CONCRETE CURING MONITORING SYSTEM

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ABSTRACT

Monitoring the strength of concrete structures in their early stages is critical to avoid failure and determine readiness for use. Automatic curing is also important to minimize water waste, prevent cracks, and achieve a long-lasting structure.To facilitate automatic curing, a moisture sensor is utilized. Generally, the curing process takes 28 days, which is crucial for attaining the desired strength. This study developed a moisture sensor that automatically monitors the moisture content of concrete structures, even remotely.The strength and moisture values are presented in a graphical format, indicating that the beam achieved a strength of 26.5N/mm2 at 28 days and 30.8 N/mm2 at 56 days, demonstrating an increase in strength beyond the 28-day mark.

CHAPTER 1

INTRODUCTION

1.1 Project Title

Concrete Curing Monitoring System

1.2 Introduction

Proper curing is an essential step in constructing durable and strong structures. This involves maintaining uniform temperature and moisture levels throughout the curing process, which typically lasts for 28 days after the structure is cast. Both temperature and moisture can significantly impact the curing process and can cause damage to the concrete structure if not properly managed. For example, insufficient moisture in the structure can prevent it from reaching its full strength, while excessive moisture can lead to shrinkage problems. Additionally, excess water content can result in cracks and is wasteful. However, unskilled laborers can also cause problems in the curing process, which can affect the strength and durability of the structure. To address these challenges, an effective and automated technique is necessary.

With the increasing use of automation in civil engineering, the development of a smart concrete curing system has become possible. This system relies on various sensor systems to monitor and control activities in the construction field, reducing human involvement and simplifying the process. Specifically, a moisture sensor is used to detect the moisture content of the structure without human intervention. When the moisture content decreases to a certain level, the sensors automatically turn on the pumping motor to supply water for curing. Once the required moisture level is reached, the motor turns off automatically. This smart curing system is an effective and automated solution that can maintain the proper moisture and temperature levels necessary for the structure to achieve its full strength and durability.

1.3 Concrete Curing:-

Curing of cement concrete is defined as the process of maintaining the moisture and temperature conditions of concrete for hydration reaction to normally so that concrete develops hardened properties over time. The main components which need to be taken care of are moisture, heat, and time during the curing process.

Key elements of a Concrete curing:

- Moisture: Moisture content in concrete is all about water and pressure. The appropriate amount of water is needed to avoid excess pressure that may force any unreacted moisture to the surface of concrete and create a non-conductive substrate condition ultimately leading to coating adhesion failure.
- Durability: Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different concretes require different degrees of durability depending on the exposure environment and properties desired

1.4 Technical Keywords

- Moisture
- Strength

1.5 Domain of the Project

Concrete curing

1.6 Problem Statement:

Moisture sensors and temperature & humidity sensors play important roles in the construction industry, especially in curing and attaining the proper strength of concrete.

Knowing the moisture content of a structure is essential for an effective curing process, and using a moisture sensor can reduce water waste. With this information, construction teams can save time and costs by completing projects on time and avoiding structural failures.

The curing system can also be turned off once the required strength is attained, further optimizing the construction process.

CHAPTER 2

LITERATURE SURVEY

2.1 Title: A systematic approach for testing and analyzing the thermomechanical behavior of high-performance concrete specimens

Author: Daniel Cusson and Ted Hoogeveen

Proposed a systematic approach for testing and analyzing the thermomechanical behavior of high-performance concrete specimens at early age under restrained autogenous shrinkage and temperature conditions. In order to avoid closing the test early in case of any restrained shrinkage, a partial degree of restraint was applied by the loading system, which allowed the concrete specimens to be characterized. The instrumentation system was used to measure strains and other parameters with high reliability and accuracy, starting from the setting time. Equations were provided to determine the time evolution of shrinkage, stiffness, thermal expansion, and creep of concrete, considering the effects of temperature on measured properties. The results obtained from testing specimens of size 200 × 200 × 1000 mm with a water/cement ratio of 0.34 were presented, analyzed, and discussed in this research to demonstrate the proposed approach.

