IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

ASSESSMENT OF STRUCTURAL DURABILITY USING ULTRASONIC SENSORS

[1]V. Maneesh, M. Mageswari, [2],A. Aishwarya, [3]

[1]Dept. of Civil and Structural Engineering, Teesside University, Middlesbrough TS1 3BX, United Kingdom

[2] Professor, [3]Student, Dept. of Civil Engineering, Panimalar Engineering College.

Abstract: Early detection of a growing crack to prevent subsequent damage, predict remaining useful life, schedule maintenance, and reduce costly downtime are all major concerns in engineering structure. During structural health management and prognosis, Ultrasonic sensor system which is a non- destructive technique with potential applications is used for locating and monitoring the cracks. The focus of this paper is on monitoring the in-situ structural health. In the beginning, the crack propagatesat a very slow rate. As a result, capturing such microscopic crack growth is extremely difficult. Of the various inspection techniques that have been used to document the growth of microcracks, only a few can provide useful information about microcracks. Detecting cracks is not only to measure the crack length and the crack growth rate of micro cracks but also to correlate the crack growth rate with the reason behind it. The costs correlated with the rising maintenance and monitoring needs of aging structures are increasing. The cost can be reduced by facilitating rapid and global assessments of structural integrity with the application of structural Health Monitoring (SHM) systems using distributed sensor networks. To quickly, routinely, and remotely monitor the integrity of a structure in service in-situ sensors can be used. This stand in need of certain structural health monitoring systems that can spontaneously process data, evaluate structural condition and signal the requirement of human intervention. Before catastrophic failures occurs, incipient damage can be detected using SHM system. It will be successful to monitor the structural health of a building, if we reduce the lifecycle cost of a building from construction to maintenance. In this proposed system, by the property of radio communication crack can be estimated. In this research, fundamental tests for the connection between crack width and the opposition of electrically conductive materials are carried out and possibility of usage of this technique is examined.

Keywords: NDT, SHM, in-situ sensors, radio communication.

INTRODUCTION

Prime importance of structural health monitoring is to detect a crack or crevices at inaccessible location. In over populated areas, the distance between two juxtaposed buildings is less for various reasons, resulting in the inability of the workforce to proceed through the gaps to assess the structure for any cracks. The human intervention can be reduced by using a remotely controlled Non – destructive techniques for monitoring structural health and thus significantly the reduce the cost involved. The evaluation of cracks involves the combination of both hardware and software modules and also the nature and extent of cracks can be identified in real time, if possible.

CAUSES OF CRACKS IN BUILDING:

PERMEABILITY OF CONCRETE

As the degradation of concrete starts with penetration of various aggressive agents, low permeability iskey to the durability of the concrete. water-cement ratio, air voids due to insufficient compaction, cyclic exposure with thermal variations, degree of hydration/curing and microcracks because of loading are some of the factors that controls the concrete permeability. water-cement ratio, degree of hydration/curing, air voids due to deficient compaction are allies with the concrete strength as well. The permeability of cement paste is a function of the water-cement ratio when the material is of good quality, the dosage is satisfactory and the practice of construction is good. Porosity and interconnection of pores of the cement paste functions directly with the permeability of concrete.

THERMAL MOVEMENT

The powerful cause for the crack in building is the Thermal Movement. Almost all materials expand during heat and contract when cooled. The coefficient of thermal expansion of brickwork in the upright direction is 50% more than that of the prone direction because of restricted movement in the upright direction. The cause of crack in the internal walls and intermediate floors are less because of less thermal expansion. Thin exterior walls that are directly bring to sunlight and roofs which are subject to considerable thermal variation are liable for cracking.

CREEP

When subjected to a sustained load, the concrete exhibits a gradual, slow deformation as a function of time known as creep. As the water and cement content, water cement ratio and temperature increase creep increases. At the time of loading due to increase in humidity of surrounding atmosphere and material aging, creep get decreases. Creep increases with the use of admixtures and pozzolanas in concrete and with rise in temperature creep in steel also increases.

MOVEMENT OF MOISTURE

Those building materials which are having pores in their structure in the form of intermolecular space expand while absorbing moisture and contract while drying. These motions are cyclical in nature and with moisture changes increase or decrease in inter pore pressure occurs. In all building materials that are lime or cement based such as concrete, lime mortar, cement mortar, masonry and plasters, initial shrinkage occurs. In general, less shrinkage occurs in heavy aggregate concrete than light weight aggregate concrete.

