RAMAIAH
Institute of Technology

BASICIS OF CIVIL ENGINEERING & MECHANICS

Course code:CV14/CV24

Credits:3:0:0

Topics Covered

New Marginal and Smart Materials

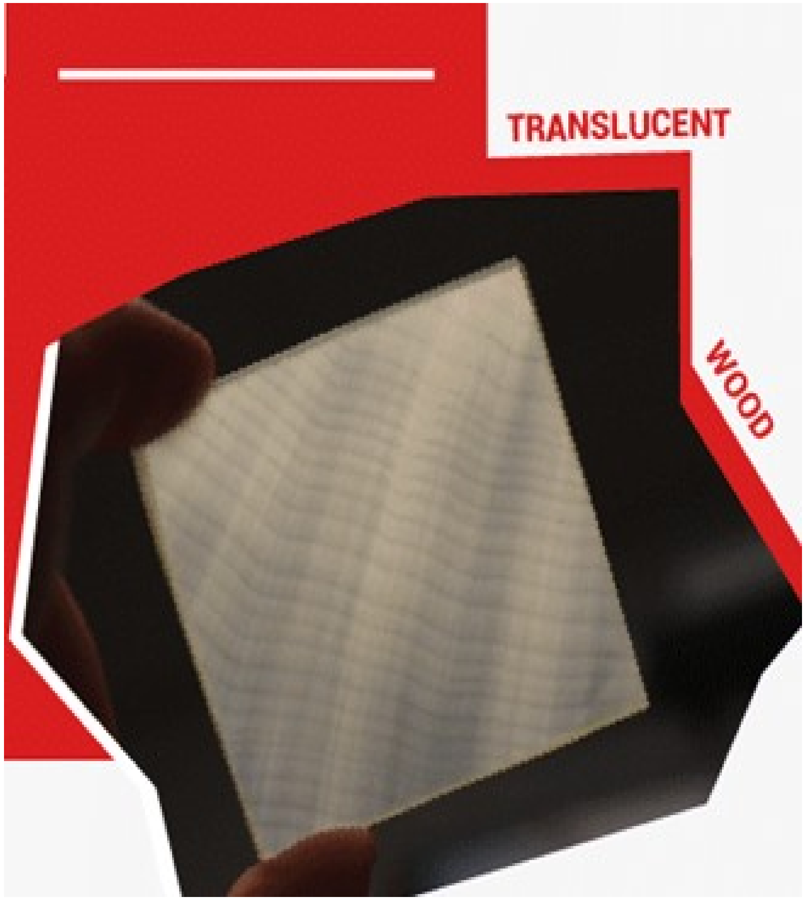
NEW AGE & MARGINAL: DEFINITION, VARIETY, APPLICATIONS

New Age Construction Materials

Innovative materials are emerging in the construction Industry that is revolutionizing and gaining momentum to have developments in concrete and other construction materials.

TRANSLUCENT WOOD

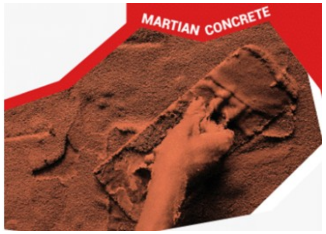
We now have translucent wood that can be used to develop windows and solar panels. It is created by first, removing the lining in the wood veneer and then through nanoscale tailoring. The resulting effect creates translucent wood that has various applications in the construction industry.



THE COOLING SYSTEM IN BRICKS

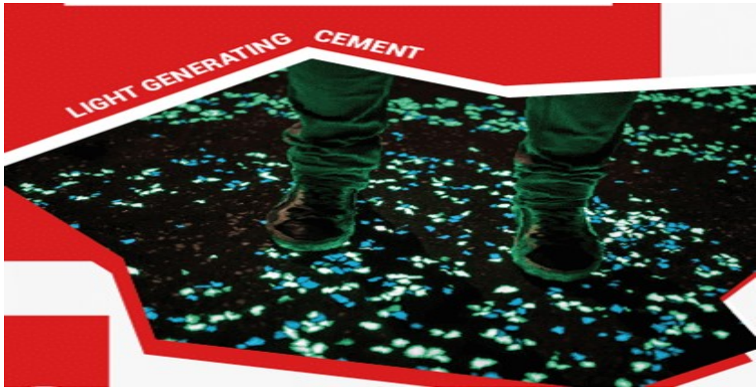
A research conducted by Advanced architecture of Catalonia has developed building material that cools the building interior by absorbing water up to 500 times of its weight in the presence of hydro gel in its structure. Hydro ceramics has the ability to reduce indoor temperature by 6 degree.

Martian concrete



Researchers at north western University have developed concrete that can be made from materials available at Mars. In order to make Martian concrete sulphur is heated to 240degree Celsius which melts it into liquid.

Light-generating cement:



Dr Jose Carlos Rubio Avalos from UMSNH of Morelia has developed cement that has the ability to absorb and radiate light and has immense application as cement can be developed at room temperature. The science behind it: Through the process of polycondensation of raw materials such as river sand, industrial waste, silica, water, and alkali. The process is done at room temperature which is why the energy usage is low.

THE CABKOMA STRAND ROD

The Komatsu Seiten fabric Laboratory based in Japan has created a new material called CARBKOMA Strand that is therrmo plastic carbon fiber composite that is lightest seismic reinforcement weighing 12kg for a length of 160 m which is 5 times lighter than metal rod

BIOLOGICALLY PRODUCED FURNITURE

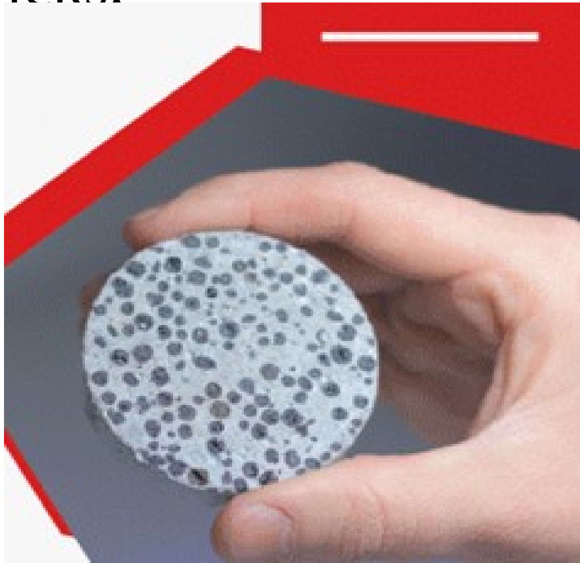
Bio plastic furniture are developed for kids furniture using low energy process. The furniture is made by a material called Mycoform, which is made by combining wood chips, gypsum, and oat bran together with a fungus called Ganoderma lucidum. This fungus is added as it has the ability to disintegrate waste products and leave a strong structural material.

Cigarette butts to make bricks:

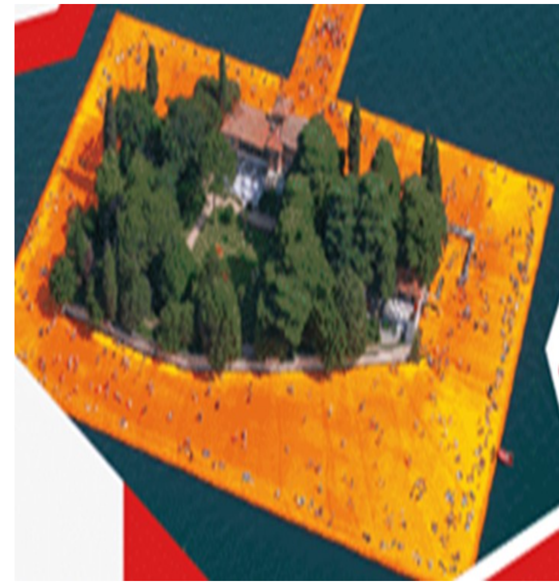
Elements such as arsenic, chromium, nickel enter the soil to have a harmful impact on the environment. About 6 million cigarettes are manufactured developing about 1.2 million tons of cigarette butt waste. In order to reduce the effect of cigarette butts on the environment researchers at RMIT have developed lighter and more energy efficient bricks.

Self-healing concrete

Self healing concrete was developed by Dr Schlangen from Delft University by breaking material into two and putting the material together and heating the concrete in microwave oven, once the melted material cools down joins together.



