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Sustainable structures for smart cities and its performance evaluation

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Abstract - *Today rapidly growing and developing nation India, as well as the other countries in world, faces a challenge towards sustainable/durable construction which should remain fit for its design life through self-sensing and self-healing. That is the reason we have to develop durable, strong and cost effective construction materials and structural systems. A major portion of the national wealth spent on civil infrastructure. Smart materials and structures are a rising innovation with various potential applications in common and important structure. This study concentrates on the introduction of smart structure and its application with its nondestructive evaluation. Also in this study general introduction is given about some modern nondestructive tests in different structures.*

Key Words: Smart material, smart structures, shape memory alloy, acoustic emission, damper, nondestructive evaluation.

1. INTRODUCTION

In this world, it is incredibly hard to do maintenance and inspection of infrastructure, due to in service expense. The quality of infrastructure is directly interrelated to the wealth of nations. Deficient infrastructure leads to diminishing in national development and financial system. With advancement and innovation in the construction industry as an engineer, focus should make on infrastructure upgrading efficiency that maintenance and repair work will diminish. Structures failures may be prevented by monitoring and prediction of their life span. By monitoring the structure, we discover options of those issues that enhance the life of the structure. There is the requirement of such structures, which can sense, actuate and repair themselves. The current age is well thought-out to be the smart material era (Kamila, 2013). Worldwide, significant exertion is being conveyed to create brilliant materials and structures (Gupta and Mnnit, 2010). The idea of designing materials and structures that react to their surroundings, including their respond to surrounding, is a fairly alien concept. There are numerous conceivable outcomes for such materials and structures in the man-made world. These structures could help likewise to give full execution history, and also the area of imperfections. At the same time as being able to check undesirable or conceivably risky conditions, for example, unnecessary vibration, and impact.

Entire man-made structures cover limited life spans and degrade after they put into service. Diverse processes condition for example fatigue, erosion, wear, corrosion, and overloads degrade them until they are no more fit (Gharibnezhad *et al.*, 2014).

Smart materials are at present being used in all around the world of human life and technology. Not just the smart materials or structures are limited to detecting additionally they adjust to their encompassing surroundings, for example, the capacity to move, vibrate and show different reactions. Besides, in structural designing, these materials are utilized to examine and monitor the respectability of bridges, dams, oil-bearing seaward towers. Fiber-optic sensors implanted in the structures are used to recognize the inconvenience zones (Kamila, 2013).

Materials technology made items and parts that are smaller, smarter, multifunctional, ecologically perfect, more survivable and adaptable. These items won't just add to the developing industrial revolutions yet will have extra impacts on assembling logistics and individual ways of life. The diversity of materials recognized as superior materials have been developed for diverse applications (Kamila, 2013; Kumbhar et al., 2014; Cornea et al., 2015).

A large group of engineers is working in the region of smart structures, including mechanical, electrical, materials and basic architects. In the present era, the field of smart structures can be very wide and multidisciplinary (Pakrashi et al., 2007; Park et al., 2007; Su et al., 2007).

2. EXPECTATIONS OF STRUCTURES AND NEW MATERIAL REQUIREMENT

Expectations of smart structures in present and future are described by a flow diagram as shown in Fig.1:

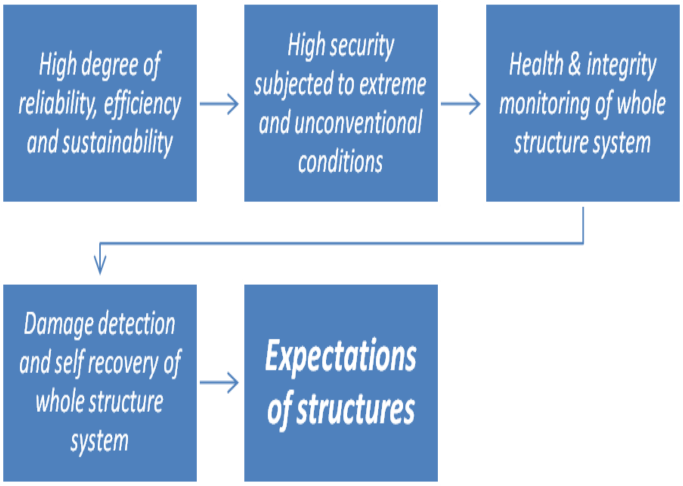

Fig-1: Flow diagram of expectations of structures in present and future

For the smart structures of the future, any new material has to fulfill not only technical, but also economical, environmental and sustainability criteria, as well as the sensing and actuating functions, are as following (Gupta and Mnnit, 2010; Akhras, 2000):

- Technical and technological properties, with mechanical characteristics and behavioral characteristics.
- Economic criteria
- Environmental characteristics
- Maintainable advancement criteria, inferring reuse and reusing limits

3. SMART MATERIALS

A smart material is individual which is having a molecular structure that will undergo controlled transformations through physical interactions. They have one or more properties such as temperature, moisture, pH, or electric and magnetic fields that can spectacularly alter (Raju *et al.*, 2014).

There is a broad variety of different smart materials. Each offer diverse properties that can be changed. Some materials are very good certainly and cover up an enormous range of the scales.