PRACTICE OF POOR CONSTRUCTION

The construction industry has a great fall due to prey of non-technical persons who has lack of knowledge in correct construction practices. Due to ignorance, carelessness, greed or negligence, there is a general lack of good construction practices. As the baby in mother's womb, the building or structure will be in its formative period under construction. Childs will be formed healthily if the child's mother is well nutrified and sustain a good health during her pregnancy. Similarly, selection of good quality material and a good practice of construction by the construction agency and owner will ensure a healthy building which is absolutely necessary. Every step of building construction should be properly supervised and should be managed without cutting corners.

POOR MAINTENANCE

After a certain period of time from its construction completion, the structure must be maintained properly. Depending on the quality of design and construction, some structure requires very early look on their deterioration problems while others can hold up for long years.

DIFFERENT NON-DESTRUCTIVE TESTING OF CONCRETE STRUCTURE

Estimation of some properties of concrete such as strength, durability and elastic parameters is obtained using Non-destructive testing methods. NDT method is used to find the hardness rebound number and also it has ability to allow ultrasonic pulse velocity to propagate through it. Estimation of its moisture content, density, thickness and its cement content show the electrical properties of the concrete. In the modern world, this has made the non-destructive technique more popular.

FIELD NDT TEST ON CONCRETE

1. Ultrasonic Pulse Velocity- UPV Test
2. Core Extraction for Compressive Strength Test
3. Rebound Hammer Test- RH Test
4. Combined Method UPV & RH Test

TYPES OF ULTRASONIC SENSOR SYSTEM

1. Hardware Module
2. Software Module

HARDWARE MODULE

1. IC micro controller (PIC16F877A)
2. Bridge rectifier
3. Capacitor

4. Ultrasonic sensor
5. Transmitter
6. Receiver

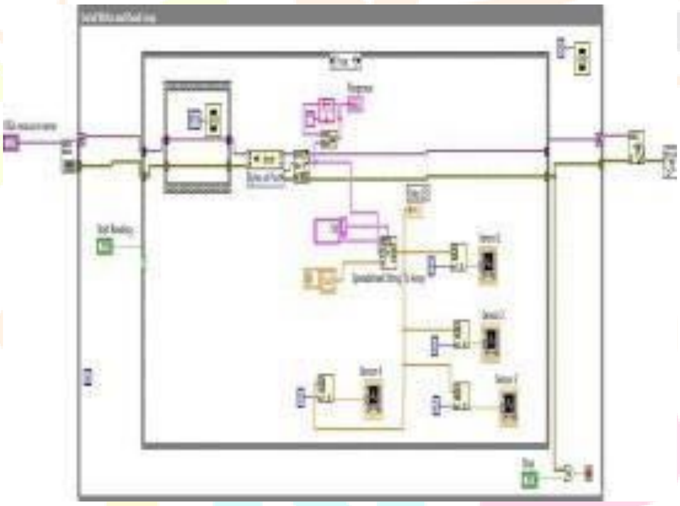
SOFTWARE MODULE

Laboratory Virtual Instrument Engineering Workbench (LAB VIEW) is a systematic design principle and development environment for data interpretation and visual programming that has been used to simulate an environment to identify the crack depth and fissures seen on the surface of the structure. While the execution of this module the depth of variation in structure is provided in the form of graphical representation and also the programmer connects different function nodes by wires using the block diagram that was inferred from this module. These wires generate variables that are used to run any node as soon as the input data become available.

COMPILATION OF CODE

Regarding performance, native code for the CPU platform is produced by a LabVIEW compiler. By the interpretation of syntax and compilation, executable machine code was translated from the graphical code. During the editing process, the LabVIEW syntax should be strictly enforced and it should be compiled into the machine code that was executable when asked to run or upon saving. In the second case, the source and the executable code are combined into single file. LabVIEW run engine which contains some precompiled code to perform common tasks that are defined by the G programming language helps the executable code to run. Reduction in compiler time and consistent interface to various operating systems, graphic systems, hardware components, etc. was provided by the run time engine. The code was made portable across platforms and user friendly by the run time environment.

BLOCK DIAGRAM



PRINCIPLE OF ULTRASONIC SENSOR

Emission of short and high frequency sound pulse was made by the ultrasonic sensor at regular intervals. At the velocity of sound, the sound pulse propagates in air. If they hit an object, they are sent back as an echo signal to the sensor, which automatically calculates the distance to the target based on the time intervalbetween transmitting the signal and receiving the echo.

