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Structural Health Monitoring of Bridge

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Abstract – As our nation's bridge infrastructure has aged the need for effective methods of structural health monitoring (SHM) has become increasingly important. Bridge testing has evolved considerably over the past few decades with the advent of small, versatile, and economic sensors and data acquisition on equipment. Today, single-day bridge tests can be economically conducted, and it is feasible to install a permanent SHM system that will monitor the performance of a bridge.

Keywords: SHM, Economic Sensor.

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I. INTRODUCTION

As new materials & technologies are discovered, buildings get taller, bridges get longer spans & the designs of structures become more ambitious, but more complex. In view of these developments, there is an increased requirement to providing both the costs savings with regard to maintenance & a safer environment for by preventing structural failures. India even being a developing country has picked up the structural developments including the new technologies. India has a rich cultural & historical background which is very well reflected in the varied amount of historical structures. These structures are very well built & have withstood the test of time. But due to their historical importance it becomes very important to assess health condition of these structures, so that appropriate steps can be taken before it is too late. The condition of bridge changes over their life cycle for reason such as damage & overloading .Serve environment inputs & ageing due normal use .Structural performance often as result of change in condition. Structural Health Monitoring is a measurement of structure under operational environment incident, damage & deterioration .It Commonly known as Structural Health Assessment (SHA) or SHM, this concept is widely applied to various forms of infrastructures, especially as countries all over the world enter into an even greater period of construction of various infrastructures ranging from bridges to skyscrapers. Structural Health Monitoring (SHM) is a process aimed at providing accurate & in-time information concerning structural condition & performance on a proactive basis. It consists of permanent continuous, periodic or periodically continuous recording of representative parameters, over short or long terms. The information obtained from monitoring is generally used to plan & design maintenance, increase the safety, verify hypotheses, reduce uncertainty & to widen the knowledge concerning the structure being monitored. In spite of its importance, the culture on structural monitoring in India is not yet widespread. Thus several defect are identity by SHM, by Audit we can give remedial.

The Bridge Audit is an overall health & performance checkup of bridge like doctor examine patient. It ensure that bridge premises are safe & have no risk. It analyzes & suggest appropriate repairs & rectifying measure require for bridge to better service in future.

The Process of Structural Health Monitoring is process similar to the pain & illness experienced by human body & how it is cured if the body is considered like a structure. When a person has some damage or problem with his body, the unhealthy condition is detected by the nervous system & it sends signals to the brain about the issue. Person realizes that he is ill & visits a doctor in order to prevent its further development. Synonymously the sensors act as the nervous system & the acquisition system act as a brain. The structural expert is like a doctor for the structure & listens to the responses & proposes a solution/repair strategy.

The important aspects are responses in the structure. Responses which can be commonly measured can be in general divided in

- Mechanical: strain, deformation, dis-placement, cracks opening, stress, load.

- Physical: temperature, humidity, pore pressure.
- Chemical: chloride penetration, sulphate penetration, pH, carbonatation penetration, rebar oxidation, steel oxidation.

The physical diagnostic tool of SHM is the comprehensive integration of various sensing devices & auxiliary systems, including:

- Sensory system.
- Data acquisition system.
- Data processing system Communication system.
- Damage detection & modelling system.

Monitoring is not supposed to make a diagnosis. To make a diagnosis & propose the cure. It is necessary to carry out a detailed inspection & related analyses. Detection of unusual structural behaviors based on monitoring results is performed in according with pre-defined algorithms. The efficiency of monitoring depends on both the performance of the applied monitoring system & the algorithms employed.

II. LITERATURE STUDY

[2.1] Gregory Hackmann, Weijun Guo, Guirong Yan, Zhuoxiong Sun – [2014]: Our deteriorating civil infrastructure faces the critical challenge of long-term structural health monitoring for damage detection & localization. In contrast to existing research that often separates the designs of wireless sensor networks & structural engineering algorithms, this paper proposes a cyber-physical co-design approach to structural health monitoring based on wireless sensor networks. Our approach closely integrates 1) flexibility-based damage localization methods that allow a tradeoff between the number of sensors & the resolution of damage localization, & 2) an energy-efficient, multilevel computing architecture specifically designed to leverage the multi resolution feature of the flexibility-based approach. The proposed approach has been implemented on the Intel Imote2 platform. Experiments on a simulated truss structure & a real full-scale truss structure demonstrate the system's efficacy in damage localization & energy efficiency.

[2.2] Jerome Peter Lynch - [2012]: Wireless monitoring has emerged in recent years as a promising technology that could greatly impact the field of structural monitoring & infrastructure asset management.

This paper is a summary of research efforts that have resulted in the design of numerous wireless sensing unit prototypes explicitly intended for implementation in civil structures. Wireless sensing units integrate wireless communications & mobile computing with sensors to deliver a relatively inexpensive sensor platform. A key design feature of wireless sensing units is the collocation of computational power & sensors; the tight integration of computing with a wireless sensing unit provides sensors with the opportunity to self-interrogate measurement data. In particular, there is strong interest in using wireless sensing units to build structural health monitoring systems that interrogate structural data for signs of damage. After the hardware & the software designs of wireless sensing units are completed, the Alamosa Canyon Bridge in New Mexico is utilized to validate their accuracy & reliability. To improve the ability of low-cost wireless sensing units to detect the onset of structural damage, the wireless sensing unit paradigm is extended to include the capability to actuators & active sensors.