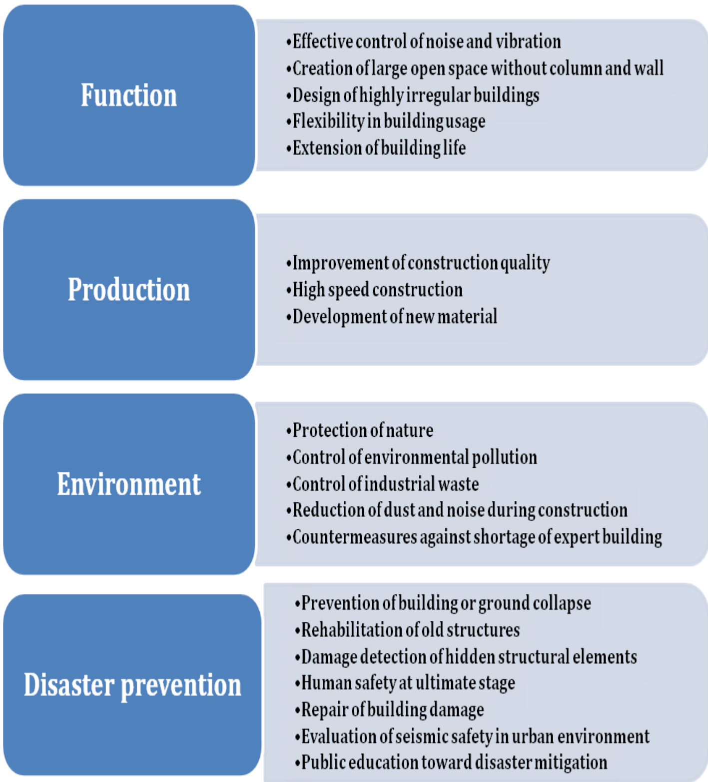

Fig-2: Requirement of new material

3.1 Types of smart material

Smart materials can be classified into the subsequent categories:

(i) Sensing materials: Materials that can provide information about the health and condition on present statuses, such as strain, stress damage and temperature (Chung, 1998; Chung, 2004).

(ii) Actuating materials: Materials that can change the dimensions under the external stimulus as heating/cooling or electromagnetic field.

(iii) Self-repair materials: Materials that can repair themselves, for example, automatic healing of cracks.

Few examples of smart material are as follows:

i. Piezoelectric substances are materials that produce a voltage when stress being utilized. An account that this influence in a reverse manner, a voltage across the sample will produce stress within the sample. Suitably designed structures created from these substances can, for this reason, be made that bend, develop or contract when a voltage was applied (Waghulde and Kumar, 2011; Akhras, 2012; Raju *et al.*, 2014).

ii. Shape-memory alloys and shape-memory polymers are substances where gigantic deformation may also be triggered and recovered using temperature changes or stress alterations (pseudoelasticity). Nitinol (Nickel - Titanium alloy discovered in the Naval Ordinance Lab) is the most commonly used shape memory alloy (Waghulde and Kumar, 2011; Akhras, 2012).

iii. Magnetostrictive materials exhibit exchange in shape below the impact of the magnetic subject and also show off-exchange in their magnetization under the effect of mechanical stress (Waghulde and Kumar, 2011).

iv. Magnetic shape memory alloys are substances that fluctuate their form according to a giant change in the magnetic subject. Magnetic shape memory alloys are materials (the most common form is the Ni-Mn-Ga alloy (Faehler, 2007).

v. pH-sensitive polymers are substances that fluctuate in quantity when the pH of the encompassing medium changes (Gupta and Mnnit, 2010).

vi. Temperature-responsive polymers are substances that undergo changes upon temperature.

vii. Halochromic materials are regularly used substances that modify their color for that reason of adjusting acidity. One urged software is for paints that may exchange color to denote corrosion within the metal beneath them.

viii. Chromogenic methods exchange color according to electrical, optical or thermal alterations. These incorporate electrochromic materials, which exchange their colour or opacity on the appliance of a voltage (e.g., liquid crystal shows). Thermochromic materials alternate in colour relying on their temperature, and photochromic substances, which trade colour in keeping with the gentle—for illustration, light touchy sunglasses that darken when uncovered to vivid sunlight.

ix. Dielectric elastomers (DEs) are sensible fabric techniques which produce huge strains (as much as 300%) under the have an impact on of an outside electrical discipline.

x. Magnetocaloric materials are compounds that endure a reverse exchange in temperature upon publicity to an altering magnetic area.

xi. Thermoelectric materials are used to construct devices that convert temperature differences into electricity and vice-versa.

xii. Smart gels that reduce in size or swell up by a factor of 1000, and that can be planned to absorb or discharge fluids in reply to almost any chemical or physical stimulus (Gupta and Mnnit, 2010).

xiii. Electrorheological and magnetorheological fluids that can revolutionize state instantaneously through the appliance of an electric or magnetic accusation. These fluids assure to absorbers shock and dampers for vehicle seats and exercise equipment, and optical finishing (Gupta and Mnnit, 2010; Waghulde and Kumar, 2011).

