirements of the concrete bricks in real-time, ensuring that water is provided only when necessary. In the face of escalating global water scarcity exacerbated by population growth, the efficient utilization of water resources has become an imperative, particularly in sectors like construction where significant volumes of water are consumed.

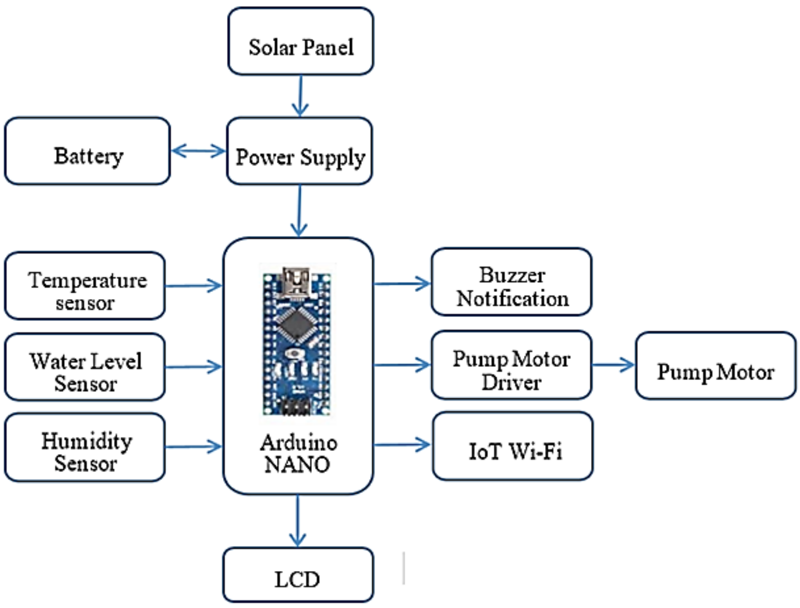

Figure 3.1. Block Diagram of Smart Bricks Curing System Using IoT

The curing process in concrete bricks, is important for ensuring the strength and durability of structures, and represents a notable area for water conservation efforts as shown in the Figure 3.1. Currently, the lack of monitoring and control over water usage during concrete curing leads to substantial wastage. Despite the availability of moisture-sensitive technologies, such as moisture sensors, to gauge hydration levels, these tools are often underutilized, resulting in overwatering and needless resource depletion.

4. Components

Moisture and Temperature Sensor: The system begins by continuously monitoring the moisture and temperature levels of the concrete bricks using a humidity and temperature sensor.

Arduino Nano Microcontroller: The microcontroller receives data from the sensors and is programmed with control logic to determine the appropriate actions based on moisture content readings.

Pumping Motor: A 0.25 horsepower pumping motor is activated by the control logic when low moisture levels are detected. It is responsible for delivering water to the concrete bricks for curing.

IoT Wi-Fi Module: The inclusion of an IoT Wi-Fi module enables remote monitoring and control of the curing process, allowing users to access real-time data on moisture and temperature levels and adjust settings as needed.

Solar Panel: A solar panel provides a renewable energy source for power supply, ensuring uninterrupted operation of the system even in areas without reliable access to electricity.

LCD Display: The LCD display shows real-time data on moisture and temperature levels of the concrete bricks. This information allows users to monitor the curing process and ensure optimal conditions for strength development.

Buzzer Indication: A buzzer is integrated into the system to provide audible alerts when the water level decreases below a certain threshold. This alert notifies users that water replenishment is required for continuous curing.

