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# Review of Recent Advances in Smart Materials

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**ABSTRACT:** Nanotechnology being 21st century's important technology with its ability to create new materials and devices with a vast range of applications. The expenditure of research in nanotechnology is remarkable; however, the research is perpetually moving forward with rapid profitable return.

The construction industry might harbour broad application in nanomaterials such as Nano sensor, structural composites, smart materials and many more. Smart materials which were initially used in fields such as aerospace, mechanical and biomedical engineering have now come into use in civil engineering.

A smart material plays a critical role in building technology development in the mechanical world and performs like a living system. This review paper provides a new insight into the innovative methods available and the type of smart materials. The smart material for structural applications include ferromagnetic sensors, shape memory alloys, piezoelectric sensor and magneto restrictive materials. The paper focuses on the applications in environment control, security and structural health monitoring, seismic protection.

The smart materials are useful in creating sustainable environment which is eco-friendly. The scientific utilization of these materials needs attention in engineering aspects.

**KEYWORDS:** Nanotechnology, Nanomaterials, Smart materials.

### I. INTRODUCTION

Different varieties of materials and methods have been used with a considerable effect on economy as well as environment. Hence the capability to make numerous environmental friendly and economic choices with effecting the structural integrity, longevity, efficiency of material, cost and industrial ethics is of the major importance. A great attention has been given to use of inventive smart materials which offer creative solutions to repair and maintenance of the structures.

The aim of the research in smart materials is to find advanced materials with multipurpose characters. It will bring fundamental change in approach in the design and performance of building creating a new revolt in one built environment.

### II. SMART MATERIALS

The term "smart material" describes a group of material with unique properties. These are the materials that can significantly change their thermal, optical, mechanical and electromagnetic properties in a controllable and predictable manner in response to their environment. The materials correspond to the variation in heat, electricity and magnetic waves. Source of the smart materials do not possess the shape change property, but they exhibit certain properties like electro and magneto rheological fluids. Upon the application of external magnetic or electric field the fluids can change the viscosity over many orders of magnitude.

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Smart materials have its potential applications wide spread in the construction industry. These materials are characterized by high strength, toughness, durability and high resistance to corrosion by chemicals and abrasion.

### III. TYPES OF SMART MATERIALS

Smart materials are classified into following types: -

- . Shape memory alloys
- . Piezoelectric sensors
- . Magneto restrictive materials
- . Ferromagnetic sensors

#### 1. SHAPE MEMORY ALLOYS: -

Shape memory alloys are the unique class of metal alloys that can regain permanent strains when heated above certain temperature. Smart memory alloys possess unique properties such as shape memory and super elasticity. Shape memory alloys helps the alloys to return to their original shape when heated whereas super elasticity allows huge deformation with limited strain. Shape memory alloys has two phases: -

1. High temperature phase called austenite
2. Low temperature phase called martensite

When alloy repeatedly undergoes phase changes they have the superior energy dissipation capacity when compared to the normal metals. Shape memory alloys has wide range of applications such as in strengthening and repair of structures and reducing permanent deformation. Nickel-titanium shape memory alloys are most widely used. Shape memory alloys can be included into other elements like concrete beams. Permanent deformation can be reduced by including shape memory alloys in concrete structures.

#### 2. PIEZOELECTRIC SENSORS: -

Piezoelectric sensors are the devices that utilise the piezoelectric effect to measure the variations occurring in acceleration, pressure, temperature, strain by converting them to electric charge. Piezoelectric sensors are considered as one of the mature technologies with advanced reliability. The application of this type of materials include the regulation of the vibrations that are related with the plates in smart structures. Piezoelectric sensors also assist in the eradication of different types of noise produced. It is also being used as antennas and reflectors to maintain the accuracy in dimensions to obtain precise results.

#### 3. MAGNETO RESTRICTIVE MATERIALS: -

Magneto restrictive materials are the materials which possess ferromagnetic properties that cause them to modify their shape or dimensions during the magnetism process. Magneto restrictive materials undergo stretching and shrinkage when magnetic field is applied. The mechanism of magnetism can be explained at the atomic level. Under the magnetic field the magnetic domains rotate causing change in dimension. The unique property of the magneto restrictive material is that the magnetic energy and kinetic energy are interchangeable and can be used to build actuators and sensors.