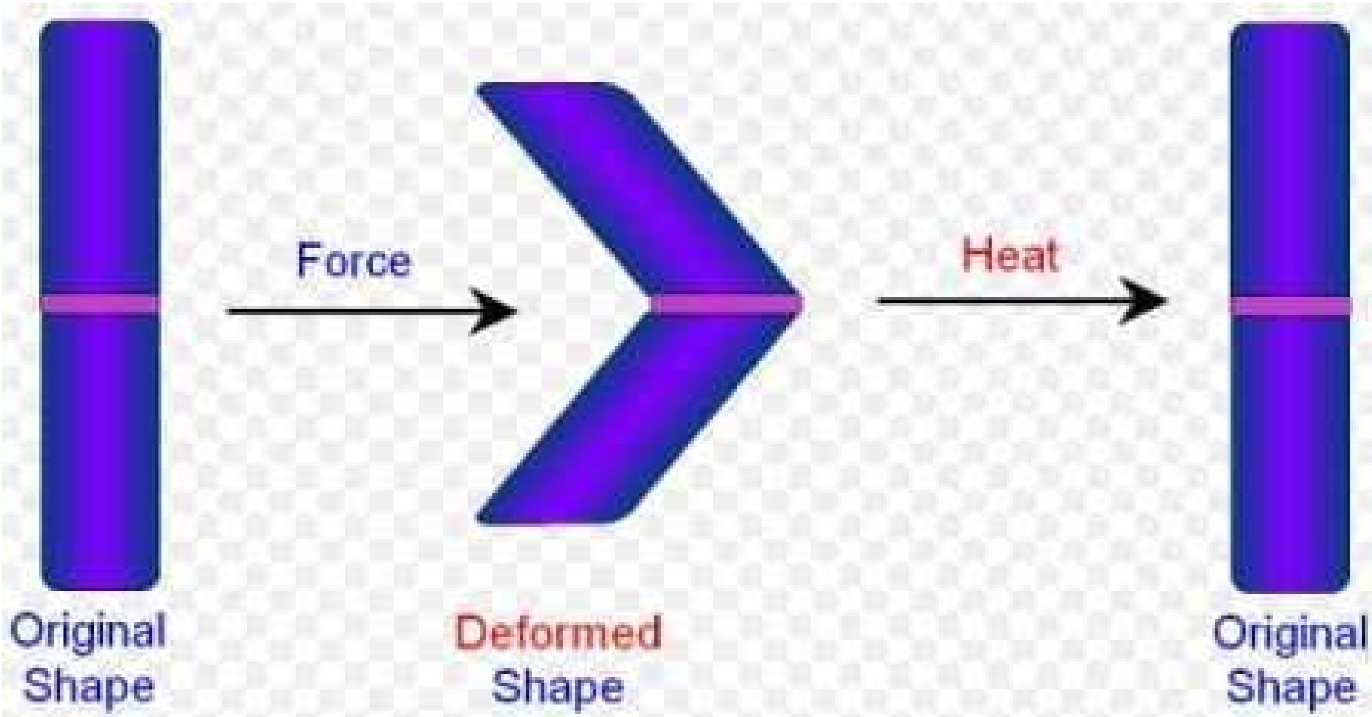
FLOATING PIERS



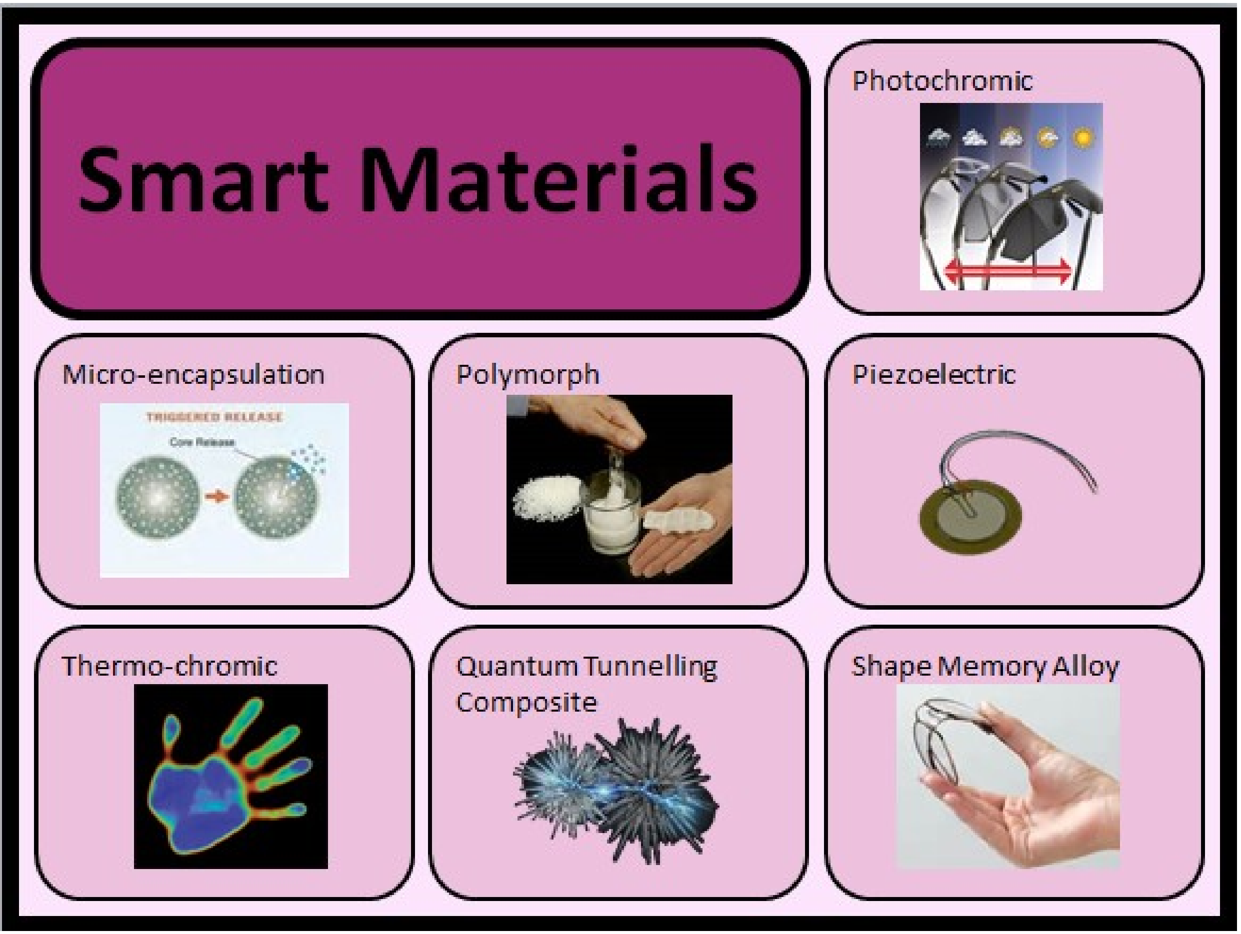
Floating piers are created by artists Christo and Jean- Claude over the water of Italy's lake Iseo. It is about 3 kilometer long walk way with 100, 000 square meters of floating docking system made of polyethylene cubes of high density.

POLLUTION ABSORBING BRICKS

Pollution absorbing bricks sucks in pollutants in air and releases filtered air consisting of two layer of façade system with specialist bricks on the outside and standard insulation on inside. From the wind tunnel tests conducted it is proven that the system can filter about 30% of fine particle pollutants and 100% of coarser particles such as dust.



SMART MATERIALS USAGE IN CIVIL ENGINEERING AND THEIR APPLICATION



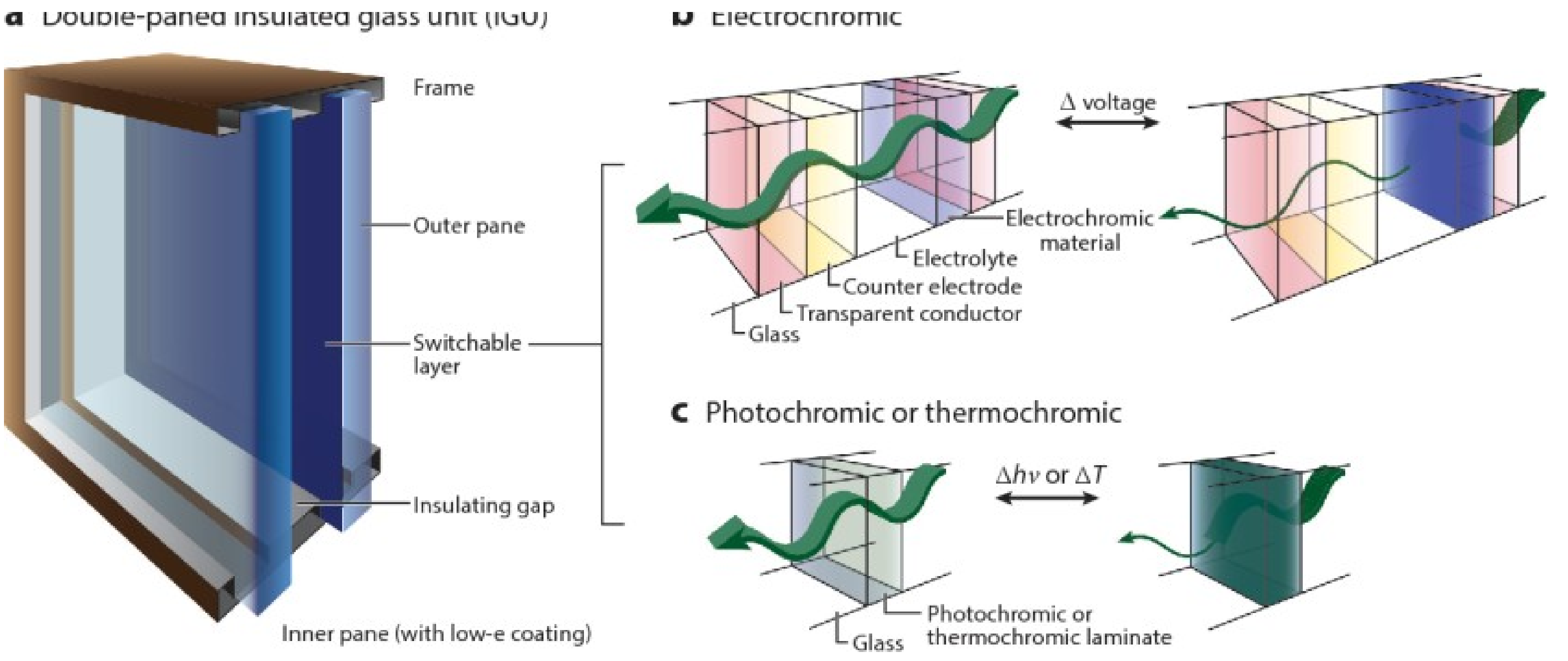
Smart Materials:

Smart materials have different properties that are affected by the external factors such as temperature, light, stress, electric and magnetic fields. They are also known as intelligent responsive materials. Smart materials are use in various civil engineering projects to increase their performance and efficiency of the structure.

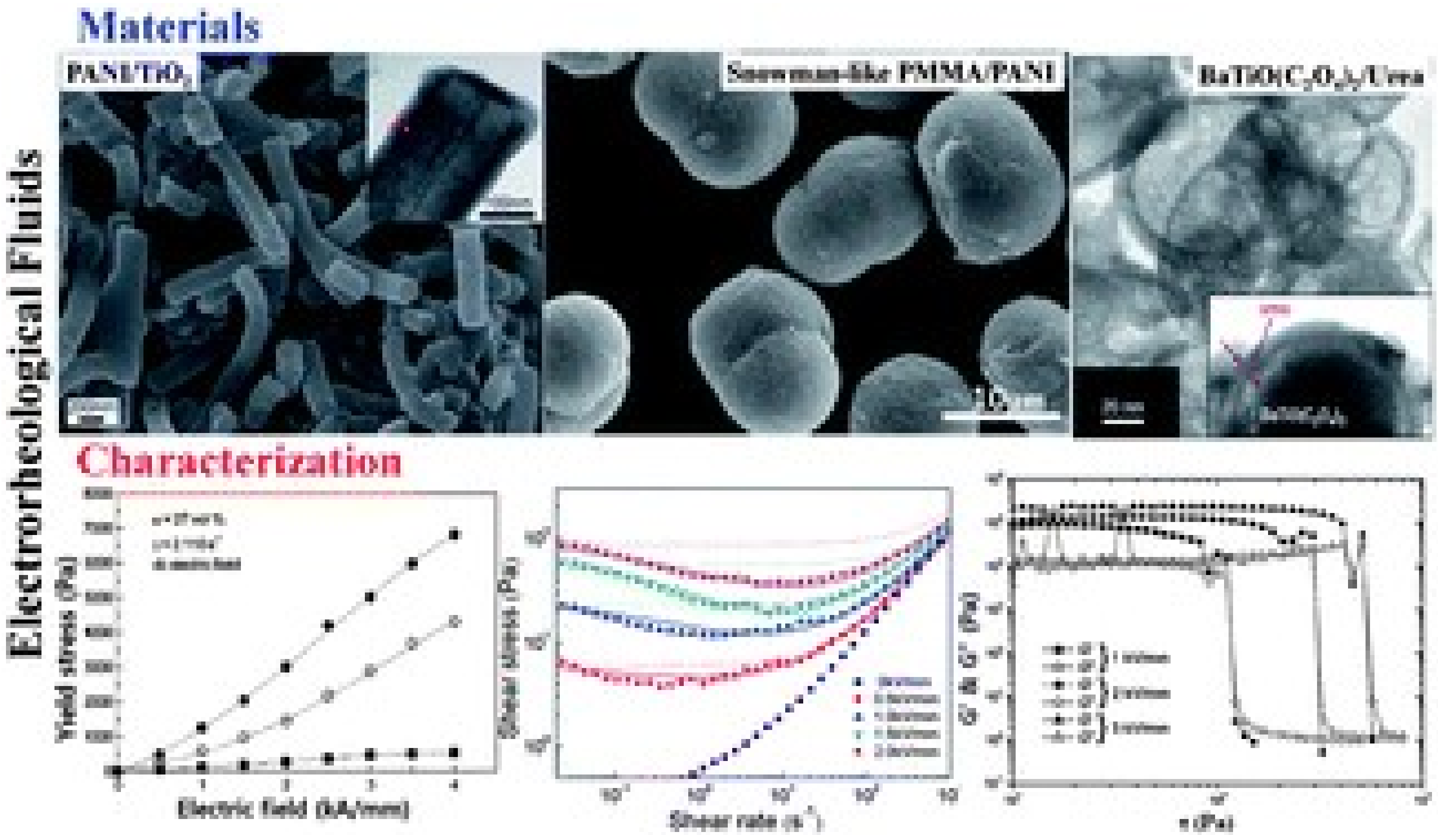
Types of Smart materials:

- **Electro chromic Materials:** These smart materials alter the light transmission properties when voltage is applied to them. They affect the optical color of a surface when voltage is applied to them and are known as chromo-phones.
- **Electro rheological Fluids:** These smart materials present in the colloidal suspension undergo changes in viscosity when subjected to electric field. These materials highly sensitive and responds to the any change in the applied electric field and are used as shock absorbers.
- **Piezoelectric Materials:** In these smart materials undergoes deformation when an electric field is applied in response to magnetic field. These materials produce voltage when surface strain is introduced.
- **Magnetostrictive Materials:** These smart materials undergo mechanical deformation that is proportional to the square of the electric field. These materials produce voltage when stretched in response to magnetic field.
- **Shape Memory Alloys:** These smart materials have the ability to regain previously define shape or size when subjected to thermal changes. These materials are used in Civil Engineering projects to absorb strain energy without permanent deformation, for resisting particularly cyclic and fatigue behavior and structures to be utilized durably in the long run.

