

# Smart Technique for NDT in High Rise Buildings

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## **ABSTRACT:**

This paper presents a cost-effective and smart technique for Non-Destructive Testing (NDT) in high-rise buildings using ultrasonic sensing technology. The proposed system detects internal cracks and structural defects without damaging the structure. Ultrasonic waves are transmitted into the material, and reflected signals are analysed using the time-of-flight (ToF) principle to identify discontinuities such as cracks and voids.

An Arduino-based controller is used to process the received signals and detect defects. Weak ultrasonic signals are amplified using an instrumentation amplifier (AD623) to improve accuracy. The results are displayed on an LCD screen and transmitted wirelessly to a mobile device using a Bluetooth module, enabling real-time monitoring. The system provides a portable, efficient, and low-cost solution for structural health monitoring.

**KEYWORDS:** NDT, Ultrasonic Sensor, Crack Detection, Arduino, High Rise Buildings

## **1. INTRODUCTION**

High-rise buildings are a key part of modern infrastructure, and their safety is very important. Over time, due to environmental effects, load changes, and ageing, structures may develop cracks or internal defects. If these defects are not detected early, they may lead to serious structural failures.

Traditional inspection methods are often time-consuming, risky, and sometimes destructive. Therefore, there is a need for safer, more efficient techniques to evaluate structures without causing damage.

Non-Destructive Testing (NDT) is widely used in civil engineering to detect internal defects without affecting the structure. Among different NDT methods, ultrasonic testing is preferred due to its accuracy and reliability.

In this work, a smart NDT system using ultrasonic sensors and an Arduino microcontroller is developed. The system detects cracks by analysing reflected ultrasonic waves. It also includes wireless

communication for real-time monitoring. The proposed system is portable, low-cost, and suitable for practical applications.

## 2. SYSTEM MODEL AND ASSUMPTIONS

The proposed system is designed as a smart and efficient Non-Destructive Testing (NDT) solution for detecting cracks in high-rise building structures using ultrasonic technology. It consists of key components such as an ultrasonic transmitter and receiver, an Arduino microcontroller, an instrumentation amplifier (AD623), a Bluetooth module, an LCD, as well as alert devices like a buzzer and LED indicators.

In operation, the ultrasonic transmitter generates high-frequency sound waves that are directed into the concrete structure. These waves propagate through the material and interact with its internal structure. Whenever the waves encounter discontinuities such as cracks, voids, or defects, a portion of the signal is reflected toward the receiver.

The receiver captures these weakly reflected signals. To ensure accurate detection, the signals are amplified using the AD623 instrumentation amplifier. The amplified signals are then processed by the Arduino microcontroller, which calculates the time taken by the waves to travel using the Time-of-Flight (ToF) principle. Based on this analysis, the system determines the presence and approximate location of defects.

Additionally, the system is designed to provide real-time feedback. The processed results are displayed on an LCD screen for immediate observation and transmitted wirelessly to a mobile device via a Bluetooth module. This enhances the usability of the system in field conditions by allowing remote monitoring.

To further improve safety and usability, the system includes a buzzer and LED indicators that provide instant alerts when a crack or abnormality is detected. The overall design is compact, portable, and energy-efficient, making it suitable for on-site inspections as well as educational and prototype applications.

The integration of embedded systems with civil engineering techniques in this model demonstrates a practical approach toward modern structural health monitoring systems.

### Assumptions:

The following assumptions are considered while designing and implementing the system:

- The concrete material is uniform and homogeneous
- Ultrasonic waves travel in a straight path
- Defects cause reflection in waves
- External noise is minimal
- Proper alignment is maintained
- Crack depth is within sensor range
- Power supply is stable

- Environmental effects are limited

### 3. EFFICIENT COMMUNICATION

The proposed system incorporates an efficient and reliable wireless communication mechanism to enable real-time data transfer between the testing unit and a mobile device. A Bluetooth module (HC-05) is interfaced with the Arduino microcontroller to establish a stable and low-power communication link.

The processed data obtained from the ultrasonic sensing system, including crack detection status, signal variations, and warning indications, is transmitted wirelessly to a mobile phone. This eliminates the need for complex wired connections and significantly enhances the portability and flexibility of the system, especially during field inspections of high-rise structures.

The communication process is designed to ensure fast data transmission with minimal latency, allowing users to monitor structural conditions in real time. The received data can be viewed using a mobile application or a serial interface, making it easy to interpret and analyse the results.

Furthermore, the use of Bluetooth technology ensures low energy consumption and ease of integration with commonly available devices. The system can be easily paired with authorised mobile devices, providing a simple and user-friendly interface for engineers and inspectors.

Overall, the wireless communication feature improves the efficiency, accessibility, and practicality of the system, making it suitable for real-world structural health monitoring applications.

### 4. RESULT AND DISCUSSION

The developed ultrasonic-based NDT system was successfully tested on a concrete cube specimen. The system was able to detect variations in internal structure based on ultrasonic signal changes.

- The system displayed three conditions: **SAFE**, **WARNING**, and **CRACK**.
- When the concrete was in good condition, the system showed **SAFE** with low depth values.
- For minor defects, the system indicated a **WARNING**, showing moderate depth.
- In the presence of cracks, the system displayed **CRACK** with higher depth values and activated buzzer alerts.

The crack depth was calculated based on signal variation and was displayed on the LCD in millimetres. The system also calculated crack affected area percentage (%) using multiple readings.