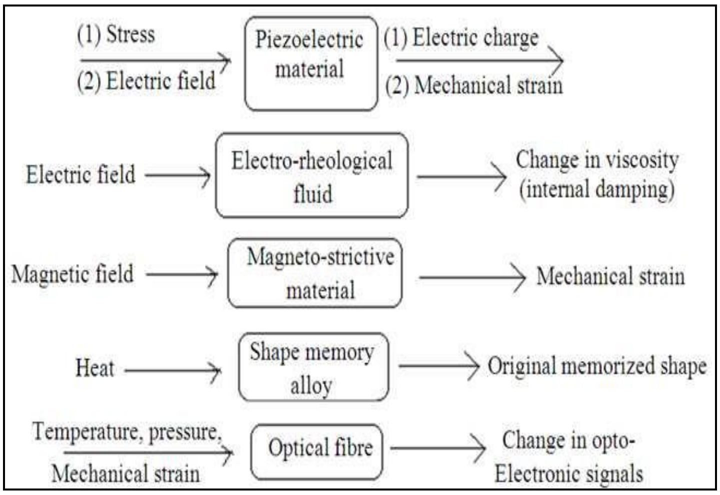

Fig-3: Common smart materials and associated stimulus-response (Kamila, 2013)

4. SMART STRUCTURES

A smart structure are often delineate as a "system that has intrinsic device, mechanism and manipulate mechanisms whereby it's capable to sense its dynamic loading environment via sensors as information, responding to that, and reverting to its traditional state once the information is removed through the integration of various elements, such as sensors, actuators, power sources, signal processors, and communications network" (Staszewski *et al.*, 2004). In other words, smart structure is an intelligent machine that can change and adapt to its environment dynamically (Adeli and Jiang, 2009; Adeli and Kim, 2009).

The relationship between these structure types has been explained by Rogers, 1990; Waghulde and Kumar, 2011 as follows:

a) Sensory structures: Structures which possess sensors that enables the determination or monitoring of system states/ characteristics.
b) Adaptive structures: Structures which possess actuators that enable the alteration of system states or characteristics in a controlled manner.
c) Controlled structures: Structures which result from the intersection of the sensory and the adaptive structures. These possess both sensors and actuators integrated into feedback architecture for the purpose of controlling the system states or characteristics.
d) Active structures: Structures which possess both sensors and actuators that are highly integrated into the structure and exhibit structural functionality in addition to control functionality.
e) Intelligent structures: Structures which are basically active structures possessing highly integrated control logic and electronics that provides the cognitive element of distributed or control architecture.

4.1 Smart structure classifications

i. Passively smart: Structures have the adaptability to counter to an incitement in an extremely supportive way, while not help of electronic controls or input frameworks.

ii. Actively smart: Structures utilize criticism circles that quicken the fame and reaction method.

iii. Very smart (or intelligent): Structures utilize the nonlinear properties of the detecting element, actuator, memory and/or criticism frameworks to tune the reaction conduct.

4.2 Components of a smart structure

The most common definition of a smart structure entails the sensing of environmental change and response to that variable. Most commonly this procedure utilizes electronic processing. To be able to carry out these activities, smart structure must have the following components:

i. Sensor(s): Used to watch environmental alterations.

ii. Actuator(s): The actuators are utilized to change the places of the smart material with the aim to acquire the favored reaction favored response.

iii. Control Systems(s): The control system regularly monitors the sensor's signal, processing the expertise and if an action is required, then a signal is applied to the appropriate actuator(s).

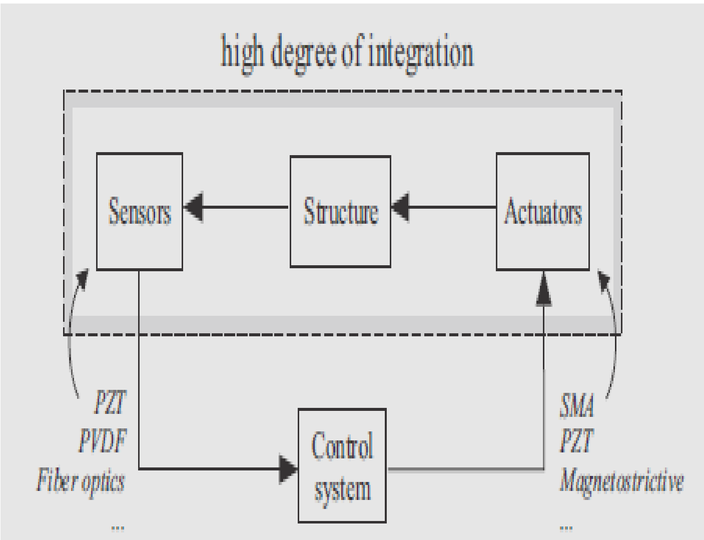

Fig-4: Components of a Smart Structure (Schaechter, 1997)

4.3 Main factors affecting structural health

Factors that mainly affect structural health are as follows:

i. Differential settlement
ii. Earthquakes and vibrations
iii. Structural distress
iv. Reinforcement corrosion
v. Stresses development due to temperature

4.4 Advantages of the smart structures

The smart structure has the following advantages:

i. This structure cut downs a lot of material cost incurred in using under-reamed pile and factor of safety.

ii. India has the 25% of area prone to earthquake. This smart technology will help in saving a lot of men and material.

iii. The health monitoring of structures will help in forecasting failure and will provide time for rehabilitation (Akhras, 2012).

iv. The structure is constantly maintained the service life and decrease the need for repair.

v. Making improvements to the framework's usefulness by way of a preventive protection and execution development (Akhras, 2012).

vi. Optimizing the reaction of difficult frameworks. This is completed with the aid of developing early warning systems, bettering the scope of survivability stipulations and/or giving a versatile reaction to adapt to unexpected conditions and circumstances (Akhras, 2012).

vii. Enhancements normally impractical, for instance, minimizing the distortion of the responses, increasing the exactness and moreover giving better control of the approach (Akhras, 2012).

