# Structural Defects Identification and Performance Based Analysis using Non-Destructive Methods

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**Abstract- Structural Health monitoring (SHM) is an emerging technology, aiming to the process of implementing a damage detection of structures. Structural inspection plays a key role in public safety in regards to both long-term damage accumulation and post extreme event scenarios. In this paper monitoring of structural elements will be done by using Non-Destructive method. Accelerometer, piezoelectric sensor And ARDUINO BOARD are the one of the Non-Destructive methods to identify the structural anomalies (Acceleration, displacement, crack, voids, vibration, etc.,). Identification of Crack images (using MATLAB) are used for many other fields like medical, veterinary, military, environment. In structural defects identification, CRACK images are used for detection of defects in concrete structures and also estimating the defect parameters like size and depth. Crack images of BEAMS IN INNER AND OUTER LAYER WITH SENSORS can help to identify the exact location of the defect (which defect cannot identify by naked eye) so that repair works can be minimized. Crack image processing will be done by using MATLAB code. In this paper explained about the Accelerometer are used to measure the displacement of the structural element in X,Y,Z directions.**

**Keywords: Accelerometer, Piezo- Electric Sensor, Arduino Board, Matlab, Python Software, Thermographic Images**

## SCOPE

1. Structural health monitoring of structures by predict the critical values of warning Parameters based on structural responses
2. Structural defects can be identified using image processing technique & NDT based analysis by using Android Mobile phonein the Application of Therma CAM infrared condition monitoring system
3. Crack detection is the main scope of this project and also detect the displacement and vibration of the structure while applying load.

## OBJECTIVE

1.To investigate the integrity of the structural element by predictive maintenance to minimize the risk of failure
2.To identify the location of voids using thermograph images
3.To enhance the performance of an existing structure
4.To monitor of structures affected by external factors
5.To identify the structural defects using NDT based analysis

## INTRODUCTION

Early detection of performance degradation can save lives and property in time by stopping exploitation and access to the structure. This guarantee the safety of the structure and its users. It also gives us a way to assess the possible damages after a natural calamity or any other type of major event which can affect the structural properties and condition.

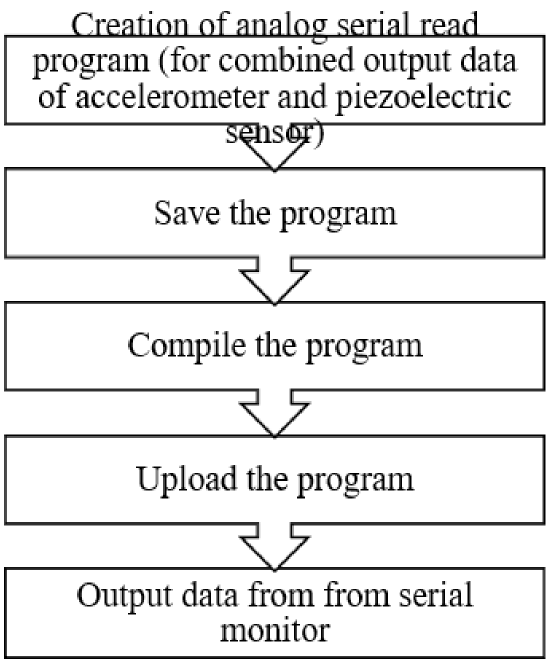
To Confirm the design parameter i.e., Detection of damages during construction which can cause any change in properties than expected by design. By providing continuous and quantitative data, a monitoring system helps you in assessing the quality of your structure during construction, operation, maintenance and repair, therefore eliminating the hidden costs of damages caused by non-achieving the required designed standards.

Learning how a structure performs in real conditions will help you to design better structures for the future. When new materials, new technologies and methods are involved in construction monitoring is an effective way to know the real behavior and to refine structural behavior theories. For this project, Structural health monitoring was done by using NDT methods (Accelerometer, Piezoelectric sensor and Thermographic camera). NDT has been used in various fields of applications such as the inspection of electrical power plant, substation, storage tanks, bridges, aircraft, pressure vessel, rail, pipeline and so on.