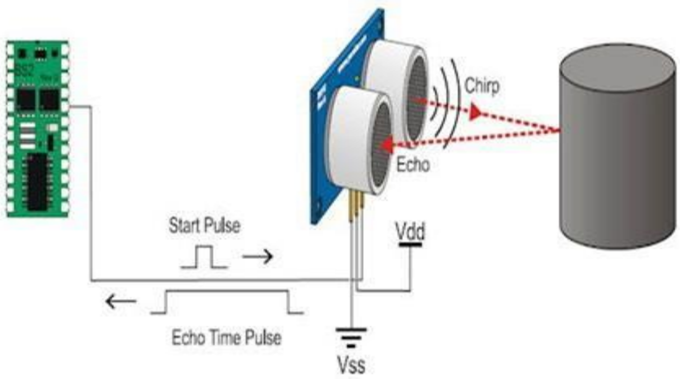


Fig no.1 Ultrasonic Sensor

The ultrasonic sensors are excellent at suppressing background interference because the distance to anobject is analyzed by calculating the time of flight and not by the intensity of the sound. Almost any material that reflects sound can be detected, regardless of color. For ultrasonic sensors, no problem willbe represented by even transparent materials or thin foil. Target distances from 20 mm to 10 m, micro sonic ultrasonic sensors are suitable. Measurement can be ascertained with a pinpoint accuracy as they measure the time of flight. Even with 0.025mm accuracy some of the sensors can resolve the signal. Through dust-laden air and ink mists ultrasonic sensors can be seen. Operation of sensor cannot be stopped with thin deposits even on sensor films. Therefore, cracks and fault in structure can be effectively detected using ultrasonic sensors. The crack detection system has the hardware modules assembled as shown with a transmitter circuit. The receiver is connected to the computer for the software module to process the signals received. This can help in remote access of the unit. From this, it became clear that the system could be effectively used to detect structural cracks at minimal cost andhelp with repair work with the exact location and extent of the crack or damage. An image of Crack Detector with all hardware modules is shown below.

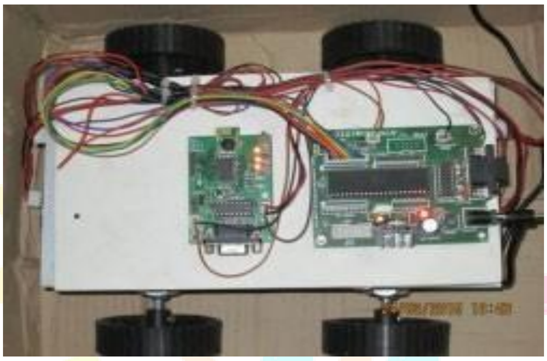


Fig no 2. Crack detector

SUMMARY

For detecting the cracks and flaws in structure, Ultrasonic sensor system is found to be the powerful tool. Real-time monitoring of the structural condition of buildings will improve their reliability and safety, and also maintenance time and cost will get reduced. The project made out of ultrasonic sensor system is cost effective and can be used for vast range of usage of different materials and locations. The failure indicator trend from the software module graph and the degree of damage are well correlated, leading to the conclusion that to detect the crack in structure using ultrasonic sensors is a reasonable technique for future application in structural health monitoring.

REFERENCE

1. BS 1881: Part 2003, recommendation for measurement of the velocity of ultrasonic pulses in concrete,London, 1986.
2. J H Bungey, S G Millard, m G Grantham, Testing of concrete in structures, 4 ed. Taylor & Francis,2006.
3. ACI Committee 224. Causes, evaluation and repair of cracks in concrete structures, ACI 224IR-07.American Concrete Institute, 2007.
4. M J Sansalone, J Lin, W B Street, “Determining the depth of surface opening cracks using impactgenerated stress waves and time of flight technique” ACI Material journal V. 95 No 2, 1998.
5. S W Shin, J Zhu, J Min, J S Popovics, crack depth determination in concrete using energy transmissionof surface waves, ACI Materials. Vo. 105. No. 5, 208.
6. Y-F Chan, C-Y Wang, A 3-D image detection method of a surface opening crack in concrete usingultrasonic transducer arrays, Journal of Nondestructive Evaluation. Vol.16. No .4,1997.
7. I O Yaman, G Inci, N Yesiller, H M Aktan, Ultrasonic pulse velocity in concrete using direct and indirecttransmission, ACI Materials Journal. Vol.98. No. 6,2001.