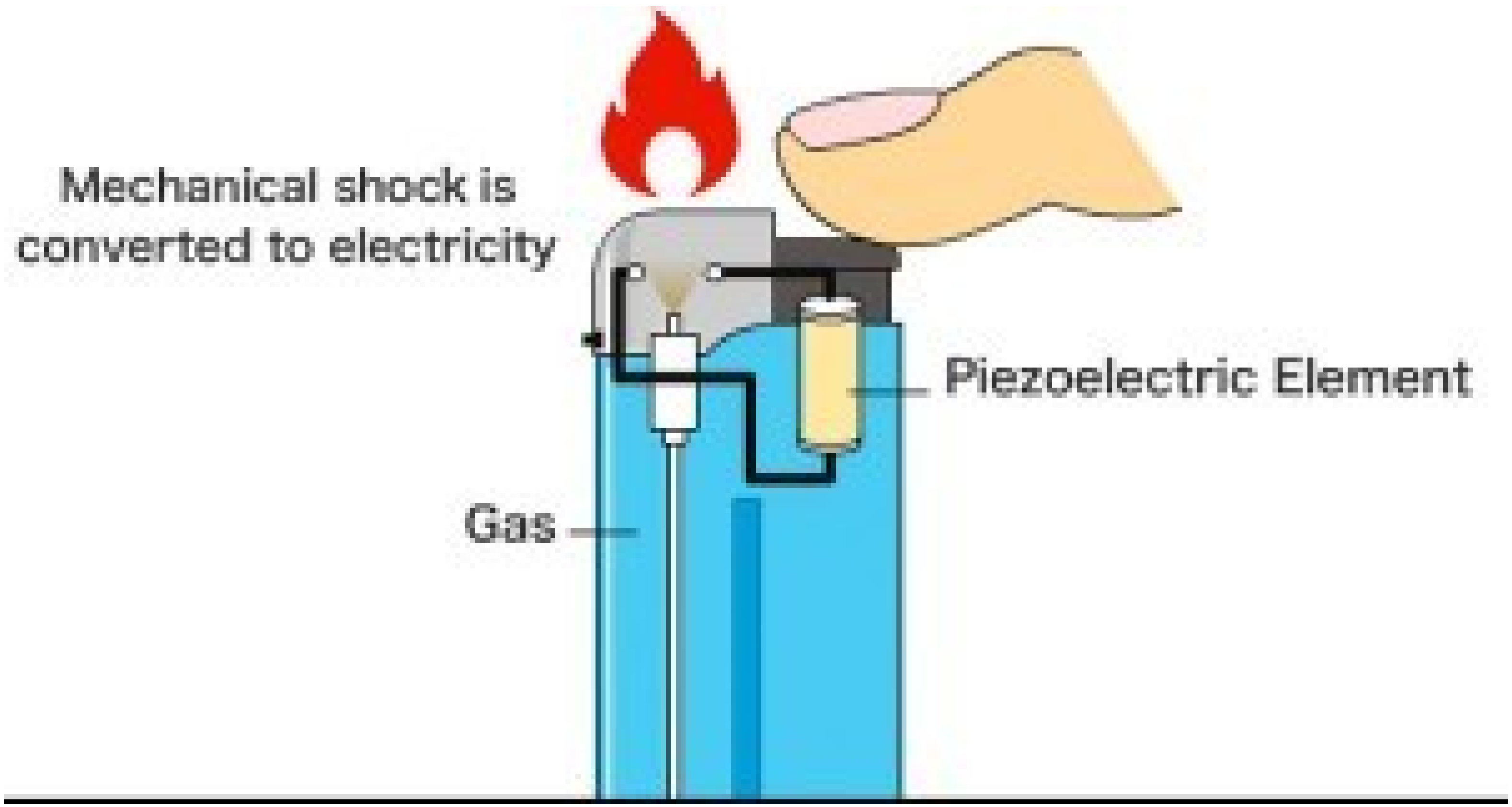
Electro chromic Materials



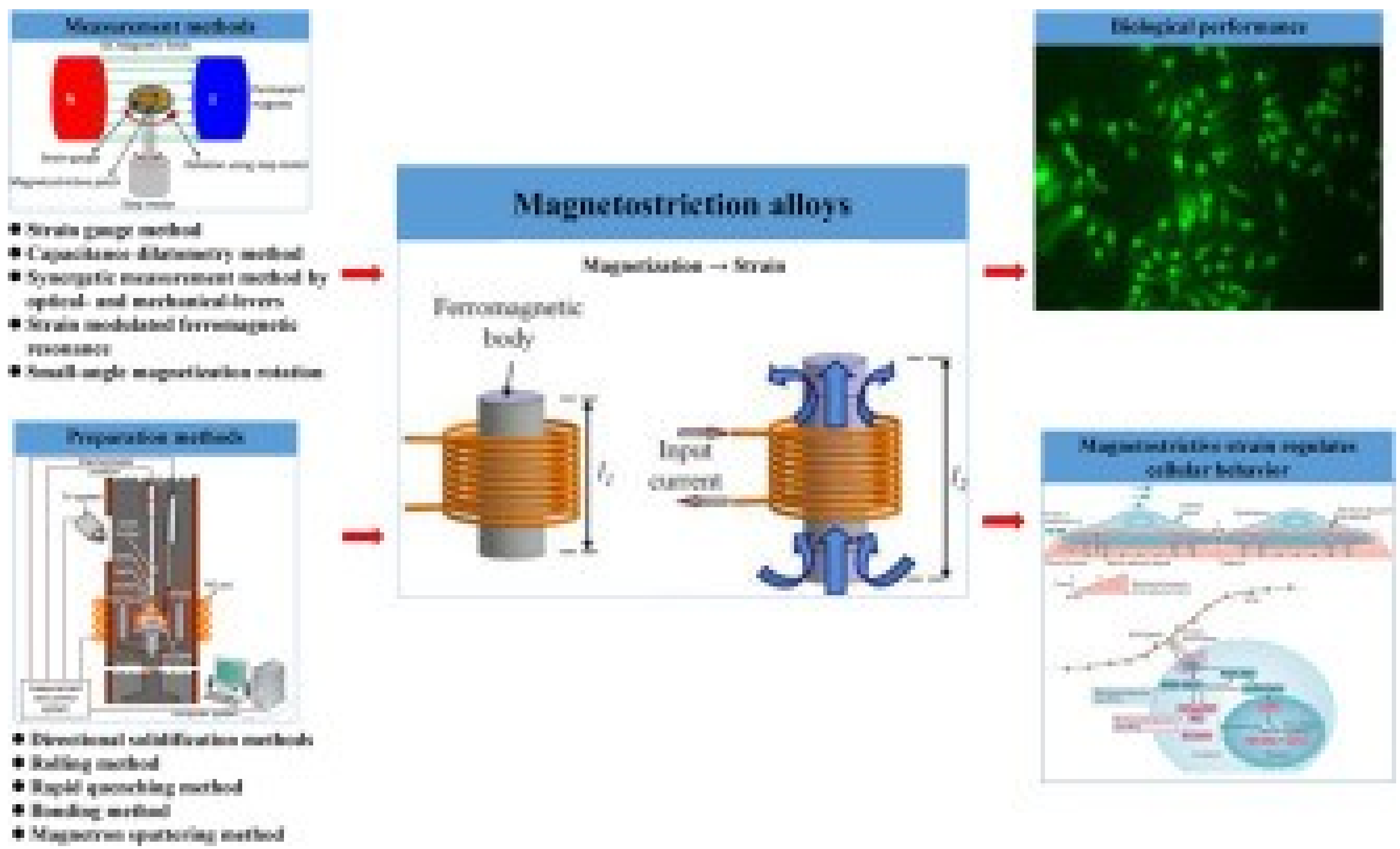
Electro rheological Fluids:



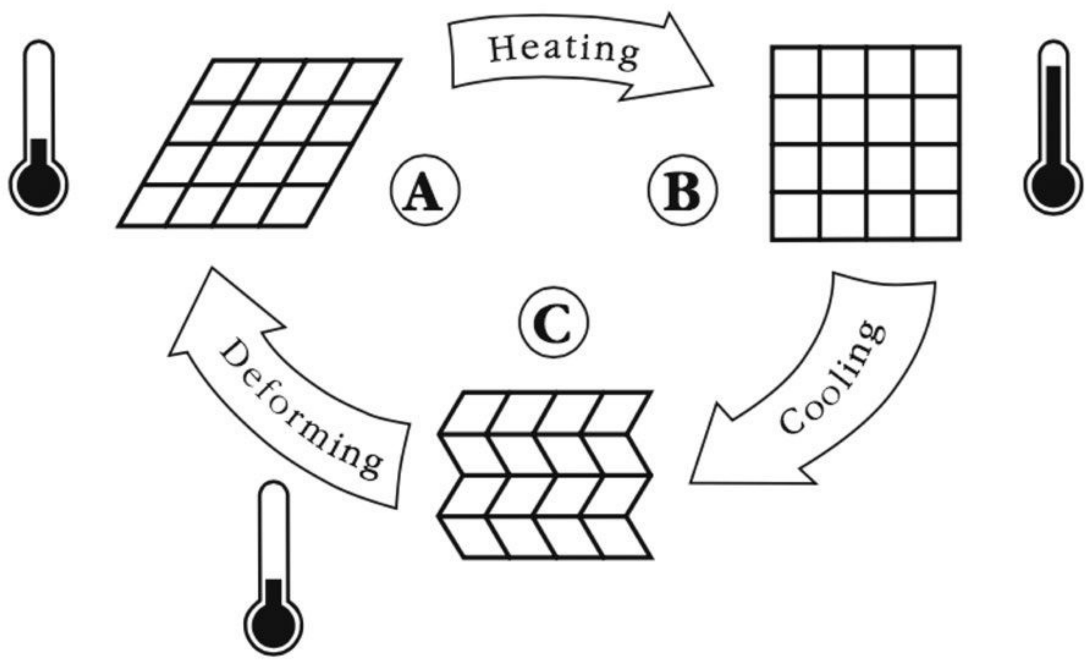
Piezoelectric Materials:



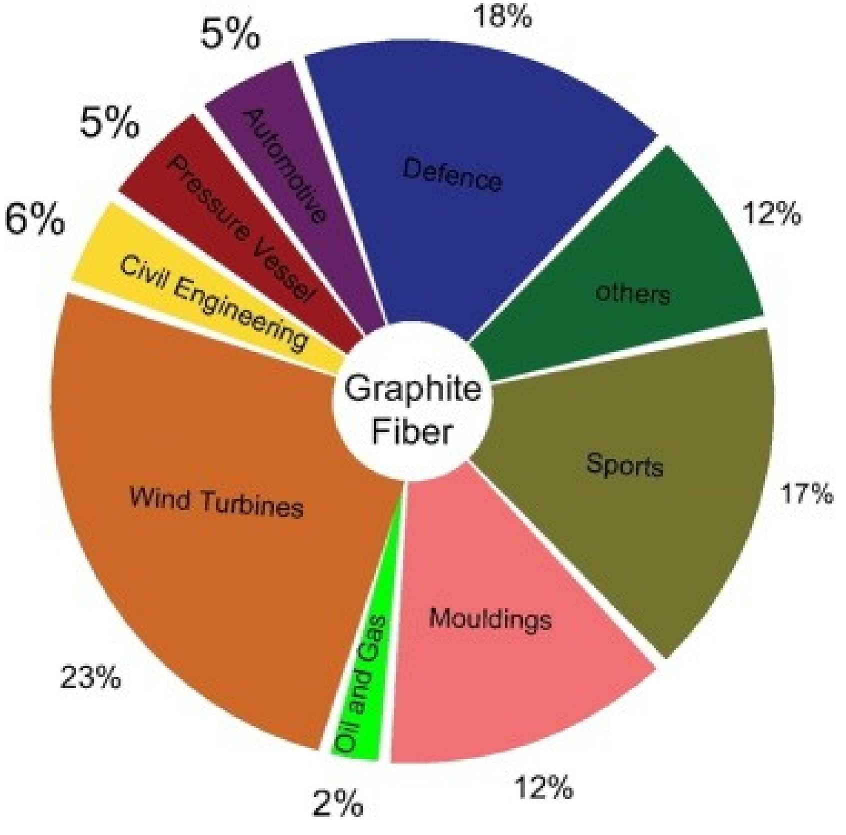
Magnetostrictive Materials:



Shape Memory Alloys:



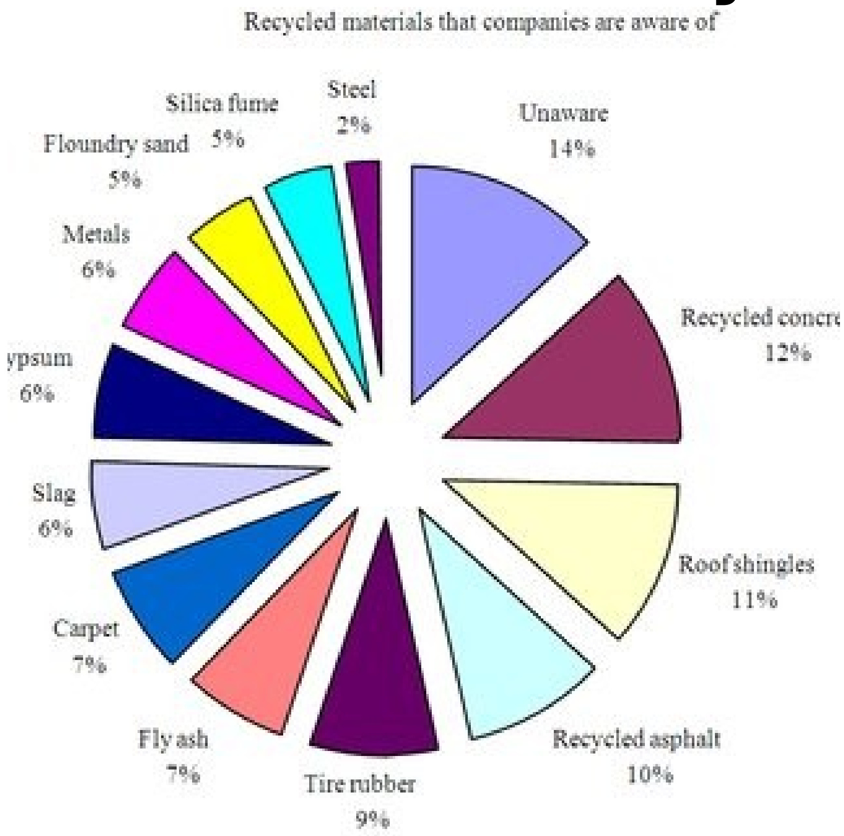
Applications of Smart materials



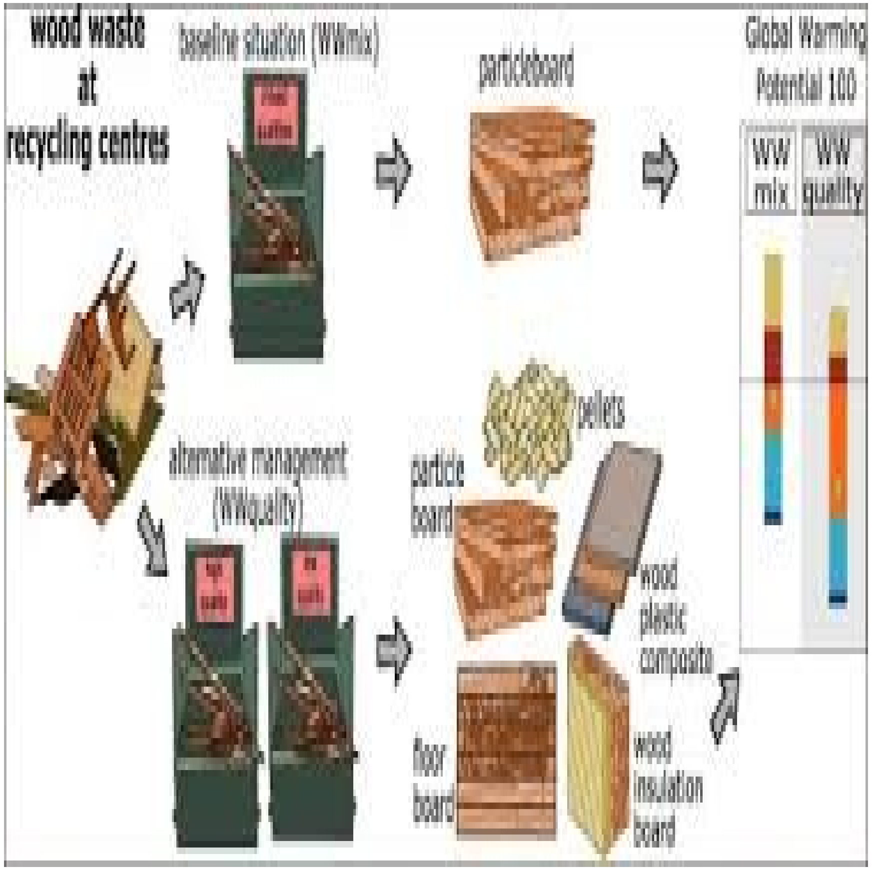
Applications of Smart materials

- Smart Materials are used in constructing smart structures and which are capable of sensing minute structural cracks and flaws.
- Smart Materials can be used for electromagnetic shielding and for enhancing electrical conductivity.
- Smart Materials plays a vital role in the construction of road pavements as a traffic-sensing recorder, and also melts ice on highway and airfields during snowfall in the winter season bypassing the low voltage current through it.
- Smart Materials are used in the designs of Smart buildings. They are used for vibration control, noise mitigation, safety and performance.
- Smart Materials are used in smart buildings for environmental control, structural health monitoring.
- Smart Materials are used to transform efficiency, comfort and safety for people and assets in smart buildings.
- Smart materials also reduce the effects of earthquakes.
- Smart Materials are used in marine and rail transport applications for strain monitoring using embedded fibre optic sensors.