5. Flow Diagram

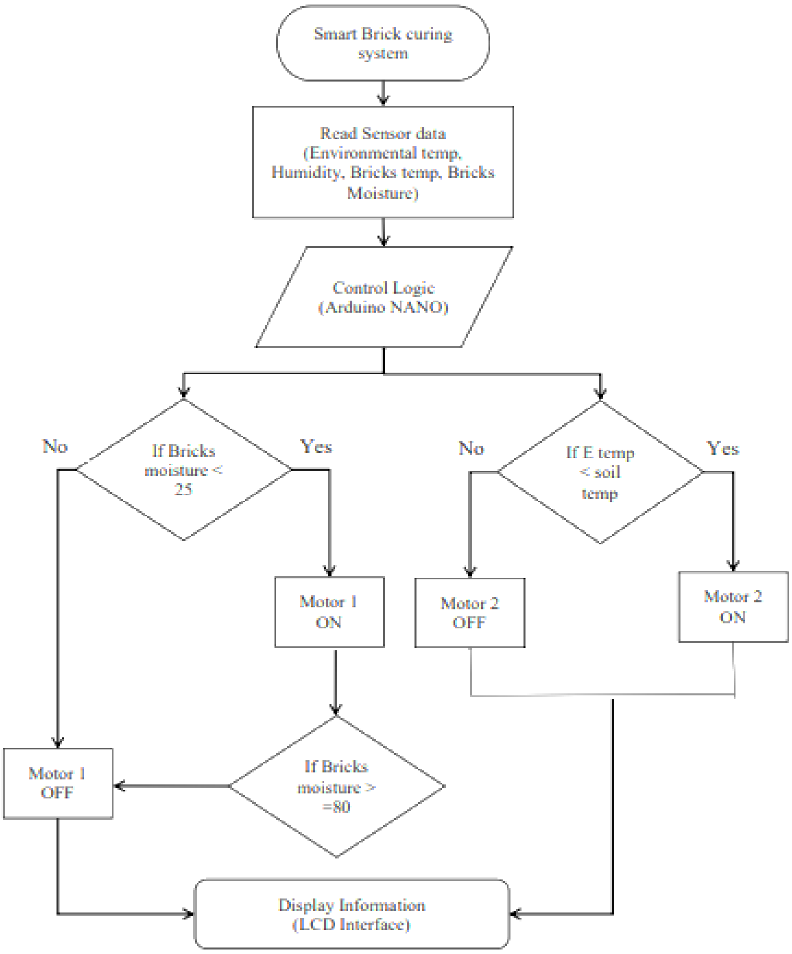

Figure 5.1. Flow Chart for Smart Bricks Curing System

The flow diagram in Figure 5.1 represents a Smart Brick curing system controlled by an Arduino Nano. The process begins with reading sensor data, including environmental temperature, humidity, brick temperature, and brick moisture. This content is fed into the control logic managed by the Arduino. The system first checks if the brick moisture is less than 25%. If it is, Motor 1 is turned on to add moisture, and the system continues to monitor until the moisture level reaches or exceeds 80%, at which point Motor 1 is turned off. If the moisture is not less than 25%, the system checks if the environmental temperature is lower than the soil temperature. If the environmental temperature is lower, Motor 2 is turned on for temperature adjustment. Otherwise, Motor 2 remains off. After making the necessary adjustments, the system displays the current information on an LCD interface. This automated process ensures optimal curing conditions for the bricks.

6. Methodology

The smart brick curing system operates on a step-by-step principle, beginning with continuous monitoring of moisture and temperature levels within the concrete bricks using a humidity and temperature sensor. This information is then acquired and processed by the Arduino Nano microcontroller, which is programmed with control logic to determine the necessary actions based on moisture content readings. When the moisture level falls below a preset threshold, indicating the need for curing, the control logic activates a 0.25 horsepower pumping motor to commence water delivery. This motor continues pumping until the moisture content reaches the optimal level for curing, as determined by the control logic.