2.2 Title: To measure the moisture content of a massive slab

Author: Virpi Leivo and Jukka Rantala

Conducted an experiment to measure the moisture content of a massive slab in a semi-detached house for three months, starting from the beginning of the first heating season. The results obtained were compared with finite element simulations. The study showed that the heating element had a significant effect on the humidity levels of the surrounding zone element, but only within a limited range. To accurately determine the relative humidity with a floor heating element in a massive concrete slab, the measurement should be taken between the heat conduit and the outer range of the surrounding drier zone. This study provides valuable insights into the effects of heating systems on moisture content in massive concrete structures.

2.3 Title: To design AEMS (automatic electrical measurement system)

Author: A. Poursaee and W.J. Weiss

AEMS (automatic electrical measurement system) is an innovative system developed by A. Poursaee and W.J. Weiss for measuring the development of material properties and permeability of cementitious materials like concrete. The system consists of an electrical impedance spectrometer, a switching unit, customized software for data transmission, and a digital multi-meter. AEMS is a controllable approach for quality control applications which allows for automatic measurement of electrical properties of different specimens. This system has great potential for expansion in the future, especially for detecting flaws in concrete using electrical

2.4 Title: Design of wireless moisture sensor network to monitor soil moisture content

Author: Xiao Kehui et al

Designed a wireless moisture sensor network to monitor soil moisture content and water height for rice growth. The network was tested in real-time monitoring of moisture data and expert data to determine its feasibility and applicability in sustainable agriculture. The study found that the system was successful in conserving water resources and promoting good agriculture practices. The researchers suggest that future improvements could include incorporating rechargeable batteries powered by solar panels for extended system working time, as well as adapting the system to meet the demands of other irrigation fields.

2.5 Title: To design a new tool for structural health monitoring

Author: Wang Dan sheng and Zhu Hongping

Introduced a new tool for structural health monitoring, using a piezoelectric lead zirconate titanate (PZT) impedance transducer in the electro-mechanical impedance (EMI) technique. In their research, they have demonstrated the limitations of conventional non-destructive methods in finding the compressive strength of concrete and introduced a PZT impedance transducer to measure the compressive strength gain of concrete. They have also explored the use of waterproof PZT patches made from asphalt lacquer material as an alternative to embedded transducers. By monitoring PZT admittance signals and measuring the strength of concrete cubes at different ages, they have established a relationship between strength gain and root mean square deviation (RMSD), as well as mean absolute percentage deviation (MAPD). Their research has demonstrated the potential of embedded PZT transducers based on EMI methods for monitoring the development of concrete strength at early ages

2.6 Title: Smart irrigation system

Author: Parth Shah et al.

They designed a smart irrigation system to address the issue of water scarcity in the agriculture. field, where traditional methods of watering plants require a significant amount of water and manual labor. The system incorporates a moisture sensor and a microcontroller that automatically supplies water to the plants based on the detected moisture level in the soil. The microcontroller operates on low voltage, and the system is designed to be energy-efficient, reducing the need for manual intervention and increasing overall efficiency. This technology can have significant implications for agriculture, especially in water-scarce regions.

2.7 Title: To investigate the development of compressive strength of cementitious material

Author: Thomas Voigt et al

Conducted an experiment to investigate the development of compressive strength in cementitious materials during early stages of construction projects. They used cylindrical specimens with a ram extruder to observe the transition of mortar from plastic state to hardened state. In addition, wave transmission and reflection with P and S waves were conducted to understand the microstructural changes during the setting and hardening process. The results showed that uniaxial compression testing of mortar cylinders is an effective method to determine green strength and the initiation and development of strength in further tested materials. P wave propagation indicated the influence of tested mortar for internal strength, while S wave transmission and reflection were sensitive to inter-particle bonding due to cement hydration and indicated an increase

CHAPTER 3

GOALS AND OBJECTIVES

3.1 Goal:

Our primary goal is to supervise the strength and moisture content of a concrete structure during the entire curing process.

