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Study of Sensors Used in Structural Health Monitoring (SHM) Systems

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Abstract: ***The article offers an overview of the contemporary digital techniques used for maintaining track of the structural life span of civil structures. The wide range of wireless sensors have been recently deployed with smart structures and are responsible for the structures health monitoring (SHM) throw-out its life span. During the past few years, studies into SHM have been conducted. Locate structural deterioration on a more extensive scale. This paper has classified various types of structures using sensor deployment then presented the study of the senior's uses to monitor these structures individually. The Dams, Bridges, and Tall Structures are mostly being using the sensors even the sensors networks. In the recent item lot of sensors uses are available on the construction site management. Paper has contribution to explore various sensing architecture and also preseted the future scope and challenges of SHM systems.***

Keywords: **Structure Health Monitoring, Sensor, FBG, Bridge Monitoring Dam Monitoring, GPS, GIS, Strain Gauge, Ultrasonic sensor , Crack Detection.**

I. INTRODUCTION

Real and efficient approaches for keeping an eye on the structural health of ageing infrastructures are needed. Preventative care is required for guaranteeing a product's dependability, which motivates us to monitor the structural health of civil and commercial buildings in, real-time to enhance living circumstances and prevent financial losses. The SHM is the field of research to assure the routine maintenance of the structures [1]. Therefore in recent times smart structures are widely being used with inbuilt SHM systems. Various structures using the sensors for SHM are repressed in the Figure1. These structures consist of the Bridges, Tall Structures, Dams, Tunnels, smart homes and the Construction site of structures. Amongst these Dam sits and bridges have significant uses of the sensors [2]. Sensors of various types are installed on the structure itself for monitoring its health for the long life. Conventional SHM relies neither on routine maintenance staff inspections, that are neither automated or nor devoid of human interaction Huge amount of and kind of sensors are deployed for the smart SHM systems in recent times. The most frequent sensors employed in monitoring structural health are illustrated in the Figure 2. These sensors include vibration sensor used in bridges and tall structures. Seismic sensors are used for earth quack detection and analysis. The GPS (Global position system) are the most frequent to be deployed on the Dam site localization and also in the bridges. In recent times GPS trackers are used for construction site workers load management. The wind speed and pressure are meteorologically measured using the anemometer.