Recycling of materials: Types of materials that can be recycled

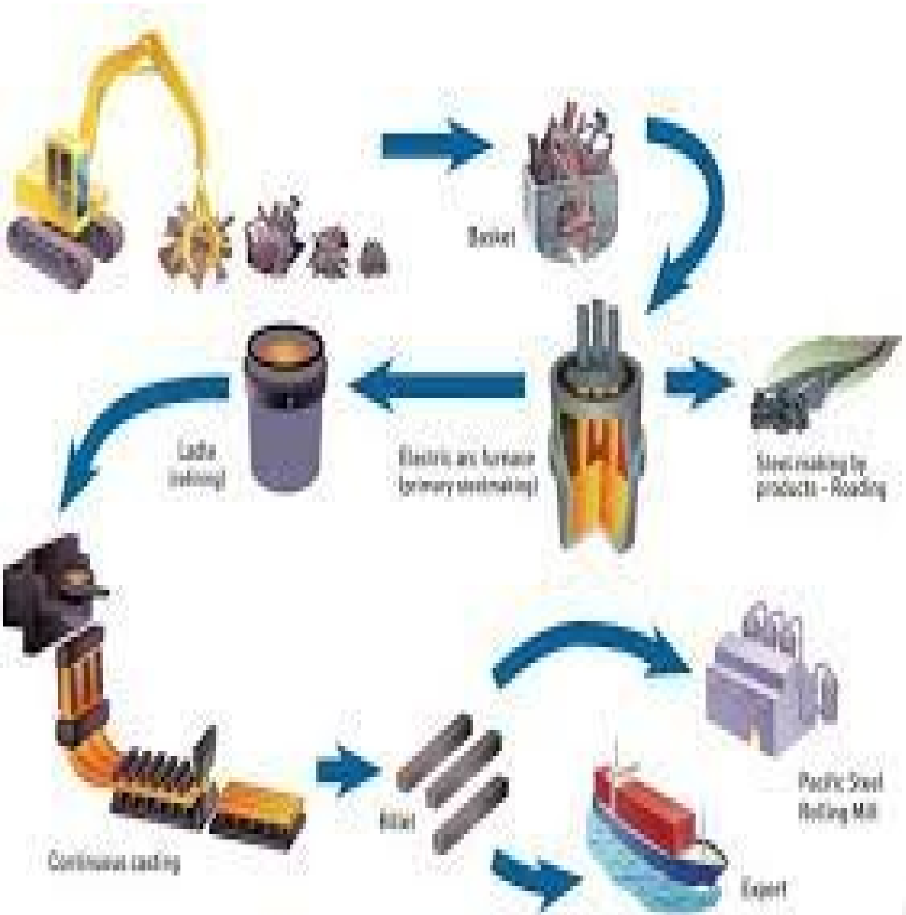


Recycling- wood



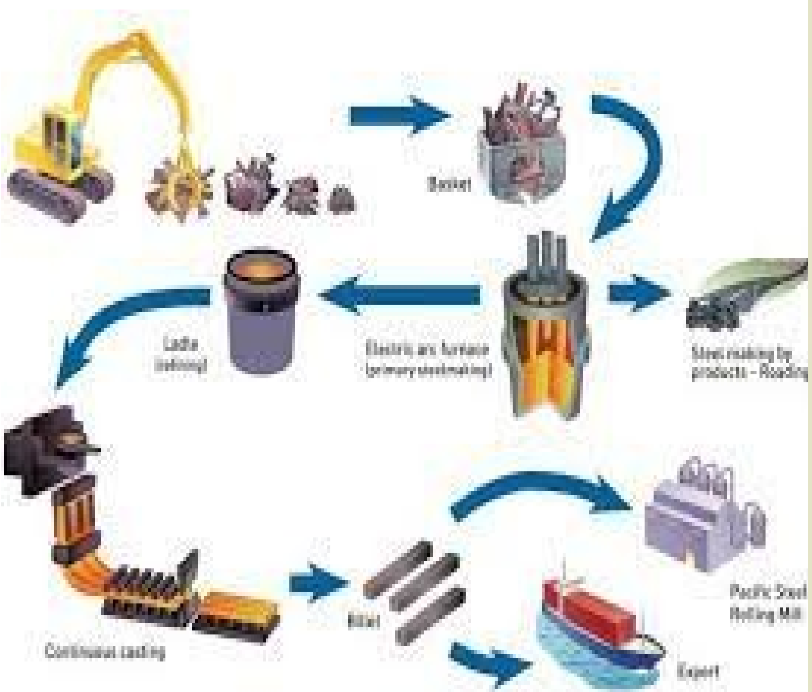
Recycling- Glass

Recycling- Metal



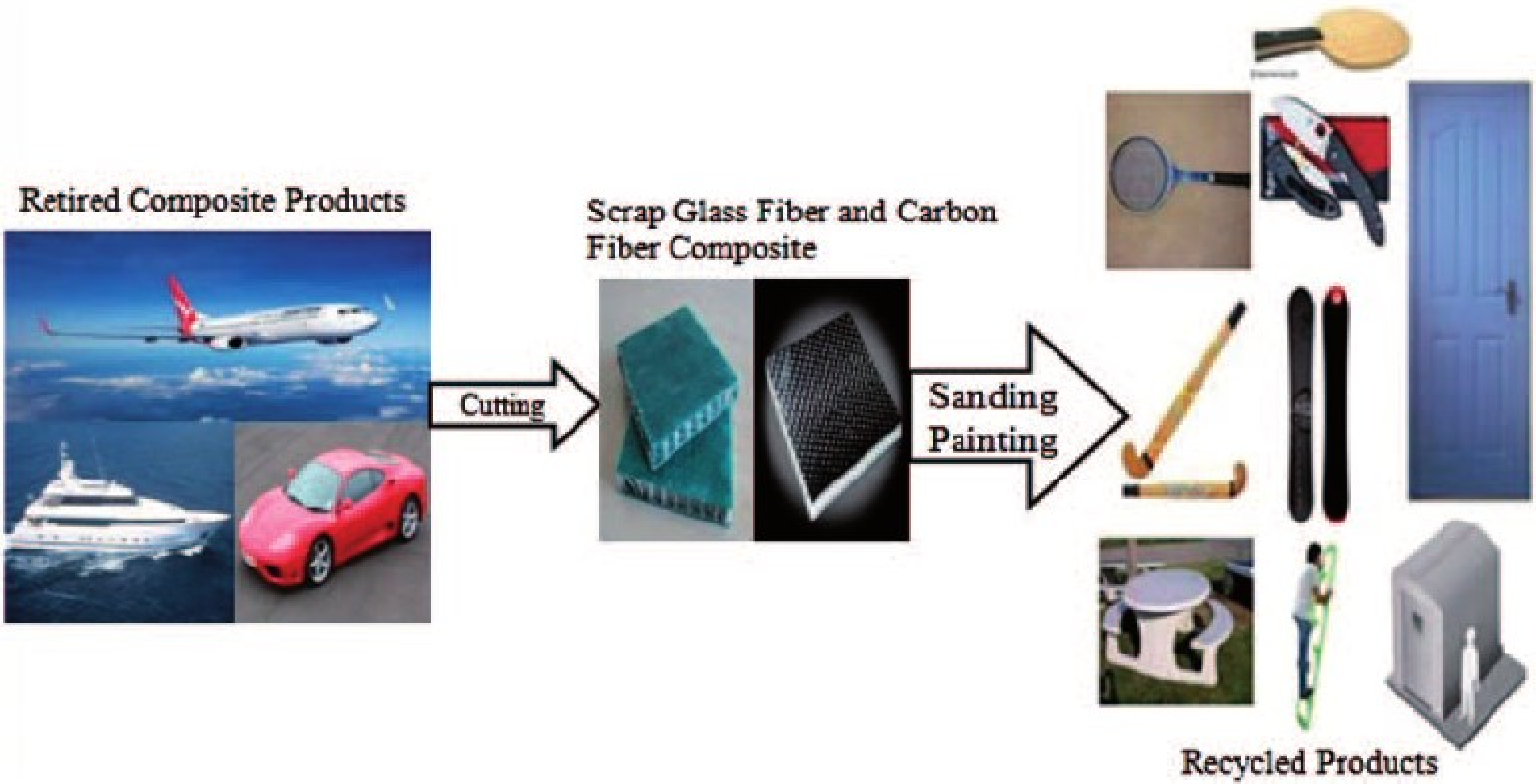
- Recycling-Glass

Recycling -Metal

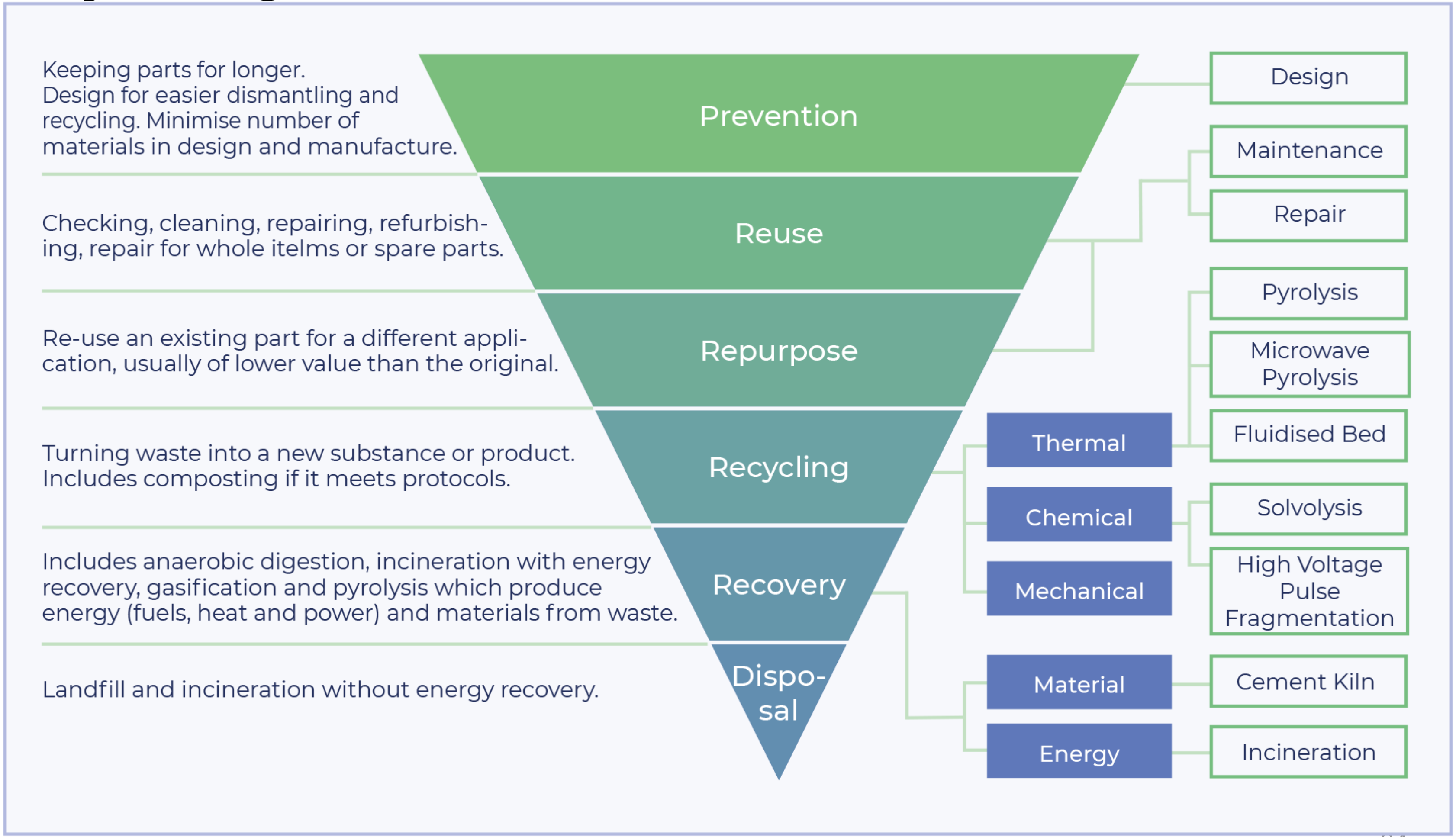


Recycling -Plastic

Recycling of materials



Recycling of materials



FLYASH:

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by;

- Electrostatic
- Precipitator

Fly ash is the most widely used pozzolanic material all over the world.

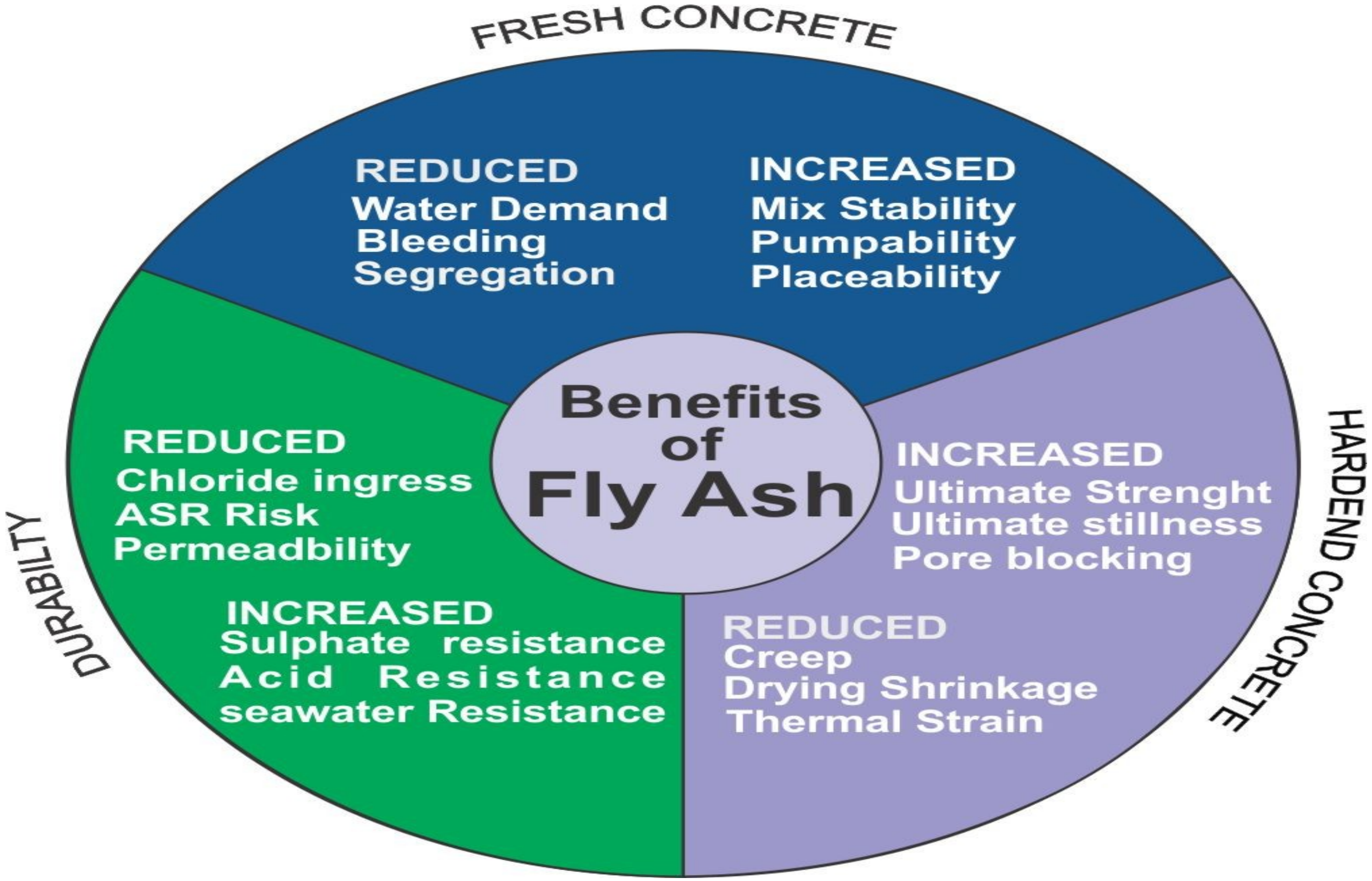
- Ingredients / composition of Flyash

Component	Bituminous	Subbituminous	Lignite
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