3.2 Objectives:

This is accomplished by: -

1. Using moisture sensors to monitor the moisture level within the structure
2. Maintaining a consistent moisture level during the curing period
3. Turning off the curing system once the required strength is achieved
4. Enhancing concrete strength through effective curing.

CHAPTER 4

METHODOLOGY

4.1 Moisture sensor:

The soil moisture sensor consists of two probes that are used to measure the volumetric content of water. The two probes allow the current to pass through the soil and then it gets the resistance value to measure the moisture value.

When there is more water, the soil will conduct more electricity which means that there will be less resistance. Therefore, the moisture level will be higher. Dry soil conducts electricity poorly, so when there is less water, then the soil will conduct less electricity which means that there will be more resistance. Therefore, the moisture level will be lower.

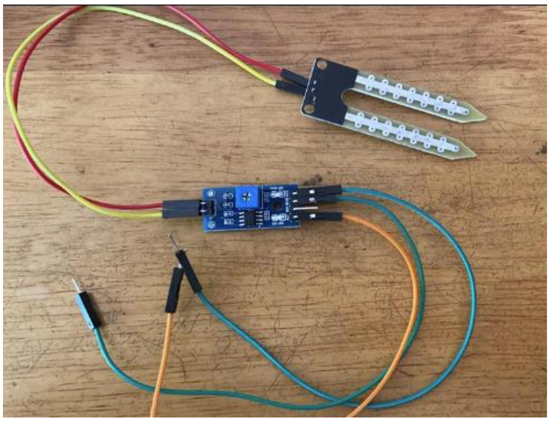

Fig.4.1

4.2 DHT11 Sensor:

The DHT11 is a commonly used Temperature and humidity sensor that comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data

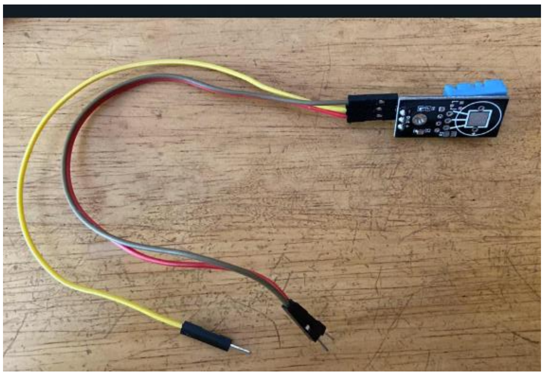

Fig.4.2

4.3 Servo motor:

Micro Servo Motor SG90 is a tiny and lightweight server motor with high output power. Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller.

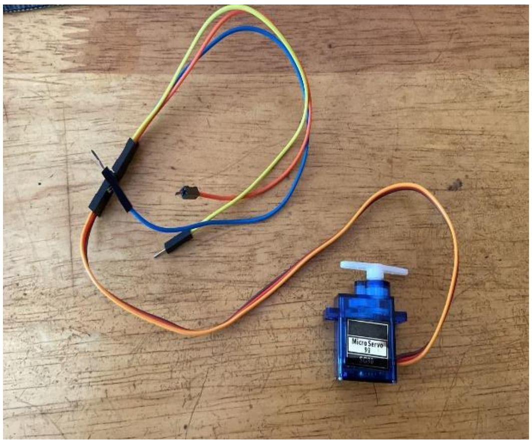

Fig.4.3

4.4 Arduino Board

The ESP8266-D1 is a wireless 802.11 (Wifi) microcontroller development board compatible with the Arduino IDE. It turns the very popular ESP8266 wireless (WiFi) module into a fully fledged development board. The layout of this board is based on a standard Arduino hardware design with similar proportions to the Arduino Uno and Leonardo. It also includes a set of standard Arduino headers which means many existing Arduino shields can be plugged directly into the board.

Fig.4.4

4.5 IOT Concept:

This concept involves transmitting sensor data to a D1 Arduino board, which is then accessed by the cloud and displayed on a mobile device. The mobile device can also control the process, with the cloud providing information to the D1 Arduino board to operate the relay. Additionally, the microcontroller within the D1 Arduino board enables the process to be automatically controlled.

