SURVEY ON DAMAGE DETECTION IN A BEAM USING CROSS-CORRELATION ANALYSIS OF VIBRATION RESPONSE

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ABSTRACT

Now a day STRUCTURAL HEALTH MONITORING (SHM) is a newly evolving technique used from last few decades. The main goal of SHM is to be able to replace current inspection cycles with a continuously monitoring system. The function required in the SHM system during the in-service operation is to identify the load applied to the structure or damage in it. Reducing maintenance costs, increasing civil structures like dam's bridges, and other type of truss structures, Reducing Weight, increasing the strength and Quality control are the primary goals of Structural Health Monitoring. However there are several advantages of SHM over the traditional inspection cycles, such as reduced down-time, elimination of component tear-down inspections and the potential prevention of failure during operation. Civil structures have one of the highest payoffs.

Keyword: - *Vibration Analysis1, Structural Damage 2, Maximum Amplitudes 3, and Response Histories 4.*

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1. INTRODUCTION

1.1Structural Damage Detection Using Vibration Analysis

A detection technique to localize and quantify the multiple damages in structures is proposed in this thesis. At first, acceleration response histories at multiple sensor locations are collected numerically from damaged and undamaged structures using **ANSYS MECHANICAL APDL**. Here cantilever beam with single as well as multiple damages has been considered. The cross correlation between the acceleration histories at each sensor location is computed and for this MATLAB code is validated. The damage indicators are used to calculate from the outputs of maximum amplitudes of normalized cross-correlation. However the accuracy of the damage-detection techniques has been shown for different-different damage cases in the result section.

1.2 Objective of Structural Health Monitoring

The main **Objective of Structural Health Monitoring** for the Beam is to
1. Enhance the Performance of an existing structural beam.
2. Monitoring of beam structures affected by an external factor.
3. Feedback loop to improve future design based on experience.
4. To minimize the cost in re-construction by continuous monitoring and growth in maintenance required.
5. Move towards performance of damaged based design philosophy.

The three fundamental steps involved in Structural Health Monitoring are **Diagnosis, Localization and Prognosis.**
Diagnosis is a process of detection, identification, &assessment of faults and flaws that may affect the performance of the structure in the future**.** However **Localization** involves the identification of the location of damages.
Prognosis involves the prediction of remaining life of the structural beam or any structures. Now days the people are more focusing on the detection of the damages which is the most important technique in structural health monitoring. As you know that, there are several methods in damage detection techniques but the vibration analysis using cross-correlation technique provides the more perfections, easier, simple, as well as cheaper way in damage detections for localizing and quantifying the damage. Cross-correlation function describes the dependence between

two sets of amplitude responses. In this analysis, the response signals are accelerations. First the beam of composite material ismodeledin **SOLIDWORKS** and meshed in the **ANSYS APDL** interface, then the boundary conditions are applied for the case of cantilever and an impulse load is applied, finally the model is simulated for transient setup to obtain the displacement values. The accelerations are obtained from the displacements, which are found by using central difference method. In order to determine the damages in the structural beam a proper excitation is given to the beam and the responses are recorded at different degree of freedoms (DOF's). Here the responses may be displacements, velocities, or accelerations based on the approach using in the cross correlation technique. However, in this approach, the acceleration values are giving the best and appropriate results.

2. LITERATURE SURVEY

Structural Health Monitoring technique is a popular and fully developed in the field of Civil Structural Engineering as well as in Aerospace Engineering, there are many literatures on Structural Health Monitoring by various authors in detecting the damages and monitoring the entire structure throughout its life.
There are few example of structural failure used for different types of structures and why the structural health monitoring is required.

Figure 2.1 the above figure represents the applications of the structural health monitoring

Structural health monitoring of civil, Aerospace and automotive engineering infrastructures has received extensive attention for decades and has been published in many journals and numerous methodologies have been proposed to accomplish various objectives of structural health monitoring.

