Energy Efficient Architecture
Lecture 10

Nano Technology

What is nanotechnology? Nanotechnology is the use of very small pieces of material by themselves or their manipulation to create new large scale materials. Creating new material out of a small piece of the existing material by modifying some properties or their physical content is called Nanotechnology. At a Nanoscale material, properties are altered from that of larger scales. The broken down material's property has been changed to create a new material which has improved performance compared to the ones which were used as primary or raw materials to which it was transformed to a new material. The Nano-scale is the size range from approximately 1nm to 100nm. Nanotechnology is an enabling technology that allows us to develop materials with improved or totally new properties. The advantages - it will have much more strength, durability, improved performance and structural stability when compared to the raw materials that we have been using over the years. This nanotechnology is widely used and spread across the world. Recently due to the advancement of technologies that we are having currently. Classification - the Nanotechnology can be classified into four major parts - Nanoparticles, Nanocomposites, Carbon Nanotubes (CNT) and Titanium Dioxide. What are nanoparticles? It is defined as a particle with at least one dimension less than 200 nm. Nanoparticles made of semiconducting material. For example - Silicon, sand grind is an example of a nano particle because it is less than 20 nanometer. Each object we observe in our day to day lives are three dimensional objects, so if a material with at least one dimension less than 20 nanometer is classified as nanoparticle. Sand grind can be example for this type of a particle. Nanocomposites - It is produced by adding Nanoparticle to bulk material in order to improve its bulk properties. Nanocomposite is a material to which this nanoparticle is being added to create a new material on a large scale with an improvement of nanoparticles basic properties.

Next is, Nano tubes. These are cylindrical in shape with a Nanometer diameter. Type of Nanotubes are; Single walled carbon Nanotubes and Multi-walled carbon Nanotubes. If the tube is in a singular frame, it is called 'Singular walled', if the wall has different layers, it referred to as multi walled. Look at this picture on the right. The one above is a perfect example of a Multi walled carbon nanotube and another example for single-walled carbon nanotubes. Nano composite is produced by adding Nanoparticle to bulk material in order to improve its bulk properties. This is called nano composite. What are the applications Nanotechnology? Nanotechnology can be used widely in construction materials as; concrete, steel, wood, glass, coating and photovoltaic cells. Almost all the major construction materials used mostly are being adapted to nanotechnology to improve its strength. In places or locations with adverse effects which need improved strength or improved tensile strength or earthquake resistant

structures, for all such needs, nanotechnology can be modified according to the site's needs and adopted in various parts throughout the world. This is much more effective and brings down the construction cost as well. Rather than using different materials or going for export materials, also brings in high transportation charges.

Nanotechnology in concrete - Concrete is a mixture of cement, sand coarse, aggregate and water. The mechanical behaviour of concrete material depends on the phenomenon that occurs on a micro and Nano scale. Nanotechnology can modifiy the structure of concrete material and finally improve the properties of materials. Nanotechnology is adopted in Nano to develop Nano concrete which varies the material property of each. Since cement particle is very small, the properties are modified and creates a new material that has improved strength. The properties that have been upgraded in concrete via Nanotechnology when compared to the regular conventional concrete that we usually produce is increase in bulk density, Mechanical performance and Volume Stability, Durability and sustainability of concrete. It has advantages and improvements when compared to the actual base concrete that we usually use. It has all improved capacities and performance. It can stay longer which is the durability that we have mentioned. Because of all this, it can be adapted in a location that demands such kind of materials to be used rather than going for a new material. The property of the concrete can be slightly adjusted to satisfy the needs of the occupants of the locality of the climatic zone which we are going to design.

Nanotechnology in concrete is exploring and modifying these Nano scale pores can result in improved concrete . These addition could compensate for its weakness in tension and result in concrete with greatly improved stress-strain behaviour. As we know, concrete lacks in tension strength which is why we are using additional steel in the reinforcement of the concrete structure like, columns, footing, pillars, etc. This Nanotechnology in concrete improves the tensile strength of the concrete itself. So, steel can be reduced drastically which adds to cost-effective construction technology methods for the client. The addition to Nano scale silica fume operates at a Nanoscale and can improve durability of concrete structures exposed to deicing salts. If the structure has been built under the sea, there is a lot of salt that is going to lessen the durability of the concrete structure. Lifetime of the structure will be less. In such cases, Nanotechnology can be used to improve the durability which will help reduce the replacement or yearly maintenance that is going to go into all this maintenance and constantly take care of it or change the structure into a new one.

These are silica fuels which are 10 nanom. Nanotechnology has been added to the concrete to change from conventional concrete to Nano concrete.

Smart Materials

Smart or intelligent materials are materials that have to respond to stimuli and environmental changes and to activate their functions according to these changes. According to change, it has to change itself, that is called intelligent material. Like how we have intelligent systems, when you leave a room, it automatically switches off the light and when you get in, it automatically switches on as well. This is called intelligent electrical system. The same goes for material in which it changes the properties according to the environmental changes. This material is called intelligent or smart material. The stimuli like temperature, pressure, electric flow, magnetic flow, light, mechanical, etc, can originate internally or externally. This type of variation with temperature present with electrical flow and mechanical changes. can modify its performance which will make it more effective and the space more interesting for the material to be adapted widely.