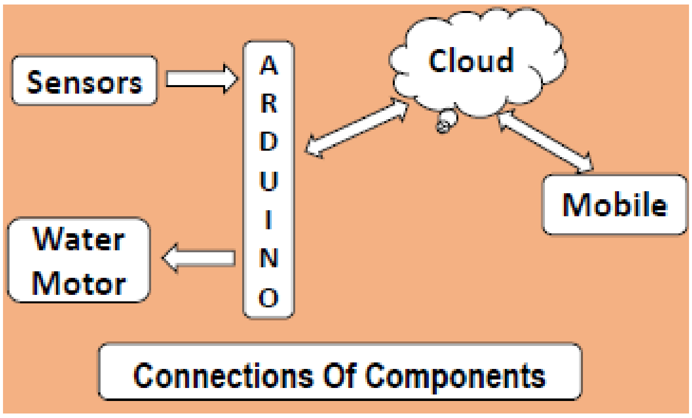

Fig.4.5

4.6 Program:

```
#include <DHT.h>  // Including library for dht

#include <ESP8266WiFi.h>

#include <Servo.h>

Servo myservo;  //Create motor instance variable

String apiKey = "7H1B7GO189MXMW97";  //  Enter your Write API key from ThingSpeak

const char *ssid = "Honor 9N";  // replace with your wifi ssid and wpa2 key

const char *pass = "24681012";

const char *server = "184.106.153.149";  //server or api.thingspeak.com

#define DHTPIN 0  //pin where the dht11 is connected

DHT dht(DHTPIN, DHT11);

float h;

float t;

float m;

int pos;
```

```
WiFiClient client;  // create wifi instance variable

void setup() {

Serial.begin(115200);  // begin transmission

delay(10);

myservo.attach(13);  //Servo pin

dht.begin();         // dht connect

Serial.println("Connecting to ");

Serial.println(ssid);

WiFi.begin(ssid, pass);  // Connect to Internet

while (WiFi.status() != WL_CONNECTED) {

delay(500);

Serial.print(".");

}

Serial.println("");

Serial.println("WiFi connected");

}

void loop() {

update_data();  // function call to update sensor data on thingspeak

if (m <= 150) {

for (pos = 0; pos <= 180; pos += 1) {  // goes from 0 degrees to 180 degrees

// in steps of 1 degree

myservo.write(pos);              // tell servo to go to position in variable 'pos'
```

```
delay(15);                       // waits 15ms for the servo to reach the position

}

//m = 300;

while (m <= 500) { //150 < m && m <= 500

update_data();

Serial.println("in while");

//m = 300;

}

} else {

Serial.println("error");

}

//m = 600;

if (m > 500) {

for (pos = 180; pos >= 0; pos -= 1) {  // goes from 180 degrees to 0 degrees

myservo.write(pos);                 // tell servo to go to position in variable 'pos'

delay(15);                       // waits 15ms for the servo to reach the position

}

Serial.print("TAP OFF");

}

// thingspeak needs minimum 15 sec delay between updates

delay(1000);

}
```

```
void update_data() {

h = dht.readHumidity();

t = dht.readTemperature();

m = analogRead(A0) / 10;

Serial.println(m);

Serial.println(h);

Serial.println(t);

delay(1000);

if (isnan(h) || isnan(t)) {

Serial.println("Failed to read from DHT sensor!");

return;

}

if (client.connect(server, 80))  //   "184.106.153.149" or api.thingspeak.com

{

String postStr = apiKey;

postStr += "&field1=";

postStr += String(t);

postStr += "&field2=";

postStr += String(h);

postStr += "&field3=";

postStr += String(m);

postStr += "\r\n\r\n";
```

```
client.print("POST /update HTTP/1.1\n");

client.print("Host: api.thingspeak.com\n");

client.print("Connection: close\n");

client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");

client.print("Content-Type: application/x-www-form-urlencoded\n");

client.print("Content-Length: ");

client.print(postStr.length());

client.print("\n\n");

client.print(postStr);

Serial.print("Temperature: ");

Serial.print(t);

Serial.print(" degrees Celcius, Humidity: ");

Serial.print(h);

Serial.println("%. Send to Thingspeak.");

}

client.stop();

}
```

4.7 Thing Speak:

Thing Speak is a powerful application that enables you to analyze and visualize sensor data. To get started, you need to create an account specifically for your project. With this account, you can create channels based on your project's requirements. These channels serve as data containers where you can store and organize sensor data. You can create multiple channels to accommodate different types of data or specific sensors.

