# CRACK ASSESSMENT IN STRUCTURAL MEMBERS: A REVIEW ON RECENT PARADIGMS

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**Abstract -** *Monitoring of health of bridges and similar structures are essential to avoid fatal accidents. In steel structures, fatigue induced crack/rupture, which is one of the most common means of failure ,that can be avoided if the crack is detected at the early stages of its formation. Cracks usually form at stress concentration areas but their precise origin is not known. In recent years, much attention has been given to structural health monitoring technology to diagnose the condition of structures using a sensor attached to them, and the number of research projects on the health monitoring of architectural structures is on the rise. In this paper, a review of previous researches are made which deals with various structural health monitoring systems concerning primarily about steel structures and affordable and efficient methods are discussed.*

***Key Words***: crack detection, SHM, vibrations, FFT, modal analysis, natural frequency

## 1. INTRODUCTION

Steel beams are extensively used due to their high strength and low structural weight. Defects in it influence the service life of structures. Detection of these defects even at a very small size is a very important point of view to guarantee structural safety and to save costs.Using vibration analysis for early detection of cracks has gained popularity over the years and in the last decade substantial progress has been made in that direction. Dynamic characteristics of damaged and undamaged materials are very different. For this reason, material faults can be detected, especially in steel beams, which are very important construction elements due to their wide spread usage in construction and machinery. Crack formation due to cycling loads leads to fatigue of the structure and leads to discontinuities in the interior configuration. Cracks in vibrating components can initiate fatal failures. Therefore, there arises the need to understand the dynamics of cracked structures. When a structure suffers from damage, its dynamic properties can change. Specifically, crack damage can cause a stiffness reduction with an inherent reduction in natural frequencies, an increase in modal damping, and a change in the mode shapes.

## 2. NEED OF STUDY

Cracks in beams are an undeniable hazard to any civil structures. Small cracks that look insignificant can grow and may eventually lead to severe structural failure ,they are very dangerous and have caused a lot of destruction and damage. Since manual inspection is ineffective and time-consuming, several non-destructive evaluation techniques have been used for crack detection. Some of them are: ultrasonic technique, vibration technique, and strain-based technique. However, there are several demerits such as some of the sensors used are either too large in size or limited in resolution. So it is crucial to discuss about their effectiveness and find alternate solutions for crack detection methods ,that are cheap and efficient.

## 3. VARIOUS CRACK DETECTION TECHNIQUES

### 3.1 Microwave Imaging Technique

This technique employs a high resolution microwave imaging technique with ultra wideband signal for crack detection in concrete structures. Various anomaly scenarios in cement bricks were simulated using finite difference time domain (FDTD)method, constructed and measured in the lab. This work is designed to use an effective means that it claims to be simple, easy, low in cost, and fast with good signal penetration for data acquisition and better image resolution through multi static arrangement. The reconstructed images showed a high similarity between the simulation and the experiment with a resolution of which enables a detection of cracks as small as 5 mm in size. This was achieved by experimentally assessing the performance of the P-Shaped wide-slot antenna as a sensor for cement based application determining the suitable frequency range that gives better signal penetration depth through the brick structure and modeling of the time domain propagation of Ultra Wide Band pulses using the finite difference time domain (FDTD) method.

### 3.2 Frequency Based Method

In this method, detection of cracks present on the structural element using natural frequency is employed. Using vibration analysis for early detection of cracks has gained popularity over the years and in the last decade substantial progress has been made in that direction. Dynamic characteristics of damaged and undamaged materials are very different. For this reason, material faults can be detected, especially in steel beams, which are very important construction elements because of their wide spread usage construction and machinery. When a structure suffers from damage, its dynamic properties can change. Specifically, crack damage can cause a stiffness reduction with an inherent reduction in natural frequencies, an increase in modal damping, and a change in the mode shapes. These changes are analysed for detecting cracks.

## 4.LITERATURE REVIEW

**4.1** Prof.A. Morassi (2001) did a study which deals with detecting a single crack in a vibrating rod from the knowledge of damage induced shifts in a pair of natural frequencies. The crack is simulated by an equivalent linear spring connecting the two segments of the bar. The analysis is based on an explicit expression of the frequency sensitivity to damage and enables non-uniform bars under general boundary conditions to be considered. The inverse problems generally ill-posed, because even if the system is not symmetrical, cracks in different locations can still produce identical changes in a pair of natural frequencies. In spite of this, it is found that there are certain situations concerning uniform rods in which the effects of the non-uniqueness of the solution may be considerably reduced by means of a careful choice of the data. The theoretical results are confirmed by a comparison with dynamic measurements on steel rods with a crack. Some of the results are also valid for cracked beams in bending.