4.5 Structural uses of smart material

Sensing and monitoring are key features of smart structural systems, and the followings are the main structural uses of smart material are as follows:

(i). Active control of structures

The concept of adaptive behavior has been an underlying theme of active control of structures that are subjected to earthquake. The structure adapts its dynamic characteristics to meet the performance objectives at any instant. Abdulridha *et al.* (2013) investigated the structural performance of super-elastic shape memory alloy reinforced concrete and to develop a preliminary constitutive model applicable to nonlinear finite element algorithms. Seven simply supported flexure-critical concrete beams, reinforced with either shape memory alloy bars in the critical region or conventional deformed reinforcement, were subjected to monotonic, cyclic, and reverse cyclic loading. The experiment results demonstrated the superior capacity of the shape memory alloy beams to recover inelastic displacements. The shape memory alloy beams sustained displacement ductility and strength capacity comparable to the conventional beams. Crack widths and crack spacing were larger in the shape memory alloy beams; however, upon removal of the load, the crack openings were recovered. Energy dissipation was lower in the shape memory alloy beams, particularly when subjected to reverse cyclic loading. The constitutive model based on a tri-linear backbone envelope response and linear unloading and reloading rules provided satisfactory simulations.

Cazzulani *et al.* (2011) proposed a manipulate methodology combining the free manipulate of system modes (as IMSC) and the expertise of the tuned mass dampers. The effect is an active control procedure that has been known as active modal tuned mass damper (AMTMD), that accomplishes the equal exhibitions of classical resonant control methods around the system resonances,

Jiang and Adeli (2008) presented other nonlinear manipulate mannequin control model for active control of 3D building structures, by means of the adroit integration of two soft computing techniques: neural networks and fuzzy logic, and wavelets. They incorporated each geometric and material non-linearity and two element coupling events within structural control formulation;

(i) coupling lateral and torsional movements of the structure and
(ii) coupling between the actuator and the constitution. A dynamic fuzzy wavelet neuro-emulator was offered for foreseeing the basic reaction in future time steps and is validated using two irregular 3D steel building structures, a twelve-story structure with vertical setbacks, and an eight-story constitution with arrangement inconsistency. They demon that the proposed neuro-emulator provides an accurate prediction of structural displacement responses

(ii). Passive control of structures

Cacciola and Tombari (2015) proposed a novel device, called vibrating barrier (ViBa) that aims to reduce the vibrations of adjacent structures subjected to ground motion waves. The ViBa is a structure buried in the soil and detached from surrounding buildings that are able to absorb a significant portion of the dynamic energy arising from the ground motion. The working principle exploits the dynamic interaction among vibrating structures due to the propagation of waves through the soil, namely the structure–soil–structure interaction. Closed-form solutions are also derived to design the ViBa in the case of harmonic excitation. Investigate the efficiency of the device in mitigating the effects of ground motion waves on the structural response. As a result significant reduction in the maximum structural acceleration of 87% has been achieved.

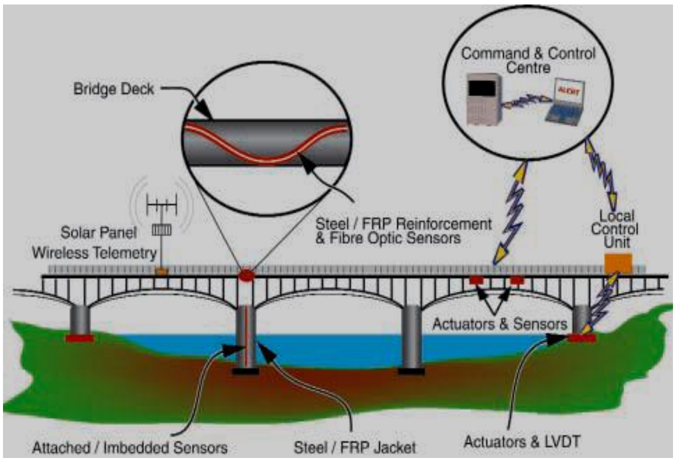

Fig-5: Schematic view of a smart bridge (Akhras, 2000)

(iii). Smart material tag

These smart material tags can be used in composite constructions. These tags can also be monitored externally using out the lifetime of the constitution to relate the internal material condition. Such measurements as stress, moisture, voids, cracks and discontinuities are also interpreted by way of a remote sensor (Schwartz, 2008).