Additionally, real-time data was successfully transmitted to a mobile device using Bluetooth, making monitoring more efficient.

The results show that the proposed system is capable of detecting internal defects in concrete structures effectively.

- The system provides a **low-cost alternative** to traditional NDT methods like UPV.
- It reduces the need for expert interpretation by giving direct output (**SAFE/CRACK**).
- The integration of Arduino enables automatic processing and real-time response.
- The crack percentage feature helps in understanding the severity of damage over a surface.

However, the system has some limitations:

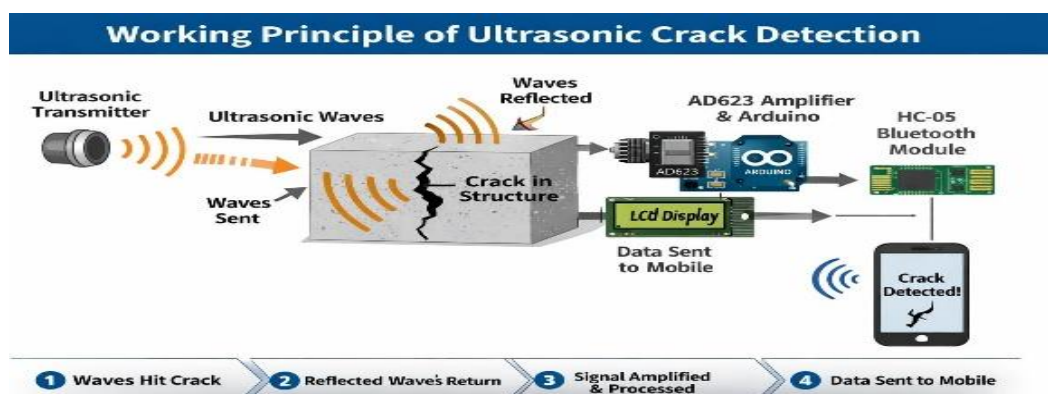
- Accuracy depends on proper calibration.
- It is suitable for small-scale testing (like cubes) and needs improvement for large structures.
- Environmental noise and material variation may affect readings.

Overall, the system is **efficient, portable, and user-friendly**, making it suitable for basic structural health monitoring applications.

**Table 1: Crack Detection Results using Ultrasonic Sensor System**

Reading No.	Depth (mm)	Status	Crack Area %
1	3.0	SAFE	0%
2	2.4	SAFE	0%
3	20.4	WARNING	20%
4	26.4	WARNING	33%
5	56.4	CRACK	50%
6	71.4	CRACK	60%
7	29.4	WARNING	66%
8	5.4	SAFE	62%

**Fig 1. Working Diagram**



## 5. CONCLUSION

The project presents a smart and cost-effective method for crack detection in high-rise buildings using ultrasonic NDT techniques. The system successfully detects surface and small internal cracks using ultrasonic wave analysis.

The integration of Arduino, amplifier, and wireless communication improves system performance and usability. The system is portable, easy to use, and reduces the need for manual inspection in dangerous areas.

Although the system has limitations in detecting deep cracks, it provides a strong base for future development. With further improvements such as IoT and AI integration, the system can be enhanced for large-scale applications.

## REFERENCES

1. **Wang, Y., Li, J., & Zhang, H. (2022)** “Digital Robotic Systems for Non-Destructive Reinforced Concrete Structures Testing” Elsevier Journal.
2. **Chen, L. & Zhou, K. (2021)** “Non-Destructive Testing Method of Concrete Based on Piezoelectric Sensor” IEEE Transactions on Instrumentation and Measurement.
3. **Singh, A., & Patel, R. (2023)** “A Scoping Review of Non-Destructive Testing (NDT) Techniques in Building Construction” — ScienceDirect.
4. **Liang, P., & Tanaka, S. (2020)** “Structural Health Monitoring of High-Rise Concrete Buildings Using Fibre Optic Sensors” Journal of Civil Structural Health Monitoring.
5. **Kumar, R., & Gupta, V. (2021)** “AI-Based Crack Detection in High-Rise Structures Using Drone Imagery”. Automation in Construction Journal.
6. **Ahmed, S., & Rahman, T. (2022)** “Integration of IoT and Cloud in Smart NDT Systems for Building Monitoring” IEEE Access.
7. **Sharma, P., & Mehta, D. (2021)** “Ultrasonic Pulse Velocity Method for Crack Detection in Concrete Structures” Materials Today: Proceedings
8. **Lee, J., & Park, S. (2020)** “Wireless Sensor Networks for Structural Health Monitoring of High-Rise Buildings” Sensors Journal
9. **Verma, S., & Singh, K. (2022)** “Development of Arduino-Based Ultrasonic Crack Detection System” International Journal of Engineering Research & Technology
10. **Brown, T., & Wilson, G. (2019)** “Signal Amplification Techniques in Ultrasonic NDT Systems” — NDT & E International
11. **Rao, M., & Kulkarni, A. (2021)** “Low-Cost Embedded Systems for Structural Monitoring Applications” — Journal of Embedded Systems
12. **Kim, H., & Lee, D. (2022)** “Real-Time Data Transmission in Structural Health Monitoring Using Bluetooth Technology” IEEE Sensors Journal
13. **Das, P., & Roy, S. (2023)** “Smart Monitoring of Concrete Structures Using IoT-Based Systems” — Journal of Smart Infrastructure