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Nanotechnology and Smart Structures

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***Abstract*— Nanotechnology deals with nano- materials having size less than 10^{-9} m. Nanotechnology produces many materials which have wide applications in different sectors like medical, manufacturing and production, construction etc. Based on its origin, use, dimensions and structural configuration, various classifications of nano-materials are proposed in the past. The concept of nanotechnology was come into picture in 1959 and now-a-days has become a broad area in research and technology. It gives boost up to medical and construction sectors by introducing new and smart composites. By using nanotechnology smart materials can be developed which make a structure smart. A smart structure can be defined as a structure which behaves in systematic manner and environmental friendly. As compared to conventional structures, smart structures are reliable, durable and have high resistance against heat and impact. Also strength and durability of individual components of structure enhanced significantly. The main purpose of building smart structures is to enhanced lifestyle/comfort of human and provides them safety against any type of impact like fire, earthquake, flood, tornado etc. It also reduces the cost of maintenance and senses itself if there is any work of maintenance is required. The present paper describes the various advantages of nanotechnology in the construction of smart structures.**

Keywords*— *Nanotechnology; Smart Structures; Nanomaterial, Construction, Advantages

I. INTRODUCTION

Nanotechnology is the science of nano particles. Nano particles are small in size, generally in order of 10-9 m or less. In the modern world the nanotechnology is widely used in medical, construction and manufacturing sectors. By adopting nanotechnology, there are some revolutionary changes in these sectors. The change in microstructure of material enhances its properties. By controlling the size and shape of the microstructure a better material or composites can be obtained. The nano materials can be classified on the basis of origin, use, dimensions and structural configuration. The classification of nano materials are listed in Table. 1.

Table 1. Different classification of Nano-materials

Categories	Classification
Origin	Natural and Artificial
Dimensions	1D, 2D, 3D and 4D
Use	Chemical and Biological
Structural configuration	Carbon based, Metal based, Composites and Dendrimers

Nanotechnology introduced in 1959 and presently widely used in different sectors. Nontechnology has a large potential to improve the conventional construction and converts the structures to a smart structure. The specific properties of nano-materials are

a. Larger specific surface area
b. Higher chemical activity
c. Higher Adsorption capacity
d. Great sensitivity
e. Self-assembly nature
f. Long-term stability

Studies conducted in the past indicated that the indicated that the nanotechnology implemented in structures makes it more reliable, workable and durable [1-8]. Studies also suggested that with help of nanotechnology, self-sensible, self-cleaning and self-reparable properties in the material or composites cab be introduced. The present paper discusses the various aspect of nanotechnology in smart structures.

II. SMART STRUCTURES

A smart structure refers to structure which is sensible and have self-supporting features. It senses stress, temperature, deformation etc. and up to certain levels it performs the 'self-treatment'. It behaves in a systematic manner and user friendly. Increase in research and technology makes it to serve for better lifestyle of mankind. As compared to traditional or conventional structures, smart structures are more durable, healthy and workable. It provides better service and lifestyle to people. Also it has higher heat and vibration resistance, better temperature control and ventilation and safety standard. Also smart structures are environmental friendly, energy efficient and have self-cleaning properties.

Smart structures are made of single or composites materials. By using the nanotechnology the material properties have been enhanced. Uses of modern technology make it sensible. There are three main elements of a smart structure

i. Structural elements
ii. Coating or protecting elements
iii. Monitoring elements

The main components of the smart structures are listed in Fig. 1.

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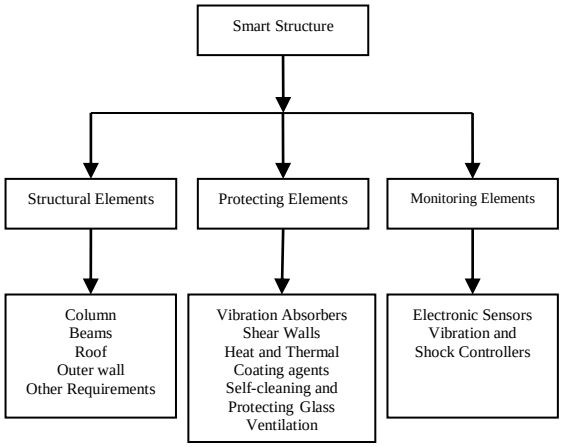

Fig. 1. Different Components of smart structures

a. Structural elements: It consists of skeleton of the structure like beams, column, roof, outer wall etc. The design of these elements depends upon the structural load. Structural load is a combination of dead load, live load, wind load, earthquake load and many others. Before construction it should be assured that the all the structural load are fully examined. The structure should be safe against any type of failure. Using smart materials or nano-materials, the properties, resistance and stiffness of the structural elements can be enhanced. However, it depends upon the type of structural and its application. For example to construct a building there are some requirements like 'all elements are safe against wind or earthquake load' and for building a ship there are requirement like 'the ship should be safe against sinking'. Nano-materials can be easily fitted to any components of the structure and a desirable structure can be made with enhanced properties.