Properties of Smart materials - Sensing materials and devices around it. Actuation materials and devices. Control devices and techniques, Self-detection,self-diagnostic, Self-corrective, self-controlled and self-healing. The material has wide range of properties which makes a material fall under smart material category. This operates according to the changes present within the device, around it and also adapts for the environmental changes that is going to happen around the material. It also changes according to the electrical flow, magnetic flow that's happening in the material. It also self controls and self heals if a material has been damaged and you don't have to replacing it often. This makes the material require less maintenance or easy maintenance. Shock absorbers and damage arrest - it absorbs shocks and it doesn't act as a conductor of electricity. It also arrests damages. If a particle has been damaged, it doesn't allow the damage to spread across the entire ceiling where the material is being used. Rather it restricts to a certain area in which the self-healing happens and the damage can be healed automatically.

Examples of smart materials - Piezoelectric Materials: When subjected to an electric charge or a variation in voltage, piezoelectric material will undergo some mechanical change and vice versa. These events are called the direct and converse effects. When there is electric charge passed through this material, certain change happens which causes mechanical changes of the material. This can be done in two methods - direct effect or reverse effect by connecting it to an electrical charge or removing it from the electrical charge. For instance - this type of lighting used in dance floors or hotels, restaurants and pubs that we have observed, is made out of smart material which changes lights based on the sound and the people tapping on the floor. The colour and the light intensity changes even according to the music that is being played and the decibel levels changes. This type of material creates interests for the users and makes

people want to use the space over and over which increases the commercial value of this space also. These are some of the advantages of smart materials.

Thermoresponsive Materials - responsive to thermal or heat energy that is present around the material or the one which the material is going to hold. Thermoresponsive is the ability of a material to change properties in response to changes in temperature. They are useful in thermostats and in parts of automotive and air vehicles. In places where you set a thermostat, where the temperature has to be maintained within certain limits, this material can be used to detect the temperature of the surrounding spaces and the material can act according to it and it can send signals and suggestions to increase or decrease the temperature according to the thermal comfort levels. This cup is being made thermoresponsive material when it is cold, the cup becomes completely black and when you fill the cup with warm liquid instead, the design automatically begins to show up. As you begin drinking the warm liquid present inside, the cool portion of the cup turns black. This is one of the examples that help denote to a user if the cup is warm or cold, if it is filled or not filled. All this information can be received by the user without having to look into the cup.

Application of smart material is really wide spread and it can be used for wide range of fields such as Aircrafts, orthopedic surgery, dental braces, robotics, reducing vibration of helicopter blades, smart fabrics, sporting goods and smart glasses. All these materials makes even the competence much more smarter and it responds to the users and it makes us much more comfortable in facing day to day activities. For example - if you consider this type of a fabric jacket which is made out of smart material, it responds according to the temperature and the environment in which we are wearing it and if it is cold, it begins to absorb the heat in the surroundings and it starts keeping the occupants much warmer and when the outside temperature is hot, it starts dissipating the heat outside and it becomes more colder to keep the occupant comfortable. The same fabric the occupant can use even it's vice versa in single day.

The next is Merits - Bio-compatibility, Simplicity, Compactness, Safety Mechanism, Good mechanical properties. These are some of the merits of smart materials, which is used in all the fields of aircrafts to smart glasses, which is simple and compact and immediately responds to occupants and it makes the occupant easier for them to change their structure or usage of material over and over again. All of this comes handy with the smart material but it does also contain some demerits. It's more expensive, low energy efficiency, complex control and limited bandwidth. The changes that happen don't happen for a wider range, it happens only for a shorter range. It cannot be adopted, the same change cannot be used for an extreme condition. Only for minor changes within a set limit can respond to it. If the limit exceeds then the

material it is designed for, then it doesn't act as it might be expected to. Due to the fact that it's a new innovation, its expensive and more energy efficient when compared to the energy we are going to give to the material rather than the raw materials that are being used.

ECBC

Energy conservation Building codes - with the background of high energy saving potential and its benefits bridging the gap between demand and supply, reducing environmental emissions through energy saving and to effectively overcome the barrier the Government of India has enacted the Energy Conservation act 2001. It is an act that has been passed by the Government of India to meet with the Energy standards to conserve energy and to save the energy for the future generations to come. This has been effectively passed and should be used in all types of building sectors and different types of building sectors that aim for energy efficiency and the percentage of energy efficiency that is mandatory to achieve. The act provides much needed legal framework and an institutional arrangement for embarking on an energy efficient drive.