## METHODOLOGY

CONCRETE MIXER WITH DESIGN MIX M 35 - CONCRETE MIX

M35 Concrete Mix – 2 BEAMS (Inner and Outer Connections of sensor and Arduino board and accelerometer setup) with laptop.M35 is a common type of concrete grade. It is used in concrete pavements because they are designed for flexural strength.



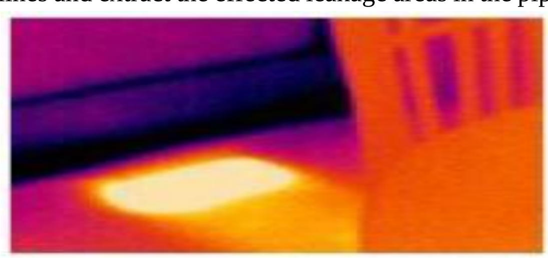

SENSORS IN OUTER & INNER LAYER OF BEAMS Beam -1 attached with accelerometer and Piezo- Electric Sensor. Both are connected with ARDUINO BOARD and Laptop for Analog reading. Beam-2 subjected to static Loading. Diff between BEAM-1 & BEAM-2 is sensor embedded in concrete of Beam-2.It gives the value of displacement in X,Y,Z Direction and Vibration. The output unit is Frequency(Hertz)

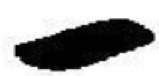
SENSOR IN OUTERLAYER IN BEAMS

SENSOR IN INNERLAYER IN BEAMS

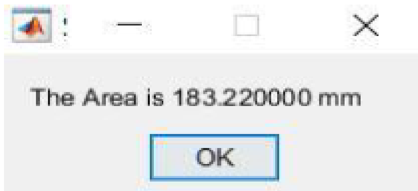
LEAKAGE DETECTION AND ESTIMATION USING IRTHERMOGRAPHY

Leakages from ceiling and floor are identified by thermal images (By using IR Camera). In this technique collect the more number of images from the IR camera and simulate in the MATLAB. It gives the input and output images as a result. The output as differentiate the leakage are in the image and also gives the area of leakage($mm^2$). In this paper, also proposing this technique in flow detection in pipe-lines and extract the effected leakage areas in the pipe.





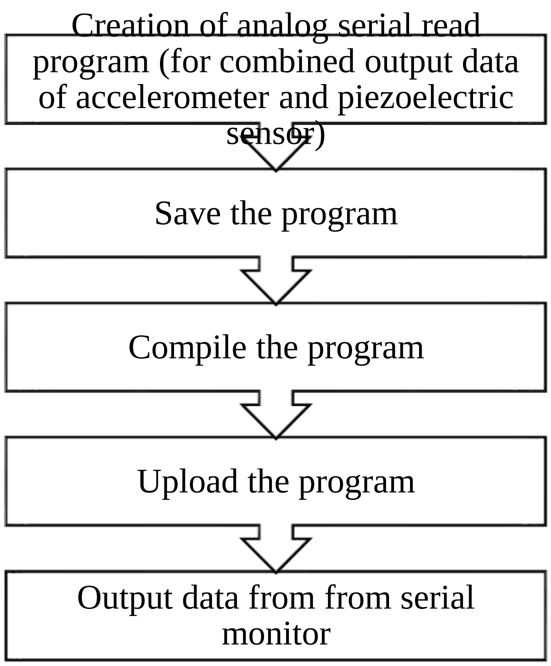
Input image of defected floor Output image as an extract area from the image




Output dialogue box(gives the area of leakage)
Leakage detection using Thermography images

PROCESS OF ARDUINO SOFTWARE

The following flow chart explained about the process of arduino software for getting the analog reading




