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CONCRETE STRENGTH MONITORING USING APPLICATIONS OF IOT

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Abstract

Monitoring and assessing the condition of civil engineering infrastructure is critical for economic development since it decreases the need for reconstruction. Material deterioration, weathering, corrosion, and environmental degradation all contribute to deterioration of structural performance over time. Early detection of degradation and monitoring of potential control components can help infrastructure last longer.

To precisely track temperature variations in concrete specimens caused by the hydration process, the thermocouple temperature sensor is employed. Concrete strength cannot be precisely determined by monitoring its temperature. This research helps when evaluating the strength of concrete by taking into account the time temperature connection.

Key Words: Compressive Strength, IOT, Sensor, Temperature.

1.INTRODUCTION

Monitoring and monitoring the status of civil engineering infrastructure is critical for a country's economic development since lengthy service life and timely maintenance of structures cuts reconstruction costs significantly. Civil engineering infrastructure's structural performance deteriorates. over time as a result of immediate or short-term factors such as improper curing, vibration, shrinkage cracks, and workmanship, as well as long-term effects such as material degradation and weathering, rebar corrosion, water seepage, loading conditions, environmental degradation, and crack formation. As a result, structural health monitoring (SHM) is critical from the beginning to the end of service life.

Instead of relying on traditional ways, we are attempting to deploy IOT with building.This aids in the prediction of compressive strength development.

Because they are supported by artificial intelligence technologies and do not require human involvement, IoT-based monitoring sensors have a significant potential for SHM and smart supervision applications in civil engineering. The rising use of the aforementioned sensors has been attributed to a number of variables.

These variables include the miniaturisation of IoT-based monitoring devices, low power consumption, and ubiquitous connection, increases in cloud computing capabilities, and quick advancements in data science. The information gathered by IoT sensors is utilised to forecast numerous structural health indicators that affect the long-term integrity of civil engineering structures. Furthermore, buildings that are well-monitored deliver excellent returns on investment in terms of energy conservation and maintenance costs.

1.1 NEED OF STUDY

- It is possible to create a low-cost wireless embedded maturity sensor that can assess the strength of the concrete and monitor the curing temperature. The sensor and data gathering station were constructed using an Arduino microcontroller and a number of other critical components.
- Using the EMI principle, a unique experimental technique for evaluating in situ concrete strength without causing damage has been devised. The novel technology outperforms previous approaches to strength prediction, such as those based on ultrasonic pulse velocity.

1.2 LITERATURE REVIEW

[1] Debajyoti Mishra, Goutam Das and Debaprasad Das. The term "internet of things" refers to a system that combines various hardware items, such as various machines, cars, buildings, and other equipment, with electronics, computer code, sensors, and the internet to enable data collection

and information exchange. It has been projected that by the year 2020, there will be 50 billion devices to be coupled through IoT According to data from India's National Crime Records Bureau (NCRB), between 2001 and 2015, the fall of multiple buildings claimed the lives of al- most 40,000 people.

[2] E.Bertino, M.R.Jahanshahi and A. Singla. Machine learning (ML) approaches will be used in many critical infrastructure and emergency management decision-making procedures in future smart cities. One use is the processing of large amounts of visual images and other types of data for defect evaluation. A swarm of IoT devices (devices, for short) collects the data, some of which are mobile, such as tiny unmanned aerial vehicles (UAVs) and robots. A critical criterion for the success of such evaluation systems is the precise identification, measurement, and localization of inadequate locations.

[3] Yijun Liu, Gongyu Hou, Zhedong Xu, Qinhuang Chen, and Gongyu Hou. The SHM is concerned with both the completed and under construction building structures. The resulting technique is likely to have an effect on structural elements and result in latent damage, which will have a detrimental influence on construction safety. As the primary priority of safety management, the digital and intelligent SHM has been widely adopted. The monitoring process necessitates the rapid updating of dynamic data, but because data storage and presentation are not well-coordinated, the monitoring data is not intuitively tied to constructing spatial relationships.