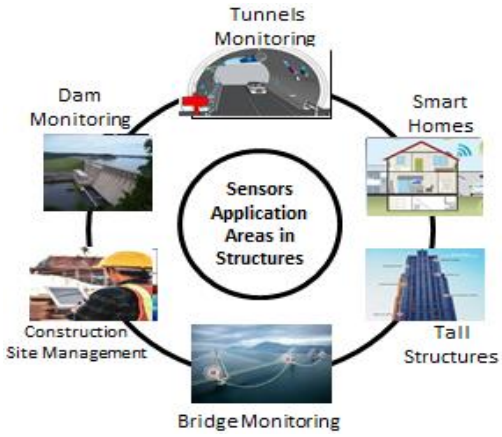

Fig.1. Various Structures using the Sensors

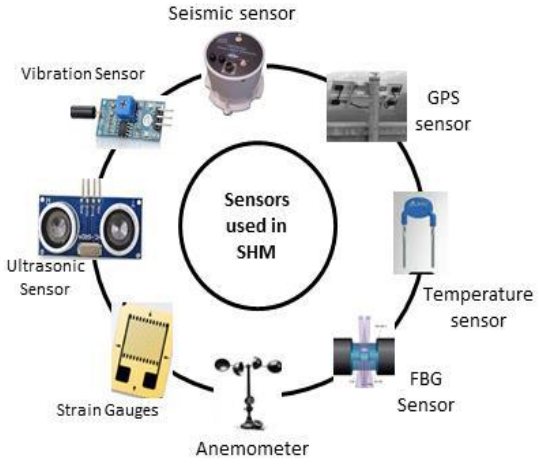

Fig.2. Most Frequent Sensors Used in the Structural Health Monitoring

Z. H. Warsi [1] studied an overview of the contemporary electronic methods used to keep track of the structural life expectancy of mechanical and civil structures. Structure health monitoring refers to the techniques used to locate and assess anomalies that cause harm to a certain structure, typically one that is mechanical or civil in nature. The majority of SHM research undertaken in recent years has sought to more broadly define structural damage. Pedro et al. [2] create a path that enables a connected world through distributed measurement systems; this paper presents a critical review of the foundations and applications of sensing technologies for SHM systems using ESs. It focuses on their actual developments and innovation as well as analyses the challenges that these technologies present.

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Kinet and others [3] addressed primary difficulties associated with the usage of FBGs in composite materials are discussed in this research. The issues of temperature, strain discrimination, amplitude spectrum demodulation during and after curing, and interaction between implanted optical fibers and the environment will be the main topics of discussion. It will be shown how much progress has been made in this subject over the past few years by summarizing and comparing the key tactics adopted in each of these three topics.

Edirisinghe et al [4] reviews 114 articles on the topic of the "digital skin" and presents a systematic and hierarchical classification of them. The hierarchical organization is built on applications that are pertinent to the construction industry, including augmented reality, building information model-based visualization, workforce tracking, supply chain tracking, safety management, mobile equipment tracking, timetable and progress monitoring. Three criteria—validation of technological viability, on-site application, and user acceptance testing—were used to evaluate the research articles.

Rocha [5].review article focuses on the most promising class of commercially and lab-made sensors for the SHM of aerospace composites. Discussions include sensing concepts, characteristics, embedding techniques, interactions between sensor and host materials, and obtained sensor data and material behavior. In the context of liquid composite molding processes, the use of sensors for in-situ process monitoring is considered, in particular for curing and mound filling monitoring. There is also a brief mention of general factors for the development of SHM systems for the aircraft environment.

Kemoto et al [6] used contactless loading sensor system that can measure the internal loading of an object structure via a variety of covering materials. Because the created system uses passive RFID for data exchange and a power source, it can be put into items without a battery. As a result of the power supply being typically very low with RFID, the system consumes less electricity. They have suggested a system architecture that is making use of two kind o the RFID tags.

Bremer and co. [7] study examines the resilience of functioning carbon structures (FCS) in an environment of very alkaline concrete. AB Noel [8] article provides a thorough review of SHM employing WSNs, highlighting the algorithms employed in damage detection and localization, explaining network design issues Edirisinghe and other [9] present smart safety vest prototype created to sense temperature and warn the wearer and nearby employees/management of thermal irregularities

Eastman and other [10] have proposed using building info management system (BIM) foe construction planning. The current study by A.Glii et al. aims to spread awareness about the advantages of using BIM in various areas of the building industry Samson Fosu Gyasi and others look into how locals in a few areas around the Bui Dam felt about the quality of their drinking water at Dam sites.

The work by Wang T et al. With the suggested algorithm, a structure's precise global features can be determined using only the observed strain responses. To decouple and extract the strain modes one at a time, singular value decomposition, power spectrum augmentation, and least square fitting techniques are used.

Svendsen and other research present a data-based SHM technique for steel bridge damage identification. A thorough research of the most prevalent types of steel bridge damage described in the literature is used to introduce damage and collect data from a genuine bridge under various structural state conditions.

Over all it is concluded that the west range of applications have been demonstrated for the use of sensors in the structures design and monitoring.. This paper has preseted some of the most frequent sensor deployment and uses in the most common civil structures. The uses of sensors for the reservoirs of the dam sits are also part of future discussion. It is expected to explore the various possibilities of seeing in smart structure designs.