The applications of this include elastic waves behaving like a transducer to detect the defect and the depth of concrete structures. It also includes monitoring of the emission wave in structures to evaluate the position and propagation of the cracks.

#### 4. FERROMAGNETIC SENSORS: -

Ferromagnetic sensors basically work by detecting. Amorphous ferromagnetic material is a type of magnetic material and is most suitable. Ferromagnetic sensors can be developed without electric contact between the measuring device and the sensor. Materials with Iron, Cobalt or Nickel content are generally ferromagnetic. In magnetic drug delivery

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magnetizable particles are injected into the blood stream and these magnets concentrate on disease locations. These sensors also provide vehicle detection.

### IV. APPLICATIONS

#### 1. SMART CONCRETE: -

Smart carbon fibres are added to the conventional concrete mixture. This electrical network of conductive carbon fibres works as a distributed sensor network. This modification makes the concrete capable of detecting tiny deformations and stresses. The change can be detected by the help of electric probes places on the external surface of the structure. In a similar manner the smart concrete can be used to detect the underground stress that occur prior to earth quakes, to monitor building occupancy and to monitor traffic flow during the emergencies.

#### 2. SMART BRICKS: -

The conventional bricks are stuffed with the sensors, signal processors and wireless communication links in order to act like warning system during natural calamities like storms, earthquakes, hurricanes. The sensors include detectors for moisture, humidity, sound, chemicals, stress and forces. When the brick is built into a wall it could be helpful in monitoring the building's temperature, vibration and movement and to send information about safety of building during fire accidents.

#### 3. SMART GREEN ROOFS: -

Smart green roofs are used to give protection and covering to the building, to absorb storm water, to control temperatures by using inexhaustible source of energy like vegetated green roofs. If widely used these roofs could reduce management costs. Smart green roofs increase the life of roof decks and improve productivity of solar panels. Smart green roofs require manual protection for the roofs to remain healthy. Various sensors are mounted on the roofs and the accessibility of the data from the sensors allows to track the function of the roof remotely and it also tells when maintenance is required. Solar powered sensors are most commonly used.

#### 4. SMART SHADE: -

The smart shade employs the thermodynamics of zinc and steel which controls the amount of sunlight penetrating into building's interior with the help of elastic shape memory alloy wires. This also controls the level of carbon dioxide in the room. The temperature inside the building can be controlled by these materials. Mechanism of expansion and contraction of these materials will increase the temperature in winter and decrease the temperature in summer.

#### 5. SMART STRUCTURE FOR SEISMIC PROTECTION: -

The resonance created by high winds and seismic activity will affect the high raised building and long bridge, in order to balance the resonance effect dampers should be provided during the design.

If the dampers are not provided in place buildings and bridges may fail anytime during earthquake. Depending upon the size of the building dampers should be designed. Dampers are the device which senses the seismic wave. These waves can be migrated to ground or else it can be carried to the top floor.

### V. MERITS AND DEMERITS

#### MERITS: -

1. Smart materials are eco-friendly.
2. It has longer durability compared to other materials.
3. Less time and expenses in inspections.
4. The response of structure can be monitored remotely.
5. High energy density.
6. It works like a living system.
7. Determination of aromas in air by measuring resistance and capacitance.

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## DEMERITS: -

1. Smart materials are Non- bio-degradable.
2. Installation cost of smart materials are expensive.
3. Its long-term effects are unknown.
4. It causes global crisis.
5. It cannot be used for truly static materials.

## VI. WHY SMART MATERIALS?

1. Smart materials increase durability.
2. By including smart materials resistance to abrasion, corrosion and fatigue is increased.
3. Efficient cost.
4. Smart material like green roofs are environment friendly.
5. It requires less maintenance.
6. It's ability to self-sensing, self-rehabilitation, self-vibration damping, self-structural health monitoring and self-healing are lead characteristics.
7. Smart materials can change their properties in response to an external stimulus.

## VII. CONCLUSION AND RESULTS

Smart materials can be used in both new and existing constructions. It can serve for many purposes. They have wide range of applications in construction industry. It has ability to improve existing technology. The technologies available require further research to intensify its effects. Today's smart materials are promising way to boost revenues and profits. The building systems may be completely priced when compared to traditional building approaches, but they offer substantial savings in terms of reduced operating cost over the life span of building. The piezoelectric actuators and magneto restrictive had enough responses for smart structures. Work is to be done on developing quality for design and implementation of the construction by using smart materials.

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