(iv). Retrofitting

Shape memory alloys can use as self-stressing fibers and, therefore, it can be utilized for retrofitting. Self-stressing fibers are those in which reinforcement is positioned into the composite in a non-careworn state. A prestressing drive is presented as the procedure without the usage of giant mechanical actuators, through offering shape memory alloys. These materials don't want specialized electrical equipment nor do they produce safety issues within the field. Treatment is applied at any time when hardening of the matrix rather than throughout its solidifying and hardening. Long or short term prestressing is introduced by using triggers the trade in shape memory alloys forms utilizing temperature or electrical power (Schwartz, 2008).

(v). Self-healing

Self-healing materials can partially or completely heal the damage inflicted on them, e.g., crack formation; it is anticipated that the original functionality can be restored. In damaged concrete, water permeates through the cracks and induces the local formation of hydrates, which lead, depending on water pressure, pH-value, crack morphology and crack width, to a detectable crack healing. Jonkers

(2011) developed an innovative generation of self-healing concretes and investigated crack healing capacity of bio-chemical additive, consisting of mixture bacteria and organic compounds packed in porous expanded clay particles, resulted in efficient sealing of sub-millimeter sized (0.15 mm width) cracks.

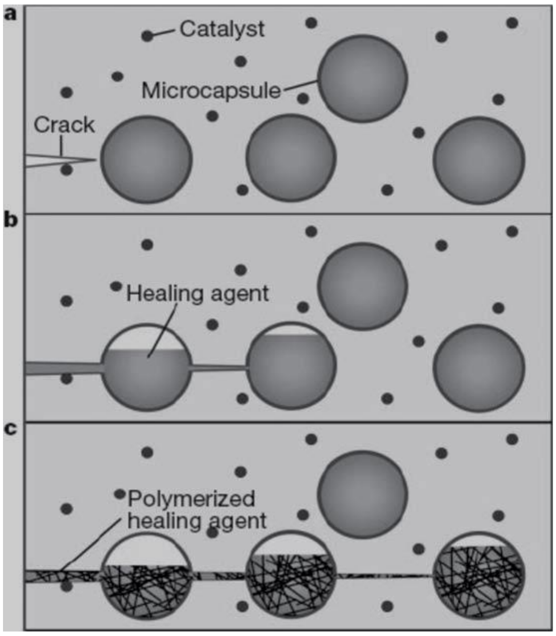

Fig-6: Self-healing with the help of microcapsules (Hager *et al.*, 2010)

(vi). Self–stressing for active control

Polymer materials are ubiquitous in everyday life and are used in various applications (medical, automobile, electronics, structural engineering etc.). These materials experience stress through normal use, which can lead to damage and failure of the product. Having the ability to detect damage and locate areas under high stress in situ is essential to eliminate failure of the material. Polymer backbones are that signals an area under stress by causing a color change in the material. This allows for damage detection via a color change of the material and thus early repair before failure, ultimately extending the lifetime of the product. The chemical incorporated into the polymer backbone is a stress-responsive mechanophore can be used with cementitious fiber composites with some prestress, which impart self-stressing thus avoiding difficulties due to the provision of large actuators in active control which require continuous maintenance of mechanical parts and rapid movement which in turn created additional inertia forces (Potisek *et al.*, 2012).

(vii). Structural health monitoring

Monitoring system technology is constantly created with a perspective to enhancing administration quality, expense, proficiency and environmental impact (St Leger *et al.*, 2014). Baptista *et al.* (2014) investigated the effect of temperature on the electrical impedance signatures of a conventional 5H Piezoelectric sensor used in structural health monitoring. The variations in both the amplitude and the frequency were analyzed experimentally by using an aluminum specimen and obtaining impedance signatures at temperatures ranging from 25 °C to 102 °C. Used 5H piezoelectric (lead zirconate titanate) ceramic sensors, which are commonly used in the electromechanical impedance technique. The experimental results showed that the temperature effects were strongly frequency-dependent, which may motivate future research in the structure heath monitoring field.
Qiu and Ji (2011) introduced a new method of structural health monitoring based on piezoelectric sensors. In this the research application of piezoelectric actuator in smart structures and their applications in semi-active vibration and structural health monitoring have been discussed.
Modern, efficient monitoring systems are proficient in providing information regarding the behavioral condition and safety of the structure to the structure owner and operator thus assisting with the progress of operation and maintenance plans as outlined in Fig. 7 (St Leger *et al.*, 2014).

From smart structures, different type of monitoring may be carried out (St Leger *et al.*, 2014):

a. Meteorological Monitoring,
b. Wind, Air Temperature and Humidity,
c. Highway Live Load Monitoring,
d. Seismic Load Monitoring,
e. Position Monitoring,
f. Hanger Load Monitoring,
g. Tower Settlement Monitoring Strain Monitoring