Advantages of using Fly ash

- Increases ultimate concrete strength and durability
- Is more economical than portland cement
- Reduces the heat of hydration (first used in mass concrete construction in the building of Hungry Horse Dam, Montana,1948)
- Reduces risk of alkali-silica reaction (ASR)
- Increases resistance to sulfate attack
- Reduces concrete bleeding (water loss at the surface after placement) Reduces concrete shrinkage during curing
- Reduces the amount of water required in mixtures
- Reduces permeability (increases concrete’s resistance to water penetration)
- Improves workability (microscopic, spherical-shaped particles create a more flowable, easier-to-finish concrete)
- Lightens the color of concrete
- Fulfills LEED points (LEED MR 4.1, Reclaimed Materials/Recycled Content) and is routinely specified on many green projects

- Advantages of Using Flyash



- Application of using Flyash
- Many high-rise buildings
- Industrial structures
- Water front structures
- Concrete roads
- Roller compacted concrete dams.

References

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Marginal materials References: Dr. **Quentin** L. **Robnett, "Use of Marginal Materials in Highway Construction",** School of Civil Engineering Georgia Institute of Technology Atlanta, Georgia

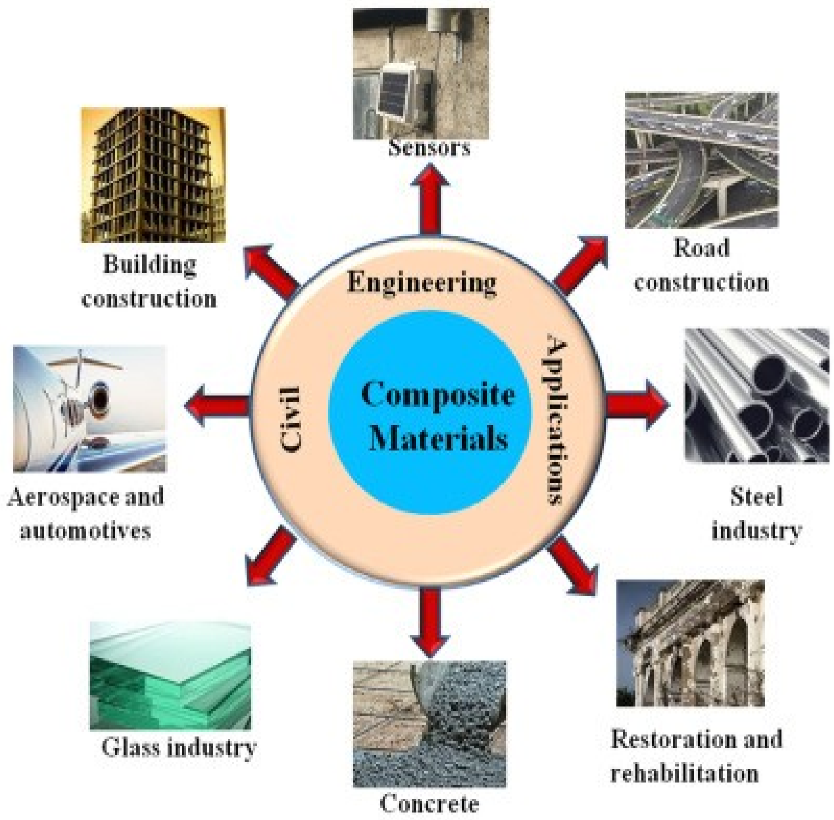
Application of smart and sustainable materials in Civil Engineering constructions .

- Introduction

Smart materials are the materials which have the ability to respond to changes in their condition or the environment to which they are exposed, in a useful and usually repetitive manner. Structures that incorporate smart materials are called as “Smart Structures”. Smart materials are developed which responds to environmental stimuli such as pressure, temperature and wind.

Smart materials used in construction technology includes self healing coatings, smart concrete, shape shifting metals, transparent metals, aerogels etc., which will change the construction technology in near future.

Smart materials are actually compositely designed materials having one or more properties significantly changeable in a controlled fashion by application of external stimuli or inputs. The inputs are mostly in the form of mechanical stress/ strain, change in temperature, pH, light or moisture, induction of electric or magnetic fields, light, or chemical compounds. Having such properties, they are rightly also called as intelligent or responsive materials.

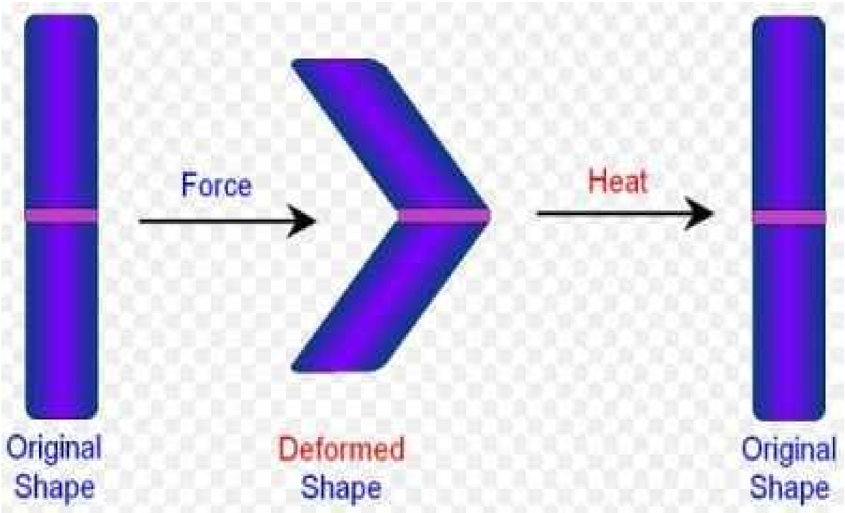


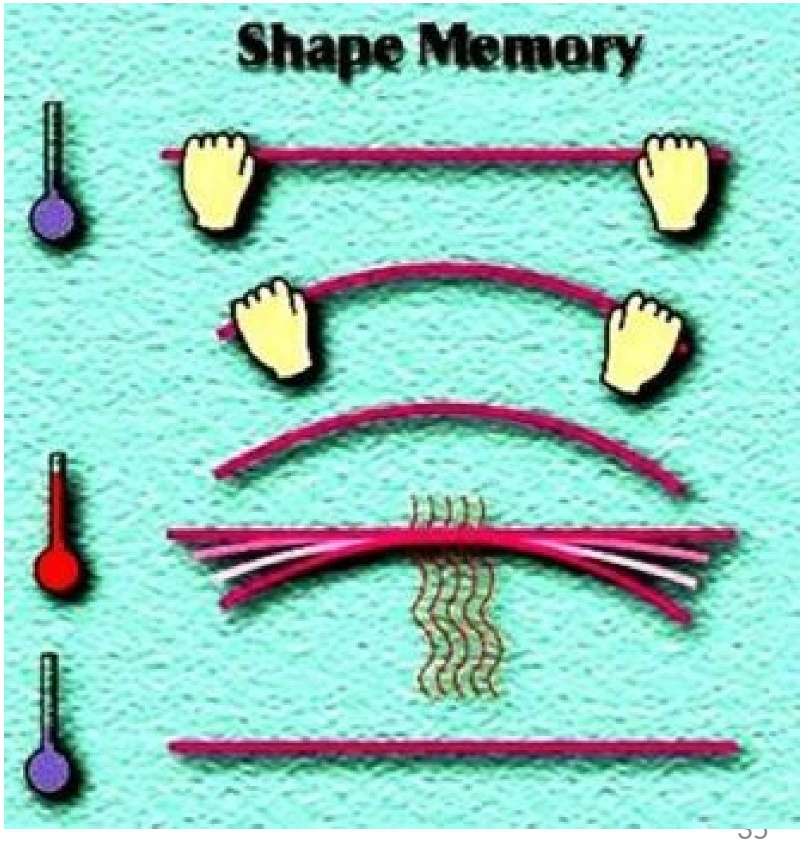
Types of Smart Construction Materials

- **Shape Memory Alloys (SMAs)**

Such materials possess the ability to regain to some previously defined shape or size when subjected to appropriate thermal changes. Shape memory alloys find their applications in new applications in civil engineering specifically in seismic protection of buildings.

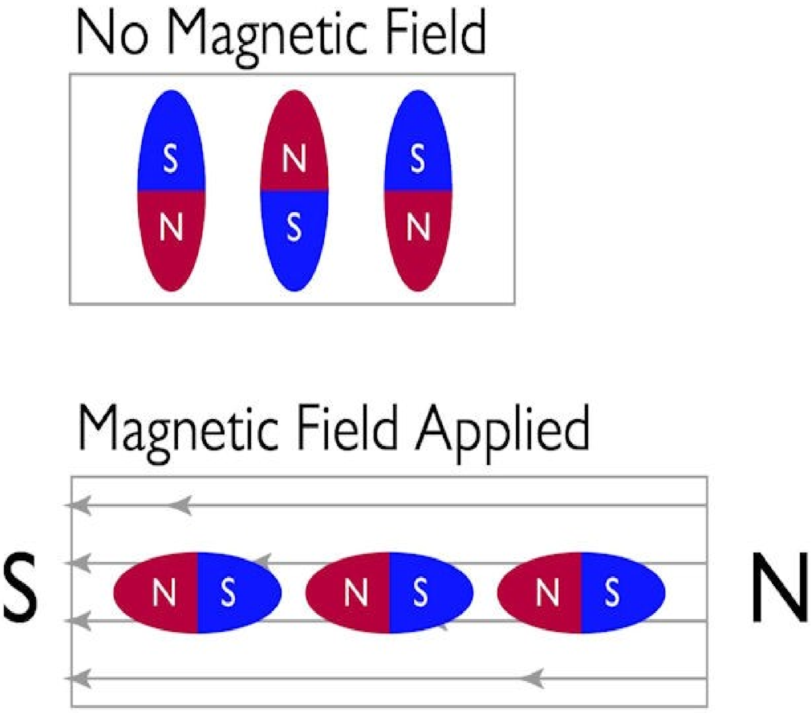
The application of shape memory alloy in civil engineering application, are- repeated absorption of strain energy without permanent deformation, for obtaining wide range of cyclic behavior, to resist fatigue resistance under large strain cycles, and due to their great durability and reliability in the long run.