[4 Siran Xu and Jianan Feng. Structural degradation is becoming increasingly prevalent in China and other parts of the world. Bridges, for example, are vulnerable to damage from frequent traffic, wind stress, ageing materials, environmental corrosion, earthquakes, and other reasons. These components have the ability to produce structural defects and damage, severely limiting the lifespan of a structure. These subtle defects can occasionally produce catastrophic security events such as collapse and subsidence, resulting in significant casualties and property loss. In an effort to address this issue, structural health monitoring (SHM) approaches have recently gained a lot of attention.

[5 Tayab Menon, Bhawani Shankar Choudhary, Ali Akbar Shah, Muhammad Aslam Uqaili, and Bhawani Shankar Choudhary. Gradient image processing, fibre brag grating, and various neural network techniques are time-consuming procedures. However, this problem can be remedied by developing IOT-based instrumentation that can assess whether or not a building is harmed in real time. Such real-time feedback can be provided using an accelerometer. The accelerometer uses the non-linear frequency response to determine the frequency response, making it easier to discover any fractures or damage. The main challenge is the expansion of the instrumentation's internet connectivity following the instrumentation.

[6] Lamia Chaari Fourati, Wael Doghri, and Ahlem Saddoud. There are undoubtedly numerous errors made when creating steps or monitoring. To reduce these catastrophic errors, which can be caused by inattentional, calculational, or testing errors, less human participation and the development of advanced monitoring systems are required. When necessary, researchers integrate a few electronic devices to extract certain measurements; as the number of devices increases, sensor networks and intelligent behaviour are formed.

[7] Xia Yang, Wenwei Yang, Shuntao Li, and Chang Wu are the members.The most often used traditional techniques for measuring the strength of concrete are rebound, ultrasonic-rebound, core drilling, pulling-out, post anchoring, and decompression. Despite the fact that these approaches are simple and effective, they usually cause damage to the building. The advancement of smart materials in recent years has made it feasible to efficiently monitor the health of structures.

[8] R. Magesh, R. Prathiban, P. V Pravin Kumar, R. Rajesh Kumar, and S. S. Manu are the members of the R. Magesh team.

A thermocouple temperature sensor is used to measure the temperature of concrete. The user can then forecast the early-age compressive strength of the concrete by using the temperature history to calculate the time and temperature factor. The size of the concrete structure will undoubtedly influence how much heat it generates. Monitoring the temperature of concrete throughout the hydration process entails taking the differential temperature, ambient temperature, and temperature of the concrete mix into account. Analyse the hydration process's effect on concrete strength at various temperatures. [9] Aditya Kamineni et al conducted research to construct a complete noise prediction model utilizing traffic and route parameters. Noise levels were measured using close-to-field and far-field estimates. The continuous noise level was determined by logging dates at one-second intervals and averaging them over time. Similarly, the SVAN 945A pocket sound level metre (SLM) was set up to measure the noise level7 witnessed while wearing the SVAN PC suit. These noise level tests were conducted in conjunction with examinations of spot speed and traffic volume. The observed noise level was higher above the limitations imposed by India's federal pollution control board (2000).

[10] Suresh Bhalla and Chee Kiyng Soh. Localised structural interrogation is employed in local damage detection techniques such as ultrasonic wave propagation, impact echo, and acoustic emission. Ultrasonic technologies often cause high frequency elastic waves to propagate into the structural component being assessed. A wave reflects back when it meets a crack. The crack location is determined by the time difference between the applied and reflected waves. The ultrasonic methods have a significantly higher damage sensitivity than the global processes.

[11] D. Serikbayev and L. N. Gumilyov. Monitoring the temperature at which concrete cures allows for early intervention and control of the strengthening process. The strength of concrete can now be regulated in two ways: nondestructively and destructively. In recent decades, nondestructive testing techniques such as embedded sensors have risen in popularity. Their main advantage is that, unlike wired systems, they are not susceptible to damage after pouring at the construction site.

[12] Sang-ki Choi, Najeebullah Taren, Junkyeong Kim, Seunghee Park, and Innjoon Park are among the cast members. This study (NPP) estimates the strength of a specific combination of high-strength concrete (HSC) with admixtures for usage in a nuclear power plant. Nuclear power station buildings require an HSC with specific extra qualities in order to run the safe options. The experimental concrete was specifically designed for this purpose in order to meet the NPP standards. In order to attain these desired characteristics, the concrete strength growth process must be monitored.