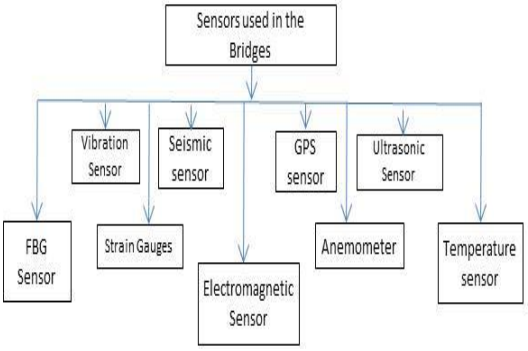

Fig.3.Classification of the Sensors used in the Bridge design and Monitoring

II. SENSORS USED IN BRIDGE MONITORING

Most frequent use of the SHM system is in the bridges. The classification of the sensors used in the Bridge design and monitoring is presented in the Figure 3. The sensors are broadly classified as the vibration sensor, Fiber brag gritting sensor, strain gauge, electromagnetic sensor, GPS sensor and anemometer. He most used sensors are fiber optics sensors (FOS) is discussed first.

Fiber Optic Sensors (FOS)

Optical Fiber Sensors Because of their non-conducting nature, lack of battery power requirements at the sensors node, as well as immunity to electromagnetic waves, FOS is becoming more and more popular among SHM engineers.

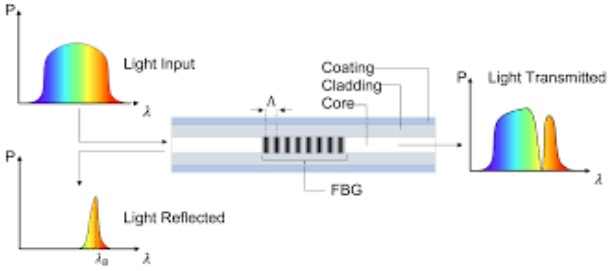

Fig.4.FBG sensors deployed to measures strain in Bridge structures

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The optical fiber sensor most frequently used is the Fiber Bragg Gritting (FBG) sensor the FBG sensors are mounted in the beams, pillars and on the bridge surfaces. The may determine the load and pressure on the bridge. The light pulse width changes across the fiber output are measure of the physical quantities. Figure 4 depicts the basic process of FBG sensors.

Anemometer: They are mounted on the various bridges especially on cable straight bridges. And used for measuring the wind speed and pressure for the materialistic measures to ensure the long life of the cables.

Ultrasonic sensors: used for the easement of the crack and the depth and width analysis of the cracks on the structures surfaces Then letter data is used for the retrofitting and the sheerness of the cracks. These sensors are used for the determination of the rver flow level also for the lifetime. And used for the risk management.

Strain Gauges: The strain grudges are pressure and displacement sensors. Huge amount of gauge are installed on the structures itself for the long life measurements.

GPS for GNSS: the GPS sensors operated using the satellites navigation are used for the measuring the dynamic deflection in the bridges.

Electromagnetic sensors: are most widely used in the bottom of pillars and ridges surfaces and used for the energy harvesting applications.

Seismic sensors Seismic and Motion sensors keep track of the frequency and intensity of shaking over time. Also measures the earth quack intensities access the structures.

These are the few sensor uses. But in actual practice there is grate scope of sensors study in the civil engineering.

III. SENSORS USED IN DAM SITES MONITORING

Dam monitoring is one of the most important engineering and monitoring challenges in contemporary society. Dams supply households, businesses, irrigation, as well as drinking water with energy. But as they get older, they often start to break and overflow, which can do a lot of harm. So, in order to foresee their overflows and ageing and to get early warnings about such conditions, we need a way to track and log them. After that, we can collect various analytical data about them. Some of the other senor uses on the Dam sits are as follows;

- Dam Water Quality Analysis: the reservoirs water quality and the water supply requires continuous testing of the water quality analysis on Dam sits.
- Dam Global Thermal Field: The thermal behaviors of dam walls are continually minters using the temperature sensors installed on the walls.
- GPS sensors are used to provide the navigation info of the Dam sites.
- Sensors are used to verify and substantiate the design's premise and presumption.
- To measure the river level on continues basis.
- Determining how reservoir application affects several variables, like stress, strain, pressure in the water, tendency, deflection, as well as water seepage.