Once the channels are set up, you can easily monitor and track the process using the Thing Speak application on your mobile device. This allows you to stay connected and informed about the real-time data collected from your sensors, providing valuable insights and analysis.

This application has a Write API key (7H1B7GO189MXMW97), which must be included in a program to connect the sensor to our channel. Name of the channel is "Automatic Curing System". In this project there are three channel numbers they are: -

Channel number 1: Digital values of moisture content. There will be 0 and 1 code to known weather motor is turned on or off. If it shows 0 the motor is turned on and if it shows 1 the motor is turned off.

Channel number 2: Analog value of moisture content. There will be values which show the value of moisture content. In this project threshold values are 680. If the value increases the motor is turned on and if it decreases the motor is turned off.

Channel number 8: Control channel for motor. This channel allows to operate the motor from anywhere.

This application helps to monitor the values from anywhere.

4.8 Moisture sensor connection:

To gather data on moisture levels, a moisture sensor is linked to a D1 Arduino board through various pins, including the ground pin, analog pin, digital pin, and power pin. The arduino is configured to receive input and transmit it to the cloud, where the moisture level and pump status can be viewed. To power the motor, the D1 Arduino board is connected to a USB connector, which is connected to the power source. The system is linked to the internet through Wi-Fi, allowing for remote monitoring of the curing process via a mobile app that accesses the data from the cloud.

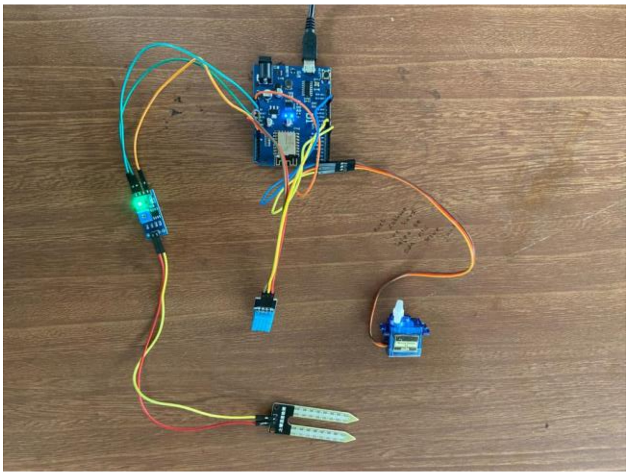

Fig.4.6

4.9 Mobile application steps:

Step 1

Open the application and navigate to the "New Project" option. Enter the project name as "AISSMS, Civil Department" and include the project's address as "PUNE."

Step 2

proceed to click on the project name you have selected. Within this project, you can add new sections, such as "Cube Slab" and other sections. For this project, you have chosen the section "Concrete Cube."

Step 3

Click on the "Concrete Cube" section, where you will find a nearby sensor. In this project, the sensor is equipped with Wi-Fi connectivity, displaying its name and signal strength.

Step 4

Click on the sensor with signal then there will be results like temperature, humidity, and moisture.

Step 5

In this project mix M20 is added. Then there you can see mix id, maturity method datum temperature and humidity. All these should be filled according to our project. In this project values are added according to strength values obtained by compression testing. With these sensors data is recorded and sent to a mobile or a laptop. (Connected to the mentioned Wi-Fi in program)

Step 6

With the presence of a "Share Project" option, we have the capability to easily distribute this project to any interested party. Upon completion of the project, a comprehensive report is also automatically generated.