PYTHON SERIAL PROGRAM

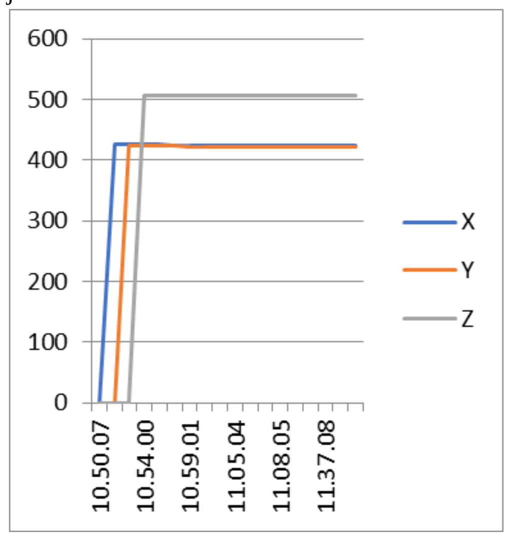
Python is an integrated, highlevel, general-purpose programming language. Created by Guido van Rossum. By using Python program, get the output data from Arduino software as CSV/EXCEL FILE or WORD DOCUMENT.

RESULT AND DISCUSSION

In this project, Beam was monitored when subjected to static load. Structural health monitoring of beam was done using Non-Destructive methods.

MONITORING THE BEAM-1 SUBJECTED TO STATIC LOAD

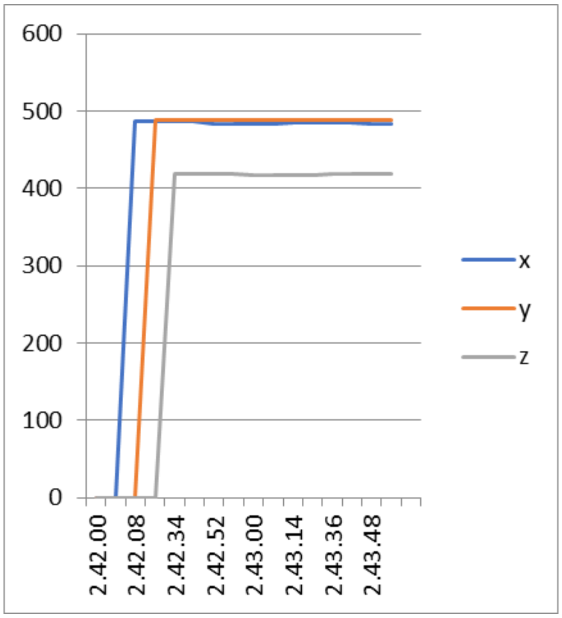
In theoretically, Application of Principal of Virtual Work is used to find the displacement of the beam. But here accelerometer was used to detect the displacement of the beam. Especially, accelerometer gives the value of displacement of the beam in three directions(X,Y,Z).But theoretically we get the value of displacement in only one direction(in which direction the load applied).Fig shows the Displacement(X,Y,Z) vs Time in Beam-1 while subjected to vertical static load.




Displacement vs Time (Beam-1 under static load)

MONITORING THE BEAM-2 SUBJECTED TO STATIC LOAD

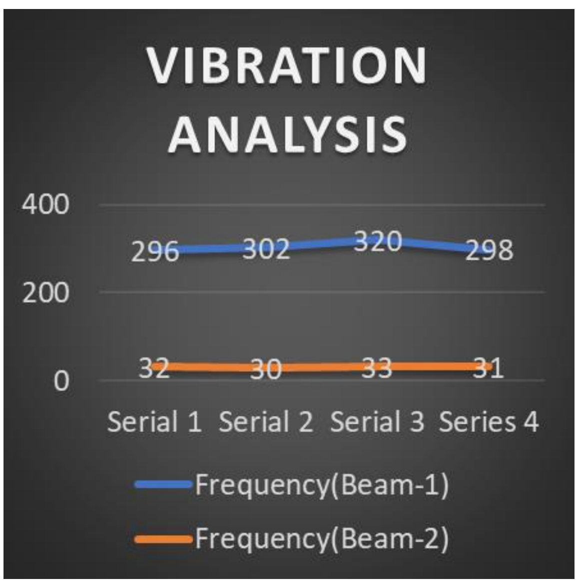
The most important is to predict the STATIC response of the structures because the damage of structures due to static loading is Medium. Fig shows the displacement of the beam-2 when subjected to static load.