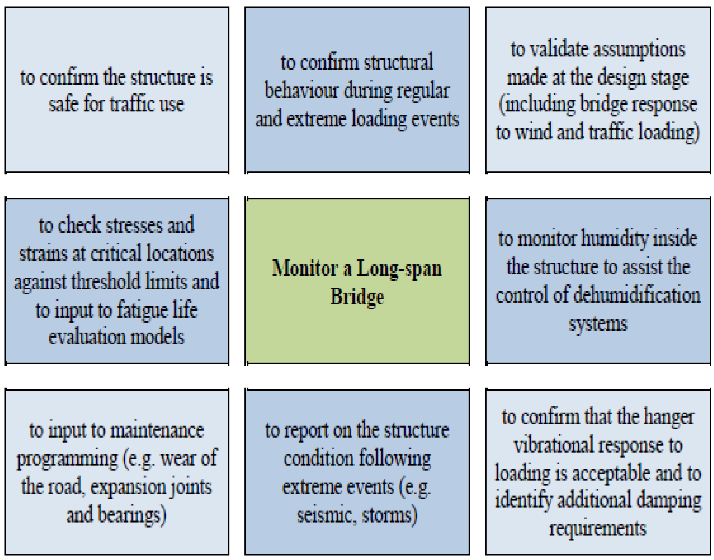

Fig-7: Information of a structural health monitoring system (St Leger *et al.*, 2014)

(viii) Earthquakes and vibrations control

Control devices can be utilized to disperse the energy of structure subjected to dynamic loading, in this way decreasing structural damage and counteracting failure. The magneto-rheological (MR) liquid damper is a promising kind of semi-active gadget for common structures because of its mechanical effortlessness, innate dependability, high element range, vast temperature working extent, strong execution, and low power prerequisites. The magneto-rheological damper is naturally nonlinear and rate-subordinate, both as a removal's component over the MR damper and the summon current being supplied to the MR damper (Jiang and Christenson, 2012).

Li *et al.* (2013) presented a recent research on the development of a novel adaptive seismic isolation system as the work for extreme insurance for structures, using the field-dependent assets of the magneto rheological elastomer (MRE) results demonstrated that the first prototypical MRE seismic isolator can provide stiffness increase up to 37.49%, while the second prototypical MRE seismic isolator gives stunning increment of lateral stiffness up to1630%.

Vibration control is a significant critical area of interest in several industrial applications. Undesirable vibration can have an unfavorable detrimental which affect serviceability, or structural integrity of mechanical systems. To control the vibrations in a system, distinctive systems have been created. Some of these strategies and systems use piezoelectric materials as sensors or actuators (Waghulde and Kumar, 2011).

Waghulde and Kumar (2011) demonstrated vibration analysis of smart cantilever structure by using piezoelectric smart material. Effect of the piezoelectric actuator placement on controlling the structural vibrations was explained by two systems, i.e. 2-D beam with piezoelectric actuator and sensor, and a 3-D plate with piezoelectric actuator and sensor modeled in ANSYS. As a result, it showed that our actuator locations used for the study were accepted since the feeding node had transverse displacement values that were not zero.

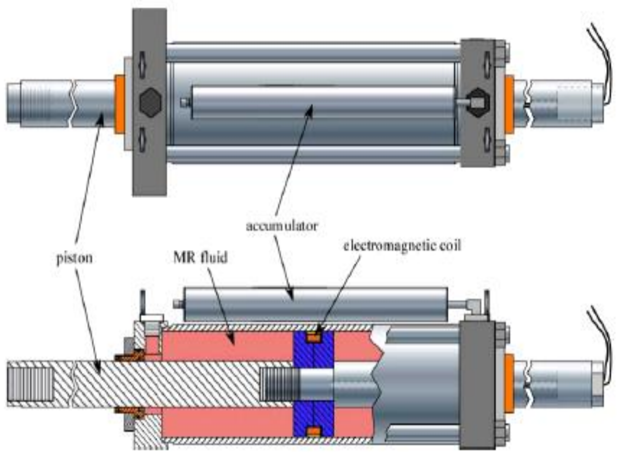

Fig-8: Large-scale semi-active damper schematic (Jiang and Christenson, 2012)

(ix) Corrosion assessment

Deterioration of concrete structures because of unforgiving ecological conditions prompts performance degradation of reinforced concrete structures, and untimely decay of structures before expected life is real major concern for engineers and researchers. The deterioration rate of structures relies on upon the exposure conditions and extent of maintenance (Hussain and Ishida, 2012).

The corrosion of steel reinforcement, started by a chloride particle assault upon the passive layer of steel, also lead to a decrease in the reinforcing steel cross-section that, in turn, results in a loss of serviceability, Occurring much earlier than anticipated for the designed service life of the structure. The predominant reason for the decay of RC structures in marine situations is chloride attack (Costa and Appleton, 2002; Shekarchi *et al.*, 2011; Dousti *et al.*, 2012).

Verma *et al.* (2014) introduced the significance of the importance of monitoring, reinforcement corrosion and describes the different methods for evaluating the corrosion state of RC structures, especially half-cell potential (HCP) method.

Corrosion in concrete structures can be avoided by restricting the corrosion rate by reducing the flow of current from anode to cathode (Ahmad, 2003).

(x) Damage detection

The damage detection process can be treated as assessment and classification of a problem as the response of structure for different loading conditions will change if a crack begins to develop (Farooq *et al.*, 2012).

Farooq *et al.* (2012) displayed the aftereffects of two multi-class damage detection and identification approaches based on classification using Support Vector Machine (SVM) and Artificial Neural Networks (ANN). Two experiments were performed for the performance evaluation of damage detection and identification, with one healthy structure and two damaged structures, with one and two small cracks with varying material properties and loading conditions (45 cases for each structure).