4.10 Process:

Once all the necessary connections have been established, the experimental work commences by closely monitoring the moisture levels through an automated curing system. Following the casting process, a threshold value of 680 is set after a 24-hour period. If the moisture value surpasses 680, indicating dryness, the system promptly initiates water pumping into the structure. Conversely, if the moisture value reaches 680, the system ceases the water pumping process. This continuous monitoring and adjustment procedure persists for a duration of 28 days.

The moisture values, along with other pertinent parameters such as temperature, maturity, and humidity, are not only visually displayed on a laptop but also presented in a graphical format on a mobile application. This allows for convenient observation and analysis of the values, enabling a comprehensive understanding of the experimental progress.

CHAPTER 5

MATERIALS USED

Materials used

5.1 Cement

Cement is a binding material which binds the other materials present in concrete. Cement with OPC 53 grade is used in this experiment. The basic test as per IS 4031-1988 code fineness test, initial and final setting time was conducted.

Fig.5.1

5.2 Fine aggregate

Fine aggregate fills the voids formed by the coarse aggregate in concrete. River sand is used in this experiment. The tests like fineness modulus, Water absorption, Specific gravity, surface water and Bulk density as per IS: 2386-1963 (part 3) are conducted.

Fig.5.2

5.3 Coarse aggregate

Coarse aggregate gives strength and volume to the concrete. The aggregate produced from crushed stone are angular and elongated. The test for physical properties as per IS 383-1970 was conducted.

Fig.5.3

5.4 Casting of cube

Casted a cube 15*15cm.

Fig.5.4

Fig.5.5

Fig.5.6

CHAPTER 6

RESULTS

6.1 Result

By employing this technique, a target mean strength of 26.4 N/mm2 is achieved within 28 days, fulfilling the required strength level. Notably, the strength of the structure continues to increase beyond the initial 28-day period.

Graphs are utilized to record the temperature, maturity, and humidity values. The thing Speak app provides graphs displaying moisture values, which are monitored and recorded daily. These moisture values can also be monitored on a laptop.