**4.2** K.Sambasivarao (2014)did a study which shows the importance of the beam and its engineering applications is obvious, and it undergoes different kinds of loading. Such loading may cause cracks in the beam. Crack depth and location are the main parameters for the vibration analysis of such beams. These cracks and their locations effect on the shapes and values of the beam frequency. So it become very important to monitor the changes in the response parameters of the beam to access structural integrity, performance and safety.

**4.3** CheeKianTeng (2012) done a research to find out inexpensive and efficient SHM method utilizing Wireless Sensor Network (WSN) is helping to facilitate the selection of the bridges that require maintenance. The changes to structural properties (i.e. stiffness) caused by damage (i.e. corrosion) will change the structural responses (i.e. acceleration responses) to ambient motions. Modal analysis algorithms applied to the vibration responses acquired through WSN provide the modal properties (i.e. natural frequency, modal shape and damping ratio) that will change with the changes in stiffness indicating possible existence of damage. Three output-only modal analysis algorithms: Stochastic Subspace Identification (SSI), Auto-regressive Moving Average (ARMA) and Fast Fourier Transform (FFT) were evaluated based on their accuracy and efficiency in extracting modal properties using two case studies. FFT was found to be the most accurate and consistent algorithm. The extracted modal properties of the Holland Bridge agree with the ones obtained from the Finite Element (FE) bridge model. The extracted damping ratios from different algorithms were not consistent.

**4.4 .** Filipe Magalhaes (2008)done an experimental and numerical studies developed shortly after construction of the bridge, characterizes the installed monitoring system and presents the results achieved with the software developed to process the data that is continuously received through the Internet. Preliminary studies included the development of an ambient vibration test and the construction of a numerical model of the bridge that was "tuned" to fit the bridge dynamic properties identified by the ambient vibration test. The routines implemented include the on-line automatic identification of the bridge's natural frequencies with the Frequency Domain Decomposition method, enabling the tracking of the bridge's first 12 natural frequencies. This unique feature is only possible due to the combination of high-quality acquisition equipment with state of the art processing algorithms.

**4.5** Yao Yao(2015) did a study for Reliable early-stage damage detection which requires continuous monitoring over large areas of structure, and with sensors of high spatial resolution. Technologies based on Large Area Electronics can enable direct sensing and can be scaled to the level required for Structural Health Monitoring (SHM) of civil structures and infrastructure. Sensing sheets based on large area electronics contain dense arrangements of thin-film strain sensors, associated electronics and various control circuits deposited and integrated on a flexible polyimide substrate that can cover large areas of structures. Yao yao presented the development stage of a prototype strain sensing sheet based on LAE for crack detection and localization. Two types of sensing-sheet arrangements with size 6 × 6 inch (152 × 152 mm) were designed and manufactured, one with a very dense arrangement of sensors and the other with a less dense arrangement of sensors. The sensing sheets were bonded to steel plates, which had a notch on the boundary, so the fatigue cracks could be generated under cyclic loading.

## 5. CONCLUSIONS

The main aim of the paper is to attain knowledge about various existing technologies about structural health monitoring and discuss about their effectiveness. Based on literature review and all investigation following conclusion have been drawn.

1. There are various methods available that can be employed to find the crack detection in beams.
2. There is a good scope for scientific advancement in vibration analysis of beams.
3. Natural frequency and modal parameters could be employed to find an empirical relation between them and crack parameters.

## REFERENCES

[1] prof. A.Morassi, Identification of a crack in a rod based on changes in a pair of natural frequencies, Journal of Sound and vibration (2001)242(4),577-596,2001.

[2] K.Sambasivarao, Yamuna. P,vibration analysis of beams with varying crack location, International journal of engineering research and general science vol 2,issue 6,pp.1008-1017,2014.

[3] CheeKianTeng, Structural Health Monitoring of a Bridge Structure Using Wireless Sensor Network, Master's Theses.79,http://scholarworks.wmich.edu/masters_theses/79,2012.

[4] Filipe Magalhaes, Cunha A. and Caetano, E,Dynamic Monitoring of a Long Span Arch Bridge, Engineering Structures, 30, 3034-3044,2008.

[5] Yao Yao and BrankoGlisic, Detection of Steel Fatigue Cracks with Strain Sensing Sheets Based on Large Area Electronics, Sensors , 15, 8088-8108; doi:10.3390/s150408088,2015.

[6] E. A. Jiya, N. S. N. Anwar, and M. Z. Abdullah, Detection of Cracks in Concrete Structure Using Microwave Imaging Technique, International Journal of Microwave Science and Technology, Volume 2016 (2016), Article ID 3195716,2016.