Pandey and Barai (1995) used an ANN for identification of damage in a 21-bar bridge truss. Zapico (2001) offered a procedure for damage identification method of steel structures based on ANN. Chetwynd *et al.* (2008) used two types of multilayer neural networks in a stiffened carbon-fiber composite panel for damage detection.

5. NON DESTRUCTIVE EVALUATION TECHNIQUES:

Various non-destructive evaluation (NDE) tests for solid individuals are accessible to focus in-situ quality and nature. Some of these tests are exceptionally valuable in the appraisal of harm to RCC structures subjected to erosion, substance, assault, and fire and because of different reasons. The term 'non damaging' is utilized to show that it doesn't impede the expected execution of the auxiliary part being tried/explored. There are mainly three reasons which alter the condition of structure i) normal aging due to usage, ii) action on the environment and iii) accidental events (Gopalakrishnan *et al.* ,2011).

Assortment of NDT systems have been produced and are accessible for examination and assessment of diverse parameters identified with quality, toughness and the general nature of cement. Every system has some quality and some shortcoming. In this manner reasonable methodology would be to utilize more than one strategy in the mix so that the quality of one remunerates the shortcoming of the other. The different NDT techniques for testing solid are recorded underneath.

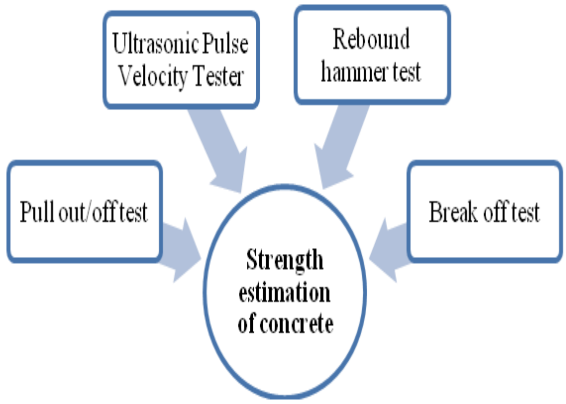

Fig-9: Various methods for strength estimation of concrete

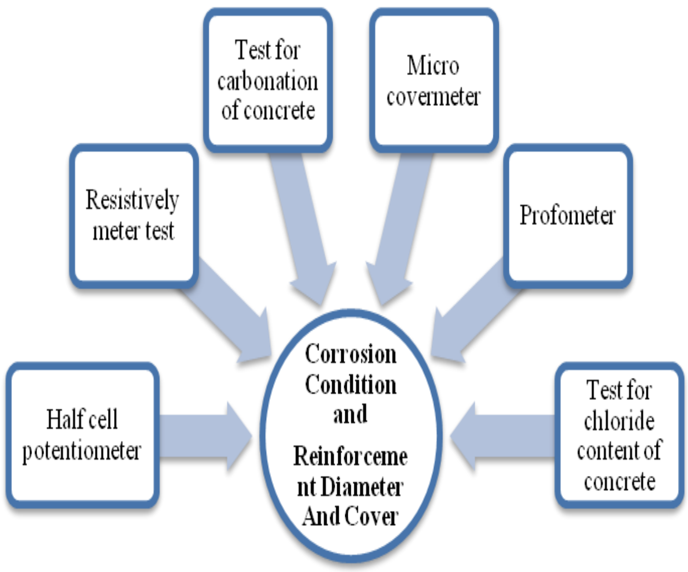

Fig-10: Various methods of appraisal of corrosion and to determine reinforcement diameter and cover

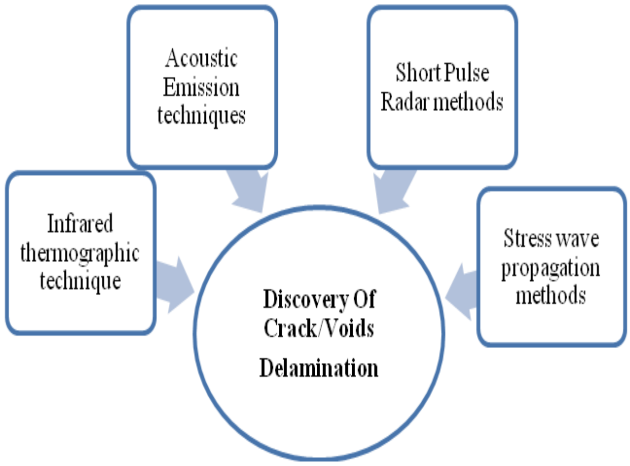

Fig-11: Various methods for discovery of cracks/voids and delamination

5.1 Infrared thermographic technique

Infrared thermography is an intense nondestructive assessment instrument which can be viably utilized for deformity discovery as a part of materials, for example, aluminum compounds and metal lattice composites and to identify and harm in composite structures amid weariness loading (Zalameda *et al.*, 2012).