IV. SENSORS USED IN CONSTRUCTION SITES

There are many applications where sensors are deployed on heavy construction sites. Few examples are as follows

- To maintain safety in the primary area and its surroundings during active construction.
- To monitor the constantly shifting parameters while building.
- To ensure the safety of nearby structures including the foundation while construction is taking place.
- Monitoring the SHM results to determine the structure's level of safety over its lifetime

The basic system block diagram for the seeing and testing units used on the SHM system is shown in the Figure 5. The sensors performance of the structures can be tested and easily used in the lab environment using the arduino boards.

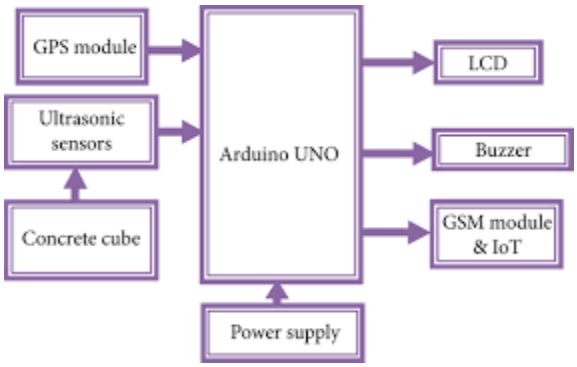

Fig.5.Most simplest SHM system hardware diagram

Examples of the most common types of the seniors used in the SHM system design for the structural uses are shown in the Figure 6. An smart homes or structures consist of smoke sensor, fire detection and warning sensor, light sensors like LDR, IR sensors for object detection and counting, also sensor for energy harvesting.

Fig.6.Most frequent sensors for smart structures

Safety is the major concern for peoples using the structures the most frequent safety sensors and applications are mention in the Figure 7

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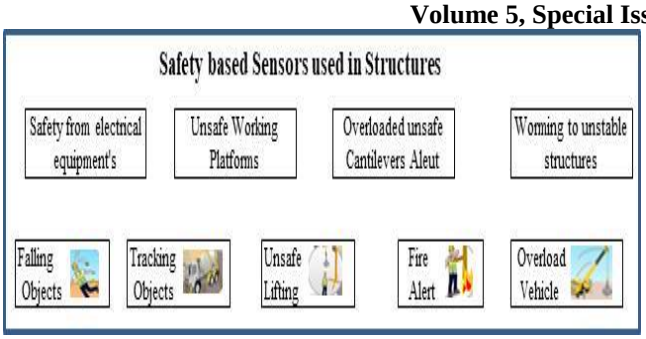

Fig.7. Safety measures to be taken on structure sites and projects.

V. SHM IOT ARCHITECTURE

IoT devices have a solid architecture that allows them to accomplish their goals. Additionally, the viability of IoT systems is determined by the level of quality of the built infrastructure. The frameworks and data flows used by various connected device types for diverse structure applications are comparable. The deployment of IoT-based SHM in different structures faces several challenges even though it has notable qualities and a wide range of applications. By way of example, sensors' battery life needs to be increased to guarantee that their durability. This issue can be resolved by employing techniques like increasing the microcontroller's sleep duration and transmitting data in short packets while the embedded system is operational.

VI. CONCUSION

Article provides a summary of the modern computerized methods for tracking the structural lifespan of civil structures. A variety of wireless sensors have lately been installed in smart structures, and they are in charge of monitoring the health of the building during its lifespan (SHM). Studies on SHM have been carried out in the recent years. Find structural degeneration that is more pervasive. This study examined the methods used by seniors to monitor each of the many types of structures that were identified using sensor deployment. Most sensors, including sensor networks, are used in dams, bridges, and tall structures. In recent item lot of sensors uses are available on the construction site management. Let's give try on analyzing and building the smart structures for future adornments.

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