Displacement vs Time (Beam-2 under static load)

VIBRATION ANALYSIS

In this project, Structural vibration was identified and analyzed using piezoelectric sensor. The vibration of beam was predicted when subjected to static load. But the position of the piezoelectric sensors were different in beam-1 and beam-2. Here Beam-1 has surface mounted sensor and beam-2 has embedded senor.




Vibration analysis of beam-1 and beam-2

Results and Comparison between Surface mounted sensor and Embedded sensor:

- ➢ Compared to surface mounted sensors, the embedded piezoelectric sensors have good noise immunity and good linear output and it occupies a small space
- ➢ Embedded sensors are used to judge on the structural integrity of the beam
- ➢ Self-generating so no external power supply is required for both sensors.
- ➢ IS 14884(2000): Mechanical Vibration and shock-Vibration of Buildings-Guidelines for the Measurement of Vibrations and Evaluation of their Effects on building. This Indian standard code book gives the typical range of structural response for various sources. By using this codal values to predict the critical warning parameters (frequency, displacement, velocity, etc.,) of the beam when subjected to static load.

| Vibration forcing function | Frequency range Hz | Amplitude range µm | Particle velocity range mm/s | Particle acceleration range m/s$^2$ |
|---|---|---|---|---|
| Traffic road, rail, ground-borne | 1 to 80 | 1 to 200 | 0,2 to 50 | 0,02 to 1 |
| Blasting vibration ground-borne | 1 to 300 | 100 to 2 500 | 0,2 to 500 | 0,02 to 50 |
| Pile driving ground-borne | 1 to 100 | 10 to 50 | 0,2 to 50 | 0,02 to 2 |
| Machinery outside ground-borne | 1 to 300 | 10 to 1 000 | 0,2 to 50 | 0,02 to 1 |
| Acoustic traffic, machinery outside | 10 to 250 | 1 to 1 100 | 0,2 to 30 | 0,02 to 1 |
| Air over pressure | 1 to 40 | | | |
| Machinery inside | 1 to 1 000 | 1 to 100 | 0,2 to 30 | 0,02 to 1 |
| Human activities a) impact b) direct | 0,1 to 100<br>0,1 to 12 | 100 to 500<br>100 to 5 000 | 0,2 to 20<br>0,2 to 5 | 0,02 to 5<br>0,02 to 0,2 |
| Earthquakes | 0,1 to 30 | 10 to $10^5$ | 0,2 to 400 | 0,02 to 20 |
| Wind | 0,1 to 10 | 10 to $10^5$ | | |
| Acoustic Inside | 5 to 500 | | | |

Typical range of structural response for various sources (IS 14884(2000)

## CONCLUSION

Structural health monitoring system used to monitor the structure and to improve structure lifespan and public safety. By using non-destructive methods, the structural defects (displacement, vibration, cracks, etc.,) are identified and analyzed. Based on new technologies explained in the review of literature, and it are clearly understood that there is scope for extending the current SHM framework to accelerometer, piezoelectric sensor and thermal image processing(MATLAB). This concept is used to identify the severity of structural defects using image processing techniques.

In this thesis work structural health monitoring and performance based analysis of beam was done using NDT methods for detect and analyze the defects of the structures. Thus the implementation of this techniques are used in taking necessary preventive and predictive action to ensure public safety.

In Thermal image processing, depending upon the crack width the cracks are classified as Thin crack <1mm in width, medium crack 1-2mm width, Wide crack >2mm in width. The piezoelectric sensor has many advantages such as fast response, low cost, simple processing. By the monitoring of the Structural dynamic response, the piezoelectric material used to monitor the changes of the structural natural frequency when the structure is damaged or the structural stiffness changes.IS 14884(2000) code book Table-1 gives the values of frequency, amplitude for different type of loading into the structures. By using this extreme ranges of structural response to predict the critical warning parameters (frequency, displacement, velocity, etc.,) of the beam when subjected to static and dynamic load. Here Piezoelectric sensor and accelerometer was positioned to collect real time data gives idea about the condition of the structure. It is used to find that the serviceability of structure within the lifespan has given data within the threshold limit.

## ACKNOWLEDGMENT

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