Force
Heat
Original Shape
Deformed Shape
Original Shape


Shape Memory

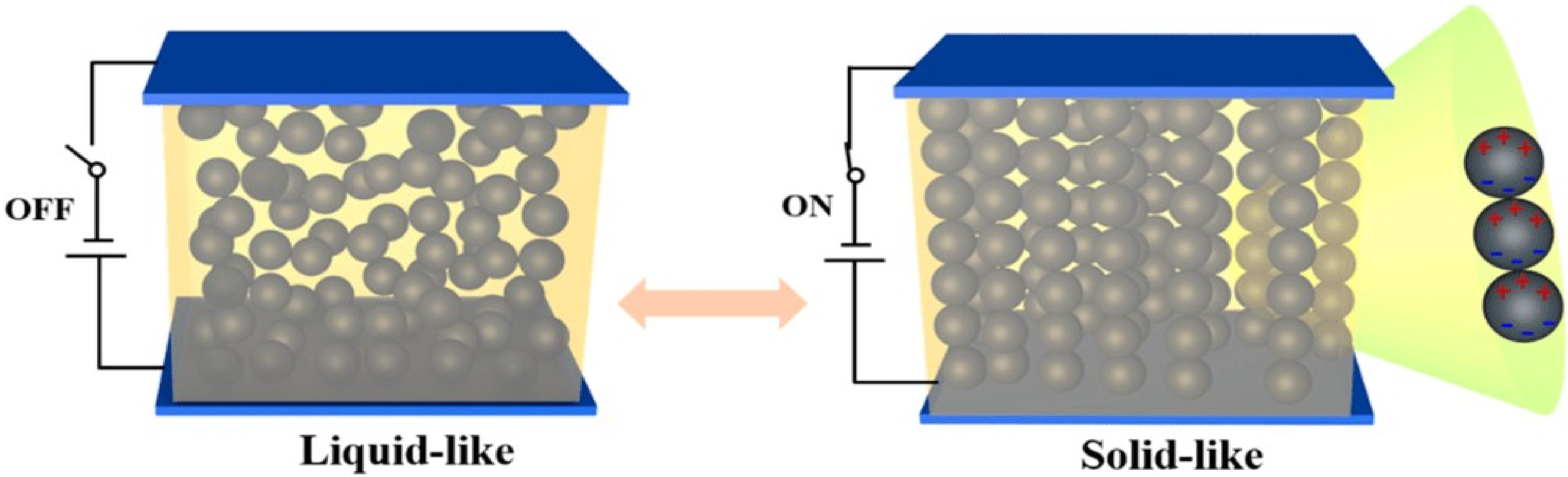
- **Magnetostrictive Materials**

These materials undergo mechanical deformation in proportional to the square of the electric field, which refers to the material quality of changing size in response to either an electric or magnetic field, and conversely, producing a voltage when stretched. These materials show promise in applications ranging from pumps and valves, to aerospace wind tunnel.



- **Piezoelectric materials**

Piezoelectric materials are such smart materials that produce a voltage when stress is applied. Since this effect also applies in a reverse manner, a voltage across the sample will produce stress within sample. Suitably designed structures designed from these materials can, therefore, be constructed that bend, expand or contract when a voltage is applied making them adaptive to environmental situations. When integrated into a structural member, a piezoelectric material generates an electric field in response to mechanical forces.

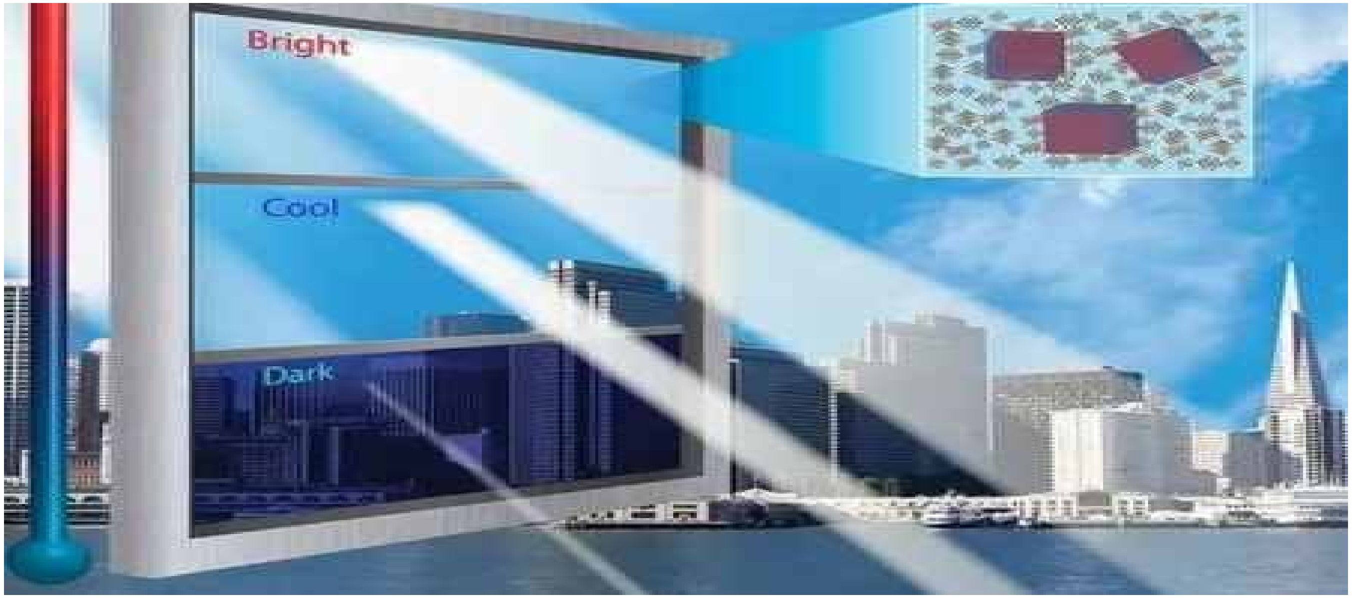


- **Electrorheological fluids**

These colloidal suspensions undergo changes in viscosity when subjected to an electric field. Such fluids are highly sensitive and respond instantaneously to any change in the applied electric field. Civil engineers mostly find their application in shock absorbers.

- **Electrochromic materials**

These materials alter their light transmission properties when voltage is applied which makes them adaptive enough to maintain chromatic panels and similar structures.

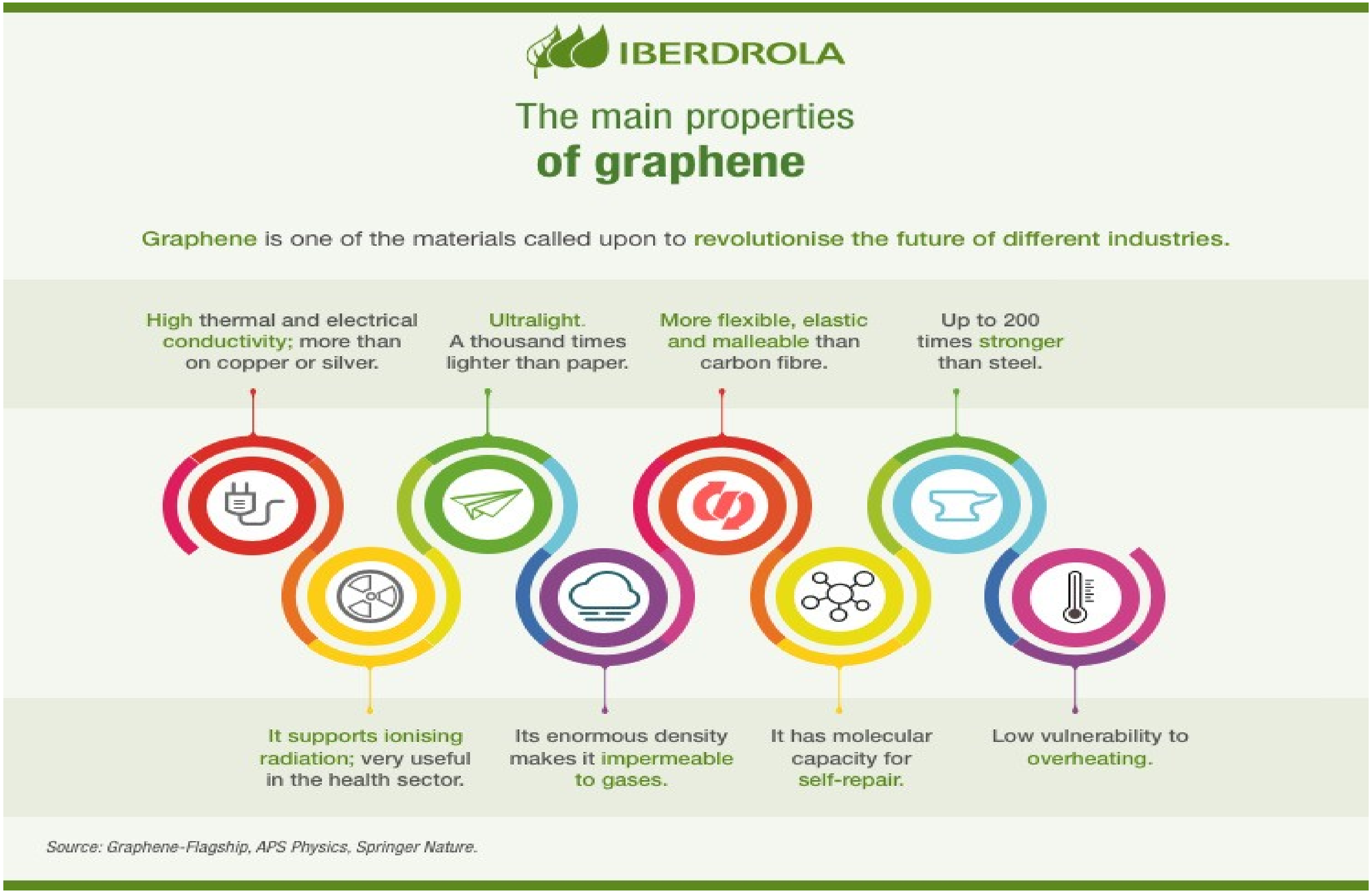


- **Examples:**

Synthetic spider web. This material is not only five times stronger than steel, but also has great elasticity. Its potential uses include: bulletproof clothing, artificial skin for burns or waterproof adhesives.

Shrilk. Its main component is chitin, a carbohydrate found in krill shells. It was created by researchers from Harvard University and is considered the ideal substitute for plastic — since its decomposition time is only two weeks and it also works as a stimulant for plant growth —.

Graphene. Its potential uses are almost unlimited: batteries with more autonomy, faster computers, flexible electronic devices, more resistant buildings, bionic limbs, etc. All this is possible thanks to their multiple properties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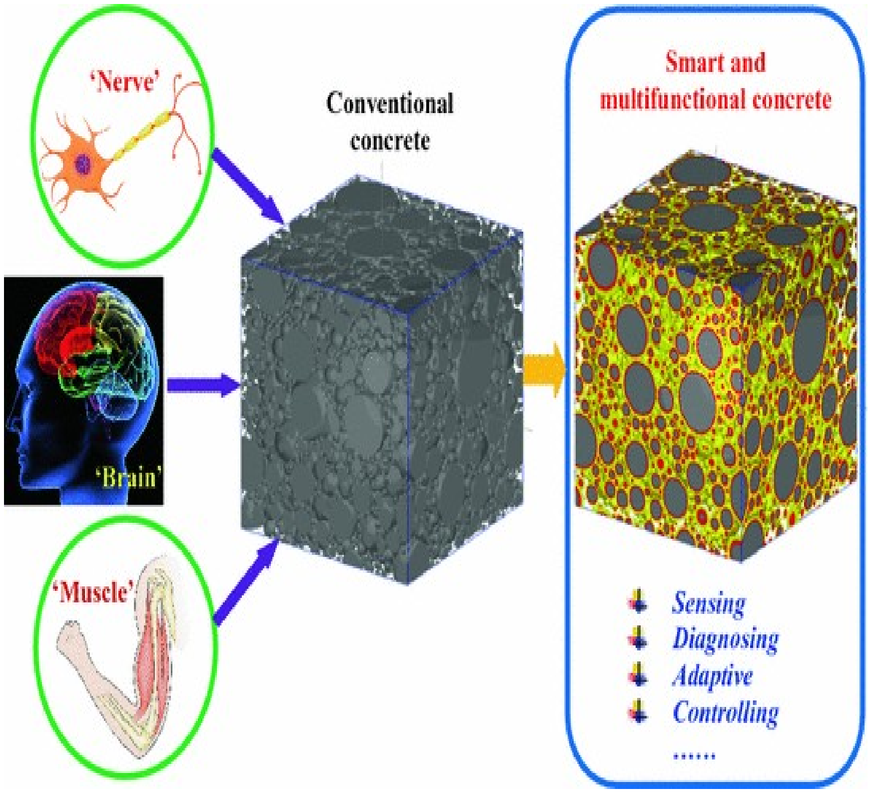
The main properties
of graphene
Graphene is one of the materials called upon to revolutionise the future of different industries.
High thermal and electrical conductivity; more than on copper or silver.
Ultralight. A thousand times lighter than paper.
More flexible, elastic and malleable than carbon fibre.
Up to 200 times stronger than steel.
It supports ionising radiation; very useful in the health sector.
Its enormous density makes it impermeable to gases.
It has molecular capacity for self-repair.
Low vulnerability to overheating.
Source: Graphene-Flagship, APS Physics, Springer Nature.