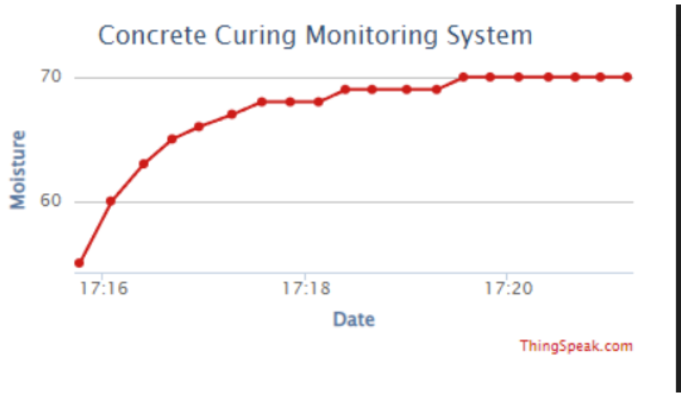

Fig.6.1

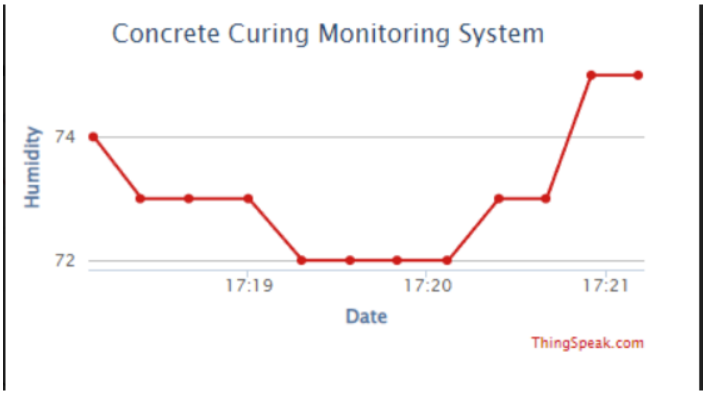

Fig.6.2

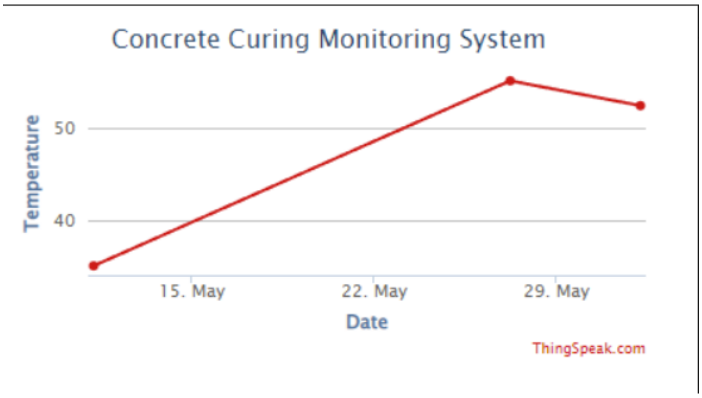

Fig.6.3

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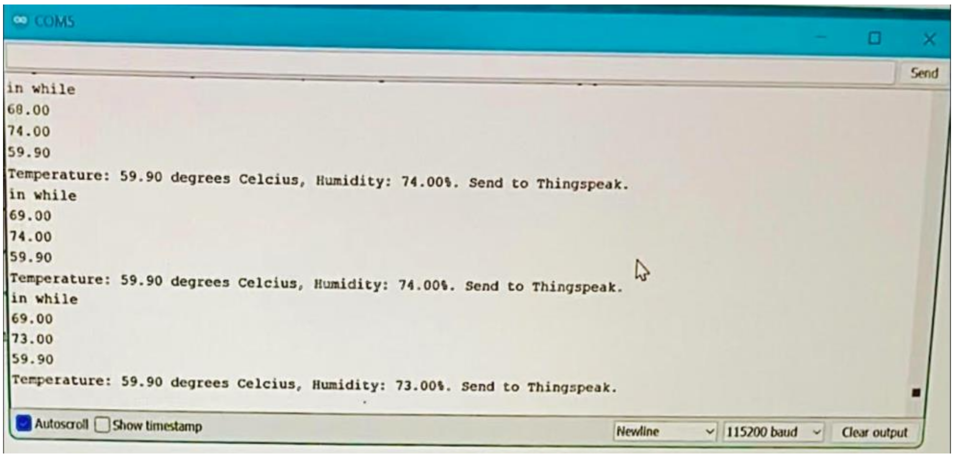

Fig.6.4

Days	Temperature	Moisture	Humidity
3 days	53	60	68.51
7 days	56	56	70
14 days	58.31	57	68
28 days	59.90	69	73

Table.6.1

CHAPTER 7

CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusion:-

The automatic curing system is a valuable tool for maintaining a consistent moisture content within a structure, thereby providing the necessary strength. 2)This system enables remote operation of the curing process, reducing the need for human labor and minimizing water wastage.

The achieved strength for the slab is remarkable, measuring 26.5N/mm2 after 28 days and increasing to 30.8N/mm2 after 56 days. This indicates that the strength continues to improve beyond the initial 28-day period.

In conclusion, this technique proves highly effective in constructing durable structures while saving both time and construction costs.

7.2 Future Scope of the Project

In the future, a unique scope for an automatic concrete curing monitoring system could involve the integration of advanced sensors and artificial intelligence algorithms to optimize the curing process and improve overall construction quality. This system would monitor and analyze various parameters such as temperature, humidity, and concrete strength in real-time, allowing for precise control and adjustments during the curing phase.

Additionally, the system could incorporate wireless connectivity, enabling remote monitoring and control from any location. Construction managers and engineers could access the data and receive real-time alerts, ensuring timely interventions if any deviations or issues arise during the curing process.

With such an advanced automatic concrete curing monitoring system, construction projects would benefit from enhanced quality control, reduced construction time, and increased sustainability, ultimately leading to safer and more durable infrastructure.

CHAPTER 8

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