Thermography was produced to focus on determining the crack growth rate using thermographic mapping of the material undergoing fatigue (Kordatos *et al.*, 2012). Infrared lock-in thermography can satisfy this need in light of the fact that it is a fast, full-field and constant examination instrument. It can be utilized to look at a moderately extensive zone of a structure and flying machine parts (Bates *et al.*, 2000; Nino *et al.*, 2009). It was likewise a non-contact procedure; the equipment is genuinely convenient and consequently can be utilized effortlessly in the field lock-in thermography finds and measures warm source under harmonic loading and adiabatic conditions. This method depends on the immediate connection between's warm varieties, brought on by warm excitation because of mechanical fatigue, and thermal stresses set up by applying thermo-versatility standards (Choi *et al.*, 2006; Kim *et al.*, 2006). Furthermore, quantitative infrared thermography as a nondestructive and non-contact strategy has been utilized to identify the physical procedure of fatigue and to assess quickly as far as possible of materials (Luong, 1998; Krapez *et al.*, 2000; La Rosa and Risitano, 2000).

5.1.1 Major advantage of IR thermography:

Various advantages of infrared thermography are as following:

i. Fast inspection method (Maldague, 2001).
ii. Detection and monitoring of sub-surface cracking.
iii. Measurement of crack length.
iv. Calculate the stress intensity factor.

v. Determination of crack initiation and prediction of crack propagation (Plekhov *et al.*, 2005).

vi. Evaluating the condition of damage in materials undergoing repeated mechanical loading by analyzing thermal effects in these materials caused through fatigue load. (Zalameda *et al.*, 2006; Risitano and Risitano, 2010; Kordatos and Matikas, 2011).

5.2 Acoustic emission technique

The acoustic emission analysis makes use of sensors mounted on the outside of parts or constructions to file elastic waves brought about inside of through microscopic processes comparable to, e.g., crack development. In precept, the evaluation enables a qualitative and, below certain stipulations, quantitative evaluation of the integrity of the part of the constitution. Acoustic emission analysis is also fitted to other industrial purposes, e.g., approach monitoring. Acoustic emission (AE) is among the non-harmful methods, which has grown used in monitoring civil and aerospace buildings, and in other functions (Prevorovsky *et al.*, 2011). This technique utilizes the elastic waves generated by plastic deformations, moving dislocations, etc. for the analysis and detection of structural defects. However, there can be multiple travel paths available from the source to the sensors. Also, electrical interference or other mechanical noises hamper the quality of the emission signals. Data has to be continuously transmitted (e.g. using the internet protocols) to the supervisor, where they are collected and stored in a database for subsequent analysis. This data can then be accessed by remote users. On the off chance that the focal unit identifies a perilous condition by breaking down the information, it ought to raise an alert message. The remote unit additionally ought to take into account remote organization, calibration and reprogramming of the sensor arrays as a way to hold the entire process flexible.

Tsangouri *et al.* (2013) detected the mechanism that activates autonomous crack healing of concrete beams under bending by Acoustic Emission and Digital Image Correlation. The position of failure within the material and the recognition of the conditions (loading, time, crack width, and fracture evolution) under which capsule breakage occurred were done by analyzing the hits activity captured by eight sensors attached to the concrete surface. Sutin *et al.* (2003) demonstrated the possibility of isolating linear from nonlinear scatters in general, ultimately providing the means to locate and discern cracks from voids for instance.

5.2.1 Advantages of Acoustic emission technique

a. Reveal hidden defects during the operational service of structures before a collapse occurs (Prevorovsky *et al.*, 2011).

b. AE technique possesses the high sensitivity and ability to identify the damage (Aggelis, 2011; Prevorovsky *et al.*, 2011).

c. AE method lies in the fact that the damage can be detected in real time.

d. AE measurement is highly efficient due to its ability to warn of crack growth (Aggelis, 2012).

e. The analysis of AE activity and the knowledge of its changes improve the lifetime prognosis and reduce the overall maintenance costs.

f. By this technique creep behavior of concretes is determine (Rossi *et al.*, 2012).

6. SUMMARY & CONCLUSIONS

The uses of smart material in structures have been broadly investigated in the recent years. This paper presents an assortment of aspects on smart structure uses and it's NDE, which could be summarized and concluded as follow:

i. The ability of smart materials in smart structural has been clearly demonstrated.

ii. Nevertheless, the field is still in its early phases, and further revolutionary work is obliged to obsess up keen substances as liable, powerful and functional materials for massive scale structural designing applications

iii. In the majority of instances, the factors of structure failure would be traced and retrofitting will most likely be accomplished with the aid of smart material.

iv. Require new or developed materials to scale down weight, push off sound, reflect more light, dampen vibration and handle more heat will motivate smart structure developments and framework with a perception to conclusively toughen our individual existence.

v. In future, the most encouraging advances for lifetime productivity and enhanced unwavering quality incorporate the utilization of smart materials and structures.

vi. It will be consequently clear that the methodology that ought to be received to control the future weakening of structure will rely on which of the above causes/reasons applies.

vii. The range of remedial solutions can vary from the minimal (patch repair of areas actually spalling) to the drastic (crust out completely & reinstate).

viii. It is crucial that each and every single possible method for Structure health checking is used, with the goal that unpredictable additional components of the earth or the solid can be recognized and the necessity solution sought by new NDE Techniques.

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