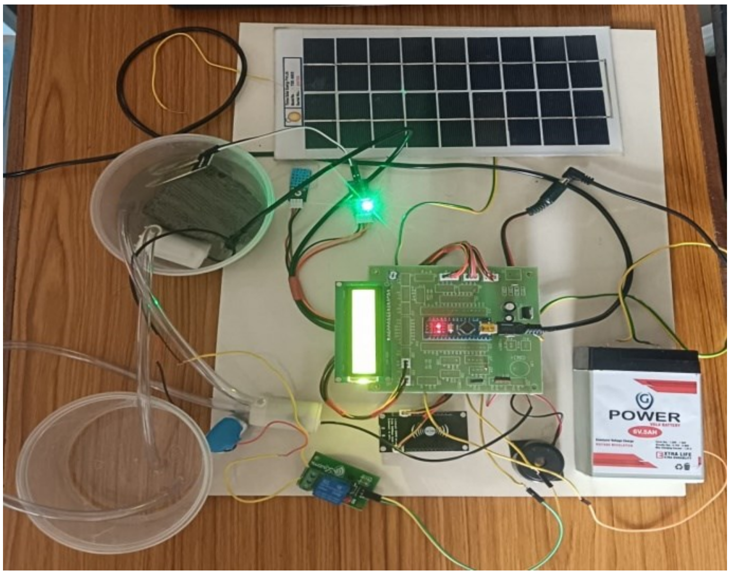

Figure 6.1. Hardware Setup of Smart Bricks Curing System

The Hardware setup of Smart Bricks Curing System is shown in figure.6.1.Additionally, an IoT Wi-Fi module enables remote monitoring and control of the curing process, ensuring flexibility and accessibility. Integration of a solar panel ensures uninterrupted operation, even in areas lacking reliable electricity access. Throughout the process, a feedback loop is maintained, allowing the system to continuously adjust water supply based on real-time moisture readings. In summary, the smart brick curing system functions autonomously, utilizing sensors, microcontrollers, motors, IoT connectivity, solar power, and control logic to efficiently maintain precise moisture levels during the curing process, reducing water waste and enhancing overall efficiency which shown in the Figure 6.2.

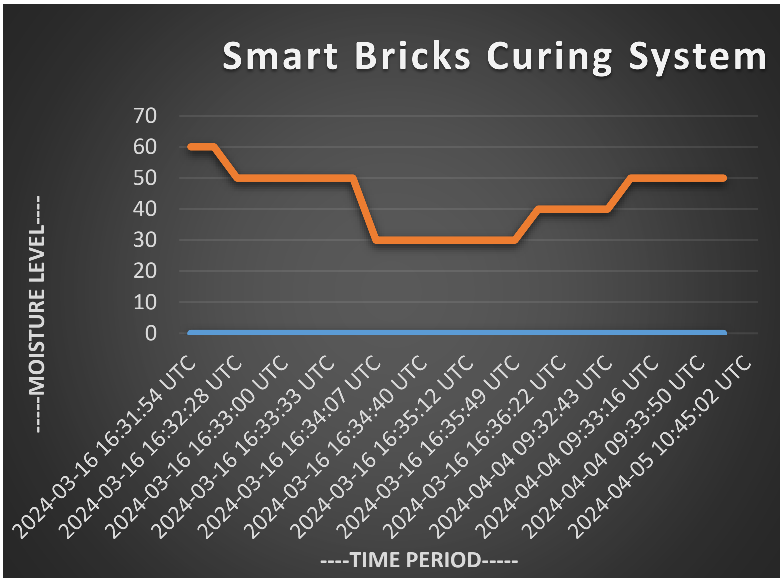

Figure 6.2. Moisture Content of the Bricks

7. Results and Discussion

The research successfully establishes a smart bricks curing system designed to revolutionize traditional curing methods for concrete bricks. By leveraging automation, sensors, and IoT technology, the system ensures precise moisture and temperature control, enhancing the strength, durability, and structural integrity of the finished product as shown in the Figure 7.1. This innovative approach mitigates water waste, reduces cracks, and streamlines the curing process, eliminating the demand for manual monitoring and intervention. Key components such as sensors, microcontrollers, motors, and IoT modules work seamlessly together to optimize water supply based on real-time moisture content. The successful implementation of this system signifies a significant advancement in civil engineering practices, paving the way for more efficient and sustainable construction methodologies.

Figure 7.1. Output Visualization in Liquid Crystal Display

In the smart brick curing system, data from sensors monitoring environmental and brick-specific moisture and temperature levels are collected by an Arduino Nano microcontroller. This information is then transmitted to the ThingSpeak platform using an IoT Wi-Fi module. ThingSpeak serves as a cloud-based repository, storing the incoming data in real-time. Users can access this stored content through ThingSpeak's web interface, which offers powerful tools for data visualization. By creating custom charts and graphs, users can track and analyze the trends in moisture and temperature over time. These graphical representations help in identifying patterns, making informed decisions, and ensuring optimal curing conditions, thus enhancing the overall efficiency and effectiveness of the curing process as shown in the Figure 7.2.

Figure 7.2. Graphical Representation of Output in ThingSpeak

8. Conclusion

The development of a smart bricks curing system tailored for concrete bricks addresses critical shortcomings in traditional curing methods. The inefficiencies and inaccuracies of manual monitoring often lead to inferior strength and durability in the finished product, as over- or under-curing can result in cracks and compromised structural integrity. By leveraging sensors to continuously monitor moisture and temperature levels within the bricks, this technology offers precise control over the curing process, mitigating the risk of such issues. Furthermore, the implementation of IoT-based wireless networks enhances communication and enables efficient water management, reducing waste and promoting sustainability. Overall, the adoption of an automatic curing system represents a significant advancement in construction practices, ensuring optimal strength, durability, and longevity of concrete bricks while minimizing labor-intensive manual intervention and human error.

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