[2.3] Soojin Cho, Hongki Jo, Shinae Jang, Jongwoong Park, Hyung-Jo Jung1, Chung-Bang Yun1, Billie F. Spencer, Jr. &Ju-Won Seo - [2010]:

This paper analyses the data collected from the 2nd Jindo Bridge, a cable-stayed bridge in Korea that is a structural health monitoring (SHM) international test bed for advanced wireless smart sensors network (WSSN) technology. The SHM system consists of a total of 70 wireless smart sensor nodes deployed underneath of the deck, on the pylons, & on the cables to capture the vibration of the bridge excited by traffic & environmental loadings. Analysis of the data is performed in both the time & frequency domains. Modal properties of the bridge are identified using the frequency domain decomposition & the stochastic subspace identification methods based on the output-only measurements, & the results are compared with those obtained from a detailed finite element model. Tension forces for the 10 instrumented stay cables are also estimated from the ambient acceleration data & compared both with those from the initial design & with those obtained during two previous regular inspections. The results of the data analyses demonstrate that the WSSN-based SHM system performs effectively for this cable-stayed bridge, giving direct access to the physical status of the bridge.

[2.4] R Zaurin and F N Catbas - [2009]: The condition of civil infrastructure systems (CIS) changes over their life cycle for different reasons such as damage, overloading, severe environmental inputs, and ageing due normal continued use. The structural performance often decreases as a result of the change in condition. Objective condition assessment and performance evaluation are challenging activities since they require some type of monitoring to track the response over a period of time .In this paper, integrated use of video images and sensor data in the context of structural health monitoring is demonstrated as promising technologies for the safety of civil structures in general and bridges in particular. First, the challenges and possible solutions to using video images and computer vision techniques for structural health monitoring are presented. Then, the synchronized image and sensing data are analyzed to obtain unit influence line (UIL) as an index for monitoring bridge behavior under identified loading conditions. Subsequently, the UCF 4-span bridge model is used to demonstrate the integration and implementation of imaging services and traditional sensing technology with UIL for evaluating and tracking the bridge behavior. It is shown that video images and computer vision techniques can be used to detect, classify and track different vehicles with synchronized sensor measurements to establish an input–output relationship to determine the normalized response of the bridge.

[2.5] A. J. Cardiniand J. T. DeWolf – [2008]: This paper presents an approach to use strain data from a multi-girder, composite steel bridge forlong-term Structural Health Monitoring (SHM). The bridge being studied is part of a research project atthe University of Connecticut in which long-term SHM systems are being installed on a series ofbridges throughout the State of Connecticut. Strain data is collected from normal truck traffic todetermine live load stresses, load distribution factors, and the location of the neutral axis in eachgirder. Known weight trucks were used along with a finite element analysis for verification of thebehavior. The long-term monitoring approach is based on determining the live load distribution factors, peak strains, and the neutral axis locations. The goal is to use existing, readily applied technology forSHM for long-term use on bridges that have raised concerns, due to corrosion noted in routine visualinspections, overloading, or fatigue sensitive details. The SHM system proposed can be used on acontinuous basis to determine if there are significant changes in the structural behavior that would beindicative of major damage to either the girders or the concrete deck.

III. NEED OF SHM IN INDIA

With an advent of all new structures coming up a time when India is competing in today's competitive global market, one cannot tend to ignore that fact that India carries the burden of numerous old structures owned not only by the state but also the people. These old structures have known or unknown deficiencies and cannot be identified unless a disaster is experienced. However, it would be too late by then as the damage would have already happened in terms of human loss. This leads to the present state of the poor affairs and needs a careful consideration to be pro-active to conduct health monitoring and providing proper solution, and then it would be up to the owner, may it be private or government to execute it in the national interest.

Structural health monitoring (SHM) in general sense is a process aimed at providing accurate and timely information about the condition and performance of a structure. It can be either short term (eg. repairs efficacy) or a long term (monitoring parameters continuously or periodically) process. A need for SHM arises with the fact that properties of both concrete and steel depends on a large number of factors, which are often hard to predict in practice. The representative parameters selected for health monitoring of a structure in general can be of mechanical, physical and chemical in nature.

In India due to negligence and non-availability of technology, SHM has not been taken seriously and therefore, misses its full potential. If safety standards are emphasized and followed SHM will grow to its full potential and be an integral part of structural maintenance and management. Safety is a serious issue and should be addressed properly in the future.

Its benefits:

Damage detection

– All types of damages at varying location.

– Autonomous data collection, reduction, evaluation, and storage.

Load rating (including better capacity estimate) and remaining life estimates.

Structural integrity or safety.

Data or Information can be collected or used as frequently as desired.

IV. CONCLUSION

1. The SHM approach has been developed to provide warning of major changes in the structural integrity, such as failure of a beam or significant deterioration of the deck slab, either for a portion of the bridge or degradation of the entire slab.

A conceptual damage index is formulated using the computer image and the sensor data for tracking the structural response under various load conditions.

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