SHM methods are presented by Sohn et al. [15], where the sensing technologies, like displacement, acceleration, strain are presented, and the feature that each method uses for SHM, like frequency response functions, resonant frequencies, damping, modal shapes, non-linear features etc. They indicate A novel approach of SHM by the application of FFT and wavelet transform using an index of frequency dispersion. **C. M. Diwakar,N. Patil, and Mohammed Rabius Sunny[13]** In this thesis, the traditional threshold-based method of detecting damages from these damage indicators has been observed to be inadequate for the detection of multiple damages. Here, the drawback of threshold-based damage-detection method is overcome by using an artificial netural network. **Le Wang, Tim P. Watersand Zhichun Yang[14]** Structural damage detection methods based on vibration responses are appealing for a variety of reasons such as their potential to observe damage from sensor placed remote from an unknown damage site. **Chiu et al.[11]**prescribed that structural monitoring in damage detection can be achieved by placing a sensor system on a structure/machine to measure a physical quantity for e.g. vibration signature, impedance, power flow, strain, acoustic emissions, etc. **Habib, Fady[6]**described various Structural Health Monitoring Techniques in detecting the damage, they mainly focused on the Acoustic-Ultrasonic(AU), Capacitance Disbond Detection Technique(CDDT), and Surface Mountable Crack Detection System(SMCDS). **Hou, Yan Fang, and Wei Bing Hu[3]**introduced the Cross Correlation Function Amplitude Vector(CorV) to detect the damage of a historic timber structure based on the random vibration. **Zhu, Yi, Wang and Sabra[1]**had described the application of cross-correlation function for structural damage detection by collecting data by using vibration analysis.
Recent and early works based on natural-frequency, the damage detection can be calculated by [16-17]. According to**Jauregui and Farrar**[17-18], standard modal parameters such as mode shapes and natural frequencies are indicating the poor damages and have higher statistical variability. For damage detection, many existing vibration-based approaches require the extraction of modal properties with the aid of the traditional Fourier transform [19]. However the researchers including**Loewke et al**. [20], **Raghavan and Cesnik** [21],**Yeung and Smith** [22],and **Pawar et al**. [23] , for structural damage detection, they have successfully used the Fourier transformation to extract the modal information from vibration responses. **Obuchowski et al**. [24] performed a short-term Fourier transformation on responses of structural vibration in the time-frequency domain to calculate the damage detection in rotary machines. Recently, **Yang et al**.[25] used Fourier spectral method for the calculation of 2-dmodal curvature for damage detection. However the use of wavelet transform has been proposed in [26,27].To calculate the damage detection through cross correlation of the response histories at different sectional locations of the structure has been proposed by several researchers to form damage indicators[28–35]. However, They conducted the laboratory experiment by introducing various Damage Scenarios to validate the damage detection approach. In their experiment, they collected the response signals using mobile sensor prototype from the undamaged structure and the structures with three different Damage Scenarios, which includes loosened bolts, including extra mass and loss of section area. The mobile sensors, which are, located at different positions on the structure record the acceleration data at corresponding locations, these acceleration data is used to find the damage indicators. With reference to, their experimental work in this thesis damage in the form of triangular cut, which indicates the scenario of loss of section, is introduced and numerical study is performed to validate the damage detection approach. The monitoring and maintenance of structures in the modern society has long been considered crucial work. Applying effective approaches to the regular repair of bridges, roads, and other structures is essential for safety of human life. In addition, to keep the buildings and other infrastructures running smoothly and maintaining safety as well as public health is also of great importance. Now days, the new technological developments & methods are being utilized as Structural Health Monitoring (SHM) process. Supporter of this emerging capability and understanding the importance of successfully maintaining the civil infrastructures. Today, the government rules and regulations for building and construction, and new mandates as well as required maintenance have also contributed to the development of SHM. This supervene trend has a number of benefits, from improving the safety standards, reducing risks up to the cost effective opportunity.

2.1 Increased Safety

However the greater efforts made to improve SHM, will ultimately work to improve the overall public safety include everything from new policies and guidelines that help to ensure the building and construction safety, due to the development of new technologies.

Advanced SHM methods have greatly improved the ability of engineers to contribute to public safety with the use of sensors, data collection and analysis. This is mainly important with aging structures. The SHM process could involve testing the faltering strength of old buildings, structures, beams, etc.,as well as it is also more effective in analyzing the corrosion levels of older pipes that transport water, fuels or gas. Advanced SHM technologies are also having more benefits in new structures. Continuous monitoring and analysis helps to pinpoint design of the new structures

2.2Detecting Early Safety Risks

In addition, it will help the engineers in recognizing the poor conditions of the structures and other safety issues, Due to advanced technical development in SHM help professionals to determine the potential future risks for safety. The modern monitoring technologies can also be used to track the geotechnical details for buildings, roads, and other structures. This also provides the ability to detect the ground movement such as risks involved with earthquakes, landslides, and other disasters.

2.3 Cost Efficiency

SHM has greatly reduced the long& short-term costs related to structural maintenance by improving safety as well as ensuring the longer life for structures. However, there are little challenges with SHM in terms of standardizing the policies and diversity of new and old structures as well as the ranges of methods of construction.

3. Conclusion

In this study we observe that especially in India, which is as a developing country, therefore we must be more aware and cautious about the Infrastructure. Major damages can lead to be irreversible in terms of losses and hence it should be well informed within the time period. However the structures especially in the hospitals and other important bridges, tunnels and buildings should be mandated with monitoring as their failure or damages causes large amount losses than any other losses. And hence at these places the structural health monitoring has become more important. However, the Structural Health Monitoring is a very important need for all structures existing in the world to keep a continuous check on their performance as well as their life span. Therefore, it has been proved that SHM is required to be more effective and has a great potential for gaining more confidence over the structures which we are making and it should not affect the humans' life, so that development happens faster with great accuracy in results.

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