[13] E. Liarakos and C. Proeidakis. This paper proposes an innovative active wireless sensing system made up of a miniaturised electromechanical impedance measuring chip and a reusable piezoelectric transducer that is properly installed in a Teflon-based enclosure to monitor the development of concrete strength at early ages and initial hydration states. EMI variations coupled with decision boundaries based on extreme value statistics (EVS) are employed during the hydration process to estimate the degree of concrete strength advancement.

[14] Jenieshtalouis, J., Sharanya Balki, R. Arun Prathap, and Seena Simon. It is necessary to develop a new method for evaluating the in-situ strength of concrete, which will boost the rate of production in the concrete sector. This technique can address important issues such as predicting the ideal time to remove formwork, post-tensioning at low temperatures while inhibiting concrete strength increase, optimising concrete mix design, and cold weather protection

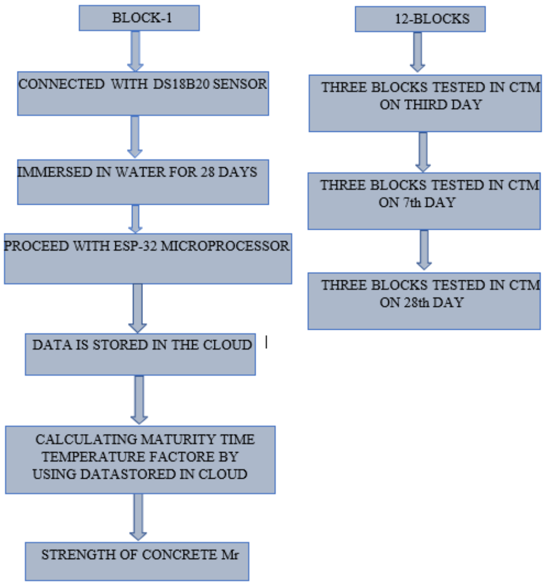
[15] Alya Abdulrazzaq, Doureat Raheem, Ther, Hahmed Sagban, and Doureat Raheem.Several nvestigations have been conducted on the behaviour of concrete at high temperatures. Furthermore, the most current study on fire-exposed concrete is still insufficient to make a significant improvement for the impact of temperature increase on concrete strength. The exposed concrete surface from the fire, on the other hand, is due to the temperature increasing to 800 °C in less than 60 minutes. Concrete used in structures prone to explosion, such as furnace walls and dampers, industrial chimneys and flues, floors beneath boilers and kilns and nuclear reactors, on the other hand, must be developed and investigated in order to be used in future designs.

2. OBJECTIVES

1]To assess the concrete strength as a result of the hydration process at various temperatures.
2] To study the performance and temperature of the concrete.
3] Time saving due to real time data, automatic notification and digital documentation.
4] Reliable information is available in real time through the web portal and the app.

3. METHODOLOGY

Preparation of 13 M25 concrete blocks of same mix proportions



3.1 WORKING

3.1.1 Plowmans formula and maturity-strength relationship: The Plowmans formula, which relates maturity and strength, is being studied in this context. The DS18B20 sensor measures the internal temperature of concrete in real time, and this data is sent to the ESP8266 Wi-Fi micro-controller. The micro-controller calculates the early age compressive strength based on the developed strength versus maturity relationship specific to the concrete mix being used.

3.1.2 C programming and Arduino IDE: A program is written in the C programming language is used to program the ESP8266 micro-controller. The Arduino Integrated Development Environment (IDE) is utilized for this purpose. The program includes the necessary code to connect to the Wi-Fi network, access the DS18B20 sensor data, calculate the maturity index and early age compressive strength, and display the data on an Organic Light-Emitting Diode (OLED) display.

3.1.3 Thingspeak.com and cloud platform integration: A new channel is created on Thingspeak.com, a cloud platform for storing and analyzing IoT data. The channel includes fields for temperature, maturity index, and early age compressive strength. The C-program fed into the ESP8266 micro-controller includes the address of the Thingspeak channel and the Wi-Fi login credentials. The micro-controller sends the data in real time to the cloud platform, allowing remote access and monitoring from any location.

4.TEST CONDUCTED & RESULT

4.1 Compression Test:

1]A compression testing machine is a universal testing machine(UTM) specially configured to determine a material strength and deformation behaviour under compressive(Pressing).