1) **Smart concrete:**(a composite of carbon fibres and concrete) used in smart structures is capable of sensing minute structural cracks / flaws.

2) Unlike conventional concrete, the smart concrete has higher potential and enhanced strength. It can be used in electromagnetic shielding and for enhanced electrical conductivity of concrete

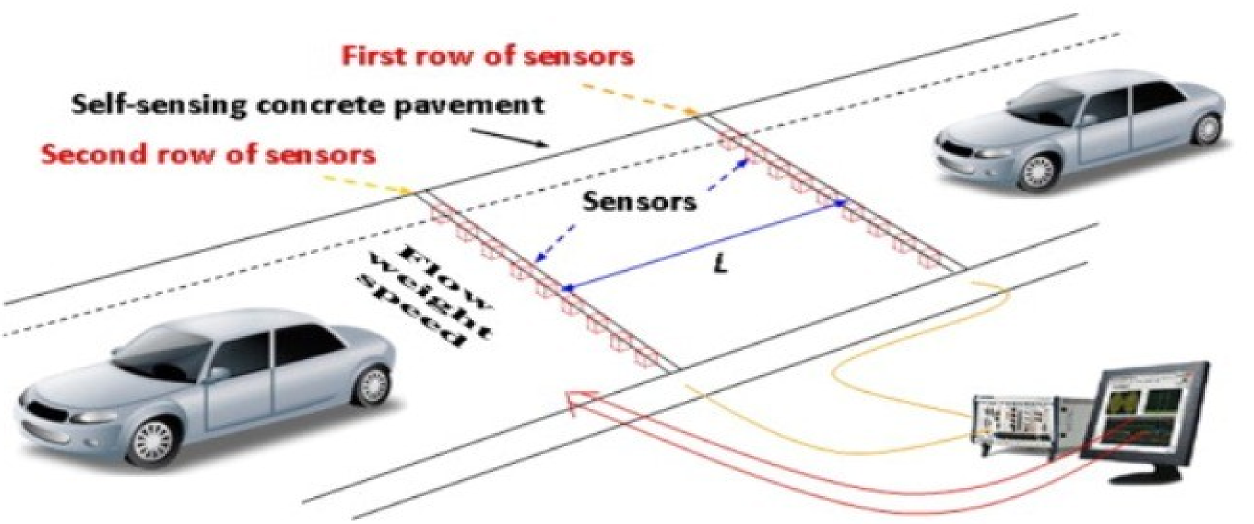
- **Applications of Smart Materials in Construction**



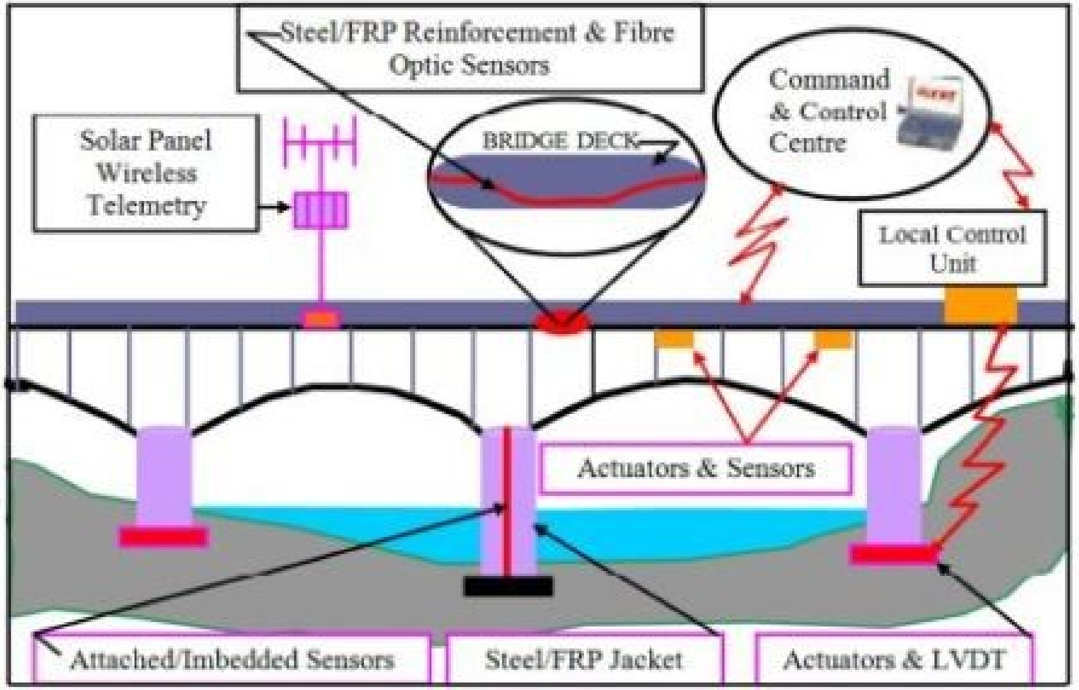
Smart concrete under loading and unloading process will loose and regain its conductivity, thus serving as a structural material as well as a sensor. Self-sensing concrete (also called self-monitoring concrete, intrinsically smart concrete, and piezo resistive or pressure-sensitive concrete) is fabricated by adding functional fillers (carbon fibers, steel fibers, carbon nanotubes, nickel powder, etc.) into conventional concrete to increase its ability to sense strain, stress, cracking, or damage in itself while maintaining or even improving mechanical properties.

- **Application of smart concrete**

Traffic Detection A vehicle detection sensor fabricated with self-sensing concrete has several advantages over conventional detectors, such as easy installation and maintenance, wide detection area, low cost, high anti-jamming ability, long service life, and good compatibility with pavement structures, because they are made of concrete materials.

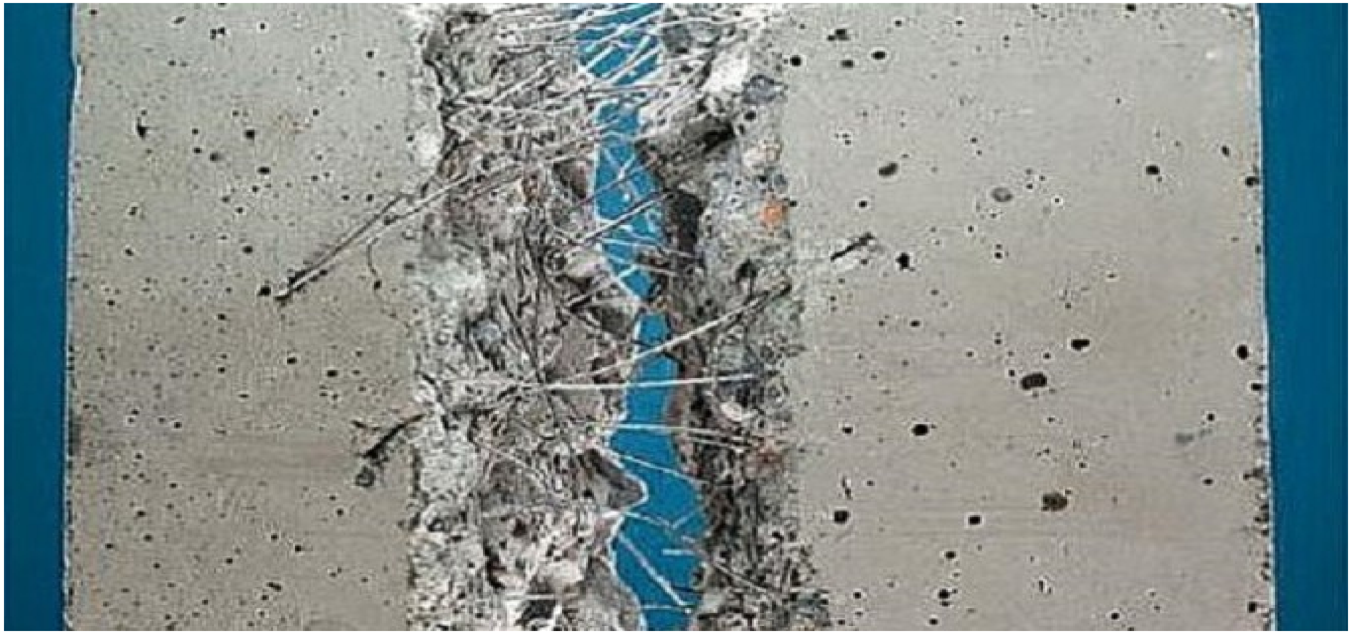


- It can automatically warn on the re-opening of a crack or on the formation of new damage in a repaired portion of the structure.
- Smart concrete can give us information of the strain level attained during an earthquake and on the potential lack for lateral confinement.



2)Fiber-reinforced concrete

Fiber Reinforced Concrete is a composite material consisting of fibrous material which increases its structural integrity. It includes mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce the bleeding of water.



3)Fly Ash

Fly ash is a fine powder that is a byproduct of burning pulverized coal in electric generation power plants. Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water.

Fly ash can be used as prime material in many cement-based products, such as poured concrete, concrete block, and brick.

One of the most common uses of fly ash is in Portland cement concrete pavement or PCC pavement. Road construction projects using PCC can use a great deal of concrete, and substituting fly ash provides significant economic benefits.

Other uses of smart materials:

- Smart materials have applications in the design of smart buildings. Smart materials are used for vibration control, noise mitigation, safety and performance.
- In construction of smart buildings, for environmental control, structural health monitoring.
- In smart building, it used to transform efficiency, comfort, and safety for people and assets.
- Smart materials reduce the effects of earthquakes.
- In marine and rail transport applications for strain monitoring using embedded fiber optic sensors.

- The use of smart materials permits the construction of smart bridges especially cable stayed bridge with a wider span to avoid the increased susceptibility to vibrations caused by ambient factors such as wind, rain or traffic. Hence, the structure required less maintenance and the response of the structure can be monitored.
- They are used to monitor the civil engineering structures to evaluate their durability.
- Smart materials in structures used to monitor the integrity of bridges, dams, offshore oil-drilling towers where fiber-optic sensors embedded in the structures are utilized to identify the trouble areas.
- They can be used to rehabilitate the cracking of concrete when super elasticity smart material is used as the reinforcement bar.