b. Coating or protecting elements: These elements protect the entire structure from adverse weather, rust, erosion, vibration and many more. It consists of different components like vibration and shock absorbers, heat and thermal insulators, water proofing paints, self-cleaning glasses etc. they provides better lifestyle and comfort the people and looks attractive. By proper ventilation and heat insulators the temperature of the structure can be maintained and controlled at desired levels. Vibration and shock absorbers protect the structures from any unacceptable vibration and shocks due to earthquake and machines. Self-cleaning glass protect the inside of the building from direct sunlight, dust and strong wind. These elements create a user –friendly environment at inside the structure and make the people efficient for work. By using electronic devices the operation of some of these elements can be controlled.

c. Monitoring elements: To evaluate or monitor the performance of the smart structure monitoring systems are used. Generally it is termed as "structural health monitoring system". It includes, smart sensors, devices, monitoring equipment and controllers. The main aim of this system is to critically monitor the performance of each components of the structure and if they are not behaving as desired report to concern authority immediately. Controllers attached to it control the vibration, shocks, heat, ventilation etc. at certain levels. However its depend upon the design of the structure and their maximum loading capacities. Structural health monitoring system, monitor the deformation, stress and temperature of the individual structural elements and if these value are exceed from their limiting values, it alarm the situation. During emergency situations like fire, earthquake, tsunami etc. it maximizes it performance at best. The major advantage of this system is to its alarming before any problematic situations. However still research is going on to optimize the performance of monitoring systems.

A comparison of smart structure with conventional structure is presented in Table 2. Over the conventional structures, the major advantage of the smart structure is, it provides higher durability and workability. However the construction cost of the smart structure is higher and special technology, highly skilled manpower and technology is required for construction.

Table 2. Comparison of smart structure with conventional structure

Factors	Smart Structures	Conventional Structures
Durable and Workability	Higher	Medium
Stability	High	Medium
Environmental Aspect	Environmental friendly	Somehow environmental friendly
Monitoring System	Yes	No
Cost	High	Low
Special technology	Required	Not required
Construction	Specialized manpower and machines are required for construction	Specialized manpower nor necessary
Repair and service	Easy	Difficult

III. APPLICATION OF NANOTECHNOLOGY IN SMART STRUCTURES

Presently there are several types of nano technology based smart materials available in the market. Using these, different types of smart materials used in structures can be created. Some of nano-materials used in smart structures are listed in Table 3. The major advantage of nano technology in construction is that it can be used for making the 'pre-fabricated structures'.

Nanotechnology involves characterization, design, formation of single or composite materials. At nano-scale by using technology and by controlled process nano-materials or composites can be easily generated. Change in nano structure generates newer materials with significant improved properties. It possesses all the state of materials solids (use in manufacturing of structural elements), liquids (anti-corrosion, water proofing and heat reducing solutions) and gas (ventilation and cleaning). With the help of nanotechnology material or composites with exclusive characteristics can be generated. The nano-material or composite is lighter in weight and robust in strength in strength. Further light weight pre-fabricated panels can also be manufactured with speed or boost up the construction. The typical advantages of nanotechnology in smart structures are

i. Better interaction or bonding of particles at nano or micro structural levels which enhanced the resistance, strength, thermal resistance, and shock absorbance.

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ii. Self-reparable, self-cleaning and self-alarming properties make the material or composite smart i.e. it senses the stress, temperature, deformation at early state. Continuous monitoring of it generates the useful data which can be used for further improvement.

iii. Reduction in maintenance cost due to sensible and intelligent properties.

iv. Safety against natural calamities like earthquake and tsunami if energy absorbent techniques are combined with nanotechnology

v. Re-habitation of old or conventional structures, with the help of nano- sensors, optical fibres and nano-scale solutions.

Table 3. Nano-particles/materials used in construction of smart structures

Nano-Materials	Properties
Carbon nanotubes	Enhanced durability, thermal resistance, reduced crack prevention
Titanium dioxide nanoparticles	Increases rapid hydration, introduced self-cleaning Anti-fogging, reduced thermal conductivity
Copper nanoparticles	Increases corrosion resistance in steel reinforcement
Silicon dioxide nanoparticles	Provide extra reinforcement and enhanced strength, increase fire resistance and reflection through surface
Iron oxide nanoparticles	Increases compressive strength and abrasion-resistant
Silver nanoparticles	Increases workability of coatings and paints.

IV. CONCLUSIONS

The nanotechnology provides energy efficient, durable, safe, comfortable and environmental friendly smart structures. Strength, stiffness, shock and vibration absorbent, thermal and heat resistance and self-cleaning properties are enhanced due to use of nanomaterials and its relative technology. Further structures smartly sense deformation, vibrations and heat. Application of nanotechnology also reduces the time for construction and maintenance cost. Also lifestyle and comfort of people enhanced and accident chances are reduced. However, the initial cost of construction is high but it will be reduced as improvement in technology and research.

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