2]A typical compression tester consists of a load cell, cross head, compression strength tools, electronics and a drive system.

3]12 blocks casted and cured for 28 days and 3 blocks tested on third day, 3 blocks tested on 7th day and other 3 blocks are tested on 28th day in CTM machine.

4]

Days	Cube	Strength (N/mm^2)	Avg Strength (N/mm^2)
3rd	Cube-1	18.075	18.46
	Cube-2	18.87	
	Cube-3	18.45	
7th	Cube-1	23.53	22.81
	Cube-2	22.22	
	Cube-3	22.66	
21st	Cube-1	27.82	27.94
	Cube-2	28.031	
	Cube-3	27.97	
28th	Cube-1	30.773	31.23
	Cube-2	31.507	
	Cube-3	31.386	

5. DATA COLLECTED FROM THINGSPEAK:

Readings from Day1 to Day7:

Day	Time	Strength
1st	13:20:43 UTC	-16.40
	15:21:54 UTC	-5.636
	20:24:55 UTC	1.495
	22:40:19 UTC	3.895
2nd	09:46:47 UTC	8.237
	13:49:08 UTC	9.547
	18:52:11 UTC	10.776
	22:54:34 UTC	11.563
3rd	09:00:43 UTC	13.499
	13:02:48 UTC	14.124
	18:05:46 UTC	14.78
	22:08:08 UTC	15.238
4th	09:14:53 UTC	16.397
	13:16:58 UTC	16.769
	18:20:12 UTC	18.026
	22:22:52 UTC	18.151
5th	09:29:14 UTC	18.497
	13:31:38 UTC	18.77
	18:34:34 UTC	19.122
	22:36:55 UTC	19.387
6th	09:43:24 UTC	20.143
	13:45:45 UTC	20.274
	18:48:41 UTC	20.539
	22:51:03 UTC	20.7380
7th	09:32:38 UTC	21.284
	13:34:59 UTC	21.473
	18:37:58 UTC	21.692
	22:40:19 UTC	21.825

Readings from Day-8 to Day-13:

Day	Time	Strength
8th	09:00:43 UTC	22.281
	13:02:48 UTC	22.455
	18:05:46 UTC	22.614
	22:08:08 UTC	22.81
9th	09:14:53 UTC	23.157
	13:16:58 UTC	23.326
	18:20:12 UTC	23.497
	22:22:52 UTC	23.640
10th	09:29:14 UTC	23.950
	13:31:38 UTC	24.082
	18:34:34 UTC	24.250
	22:36:55 UTC	24.364
11th	09:43:24 UTC	24.692
	13:45:45 UTC	24.784
	18:48:41 UTC	24.925
	22:51:03 UTC	24.977
12th	09:32:38 UTC	25.263
	13:34:59 UTC	25.389
	18:37:58 UTC	25.516
	22:40:19 UTC	25.564
13th	09:46:47 UTC	25.643
	13:49:08 UTC	25.791
	18:52:11 UTC	25.860
	22:54:34 UTC	25.951

Readings from Day-14 to Day-19:

Day	Time	Strength
14th	09:43:24 UTC	26.011
	13:45:45 UTC	26.056
	18:48:41 UTC	26.121
	22:51:03 UTC	26.225
15th	09:35:57 UTC	26.351
	13:38:19 UTC	26.455
	18:41:33 UTC	26.562
	22:43:55 UTC	26.641
16th	09:50:10 UTC	26.869
	13:52:33 UTC	26.957
	18:55:30 UTC	26.995
	22:36:55 UTC	27.024
17th	09:43:24 UTC	27.252
	13:45:45 UTC	27.325
	18:48:41 UTC	27.462
	22:51:03 UTC	27.542
18th	09:32:38 UTC	27.663
	13:34:59 UTC	27.776
	18:37:58 UTC	27.812
	22:40:19 UTC	27.863
19th	09:46:47 UTC	27.943
	13:49:08 UTC	28.024
	18:52:11 UTC	28.164
	22:54:34 UTC	28.326

Readings from Day-20 to Day-28:

Day	Time	Strength
20th	09:14:53 UTC	28.392
	13:16:58 UTC	28.421
	18:20:12 UTC	28.506
	22:22:52 UTC	28.567
21th	09:29:14 UTC	28.635
	13:31:38 UTC	28.723
	18:34:34 UTC	28.836
	22:36:55 UTC	28.954
22th	09:43:24 UTC	29.043
	13:45:45 UTC	29.082
	18:48:41 UTC	29.250
	22:51:03 UTC	29.364
23th	09:32:38 UTC	29.692
	13:34:59 UTC	29.784
	18:37:58 UTC	29.862
	22:40:19 UTC	29.892
24th	09:46:47 UTC	29.963
	13:49:08 UTC	29.986
	18:52:11 UTC	30.011
	22:54:34 UTC	30.142
25th	09:14:53 UTC	30.216
	13:16:58 UTC	30.229
	18:20:12 UTC	30.347
	22:22:52 UTC	30.398
26th	09:50:10 UTC	30.755
	13:52:33 UTC	30.862
	18:55:30 UTC	30.889
	22:36:55 UTC	30.904

27th	09:03:53 UTC	30.988
	13:24:58 UTC	31.022
	18:20:12 UTC	31.147
	22:22:52 UTC	31.224
28th	09:50:10 UTC	31.473
	13:52:33 UTC	31.507
	18:55:30 UTC	31.586
	22:36:55 UTC	31.684

6. LIMITATION AND CHALLENGES:

For greater quality control and safety, the construction sector requires a paradigm change towards IoT-based real-time monitoring systems. However, there are several implementation issues to consider when deploying an IoT-based system on a building site. This section summarises the constraints and obstacles encountered throughout the proposed system's implementation. In the event of incorrect wiring, the sensor, DS18B20, may return temperature signal data (values outside the temperature range). In the C-program, these extreme signal data are identified and processed using a filtering method. Other areas of signal processing, however, are not included in this work.

As previously stated, a Wi-Fi router or hotspot is always kept close to the monitoring structure. For a typical construction site that requires long-distance communication technology, a range extender may be required in addition to the Wi-Fi router. LoRa wireless technology, which provides long-range, low-power, and secure data transfer for IoT applications, can also be used for this. Finally, while ESP8266 modules are vulnerable to cyber-attacks, device security can be improved by utilising a secure sockets layer. Other limitations of the ESP8266 microcontroller include the possibility that the programme flashed in the ESP8266 chip will stop functioning. Furthermore, the microcontroller may take an excessive amount of time to connect to the Wi-Fi router.

7. CONCLUSION

- A thermocouple temperature sensor is used to properly track temperature differences in concrete specimens induced by the hydration process. Concrete strength cannot be assessed exactly by measuring its temperature. This study aids in determining the strength of concrete by taking into account the time-temperature relationship.
- Using this simple approach, construction chores can be completed swiftly and safely.
- It is conceivable to build a low-cost wireless embedded maturity sensor that can monitor curing temperature and determine concrete strength.

REFERENCES

[1] Debajyoti Misra · Gautam Das · Debaprasad Das
[2] E. Bertino·M. R. Jahanshahi· A. Singla · R.T. wu
[3] Gongyu Hou a,b, Le Li a , Zhedong Xu a , Qinhuang Chen a , Yijun Liu a , and Bing Qiuc
[4] Junqi Guo, Xiaobo Xie, Rongfang Bie and Limin Sun
[5] Bhawani Shankar Chowdhry · Ali Akbar Shah · Muhammad Aslam Uqaili · Tayab Memo
[6] Wael Doghri· Ahlem Saddoud · Lamia Chaari Fouratir
[7] Xia Yang , Wenwei Yang, Shuntao Li
[8] R. Magesh, R. Parthiban, P.V. Pravin Kumar, R Ra-jesh Kumar, S.S. Manu
[9] Chee Kiong SOH and Suresh Bhalla
[10] Yelbek Utepov,Assel Tulebekova, Aliya Al dungarova, Shyngys Zharassov, and Yerlan Sabitov
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[12] a*C. Providakis, E. Liarakos
[13] Sang-Ki Choi , Najeebullah Tareen , Junkyeong Kim , Seunghee Park and Innjoon Park
[14] Jenishtalouis.J, Sharanya Balki, R.Arun Prathap, Seena Simon
[15] Ashwini Wankhede, S. P. Gaikwad