The Act empowers the Govt, of India and State governments to modify the ECBC as per climatic conditions of states. Since India experiences wide range of climatic conditions from hot and dry, cold regions, mixed climates, composite climates, monsoon climate, warm and humid climate. ECBC has been verified for each and every state depending on their climatic condition. How much percentage of energy efficiency can be achieved for different sectors of building types. And to notify the code in Government Gazette to make it mandatory for commercial buildings having a connected load of 500 kW or maximum demand of 600 KVA or above or 1000 sq m of air conditioned spaces. ECBC becomes mandatory for commercial buildings for energy demands above 500 kW. Even if it has a maximum demand of 600 kVA. If you have an air conditioned space and it's more than 1000 sq m, ECBC becomes mandatory. You need to conserve energy to make your building energy efficient. What is the purpose of making all these Energy efficient building codes? The purpose of this code is to provide minimum requirements for energy-efficient design and construction of buildings. This not only provides energy efficiency, it also reduces the demand for efficiency. By passing these type of codes and rules, people become more educated and it creates an awareness amongst the public about how energy efficiency is very ideal and vital for our environment right now.

The different percentages of energy efficiency that is required -

Building sector - 33%; Commercial sector - 8%; Residential sector - 25%; ECBC compliance building - can save upto 40 to 60% of electricity. The last one we saw is for buildings that have been designed with ECBC code for schematic stage itself. This can save almost 40 - 60% of electricity compared to the same amount of conventional building. Nationwide mandatory

compliance is 1.7 billion KWH. It is the first step towards Energy conservation. This is the first step towards creating awareness towards energy efficient architecture and we need to conserve energy. Developed over extensive research work, considered comfort conditions, helpful for persons involved in design and construction of ECBC compliant building.

It has been developed with wide or vast research work for different states and different kinds of thermal comfort according to the cultural and day to day activity background, this has been developed for different states and it is becoming mandatory for all the different building typologies to follow ECBC, to reduce the usage of energy. The scope is applicable to building complexes having connected load of 500KW or greater or a contract demand of 600KVA or greater or a contract demand of 600KV or greater. It applies also if your building is more than 1000 sq m air conditioned space in a commercial sector, you need opt for ECBC, mandatorily.

Buildings or complexes having conditioned spaces of 1000 Sq m or more. It's a voluntary adoption in the country. It shall become mandatory after gazelle notification by any state or central government.

Still in process, now as an Act, if it passes as a law, then it becomes completely mandatory for all the buildings to follow ECBC which will make the architects and clients make sensible decisions to use passive design strategies and to reduce the energy demand of the buildings.

Importance of energy efficient envelope design - Helps in reducing heating/cooling load. Helps in optimizing daylight. First cost and recurring savings. Helps in utilizing latest technological advances. Simulation models greatly helps in designing high performance envelops. Having such type of ECBC envelope reduces external heating or cooling and it cuts down the unwanted demand for mechanical appliance usage because we make it from the initial harsh sunlight from coming in or harsh cold air to leak inside through the building. We are cutting from the source itself. These type of decisions will improve your design, occupant comfort, air quality and also reduce your energy bills.

ECBC codes for Heating, Ventilation and Air conditioning which is HVAC spaces, can result in - natural ventilation, suitable wind direction and orientation of buildings and openings in the buildings should be well distributed. Air to enter at low level and outward at higher level.

These are some of the design decisions to achieve natural ventilation inside the building and reduce the usage of external air conditioning spaces or air coolers.

No building should obstruct the incoming air, you shouldn't only be considerate about your building, you should be considerate about urban planning as well. If your building is going to restrict the airflow to the next building, that cannot be appreciated by ECBC. Windows of living rooms should open to open areas. Two windows instead of one on one wall, if that wall is exposed to the outside. Rather than keeping one huge window, it is better to split them into two different windows and better to keep them away from each other because one window can help in bringing in air and the other can help the used up air leave which will also induce cross ventilation effect.

Application to buildings - Minimum energy performance standards for design and construction be prescribed. Applies to new construction and major renovation. Building components included. Building envelope such as walls, roofs and windows. Interior and exterior lighting and HVAC system. Service water heating and pumping. It is used not only on envelope design but also in interior and exterior lighting, like use of what type of lights, how much energy can it save, LED lights demands very less of electricity compared to a conventional CFL electrical bulb and such. As we saw in the previous presentation, how photovoltaic cell can be used to conserve energy.

Exemptions to buildings - Buildings that do not use electricity or fossil fuels. Equipment and portion of the building systems that use energy primarily for manufacturing processes when this code is in conflict to safety and health. If there is a building that doesn't use electricity at all, this code does not apply because that is already passively made and you need not apply this code. If there is a building in which controlled air quality has to be maintained for example hospitals and sterilized rooms, this becomes an exception because controlled condition has to be achieved, mechanical systems have to be mandatorily adopted in such spaces. Environment codes shall prevail.

Impact is average energy use for light and HVAC a typical class A office building consumes 200 kWh/sqm/Yr. Mandatory enforcement of ECBC is likely to reduce the energy use by 30-40% to 120-160 200 kWh/sqm/Yr. Energy saving as per BEE estimate - saving of 1.7 billion kWh, with national mandatory enforcement in the first year itself.

Some of the barriers of energy efficiency are - lack of information about comparative energy use. Risk due to lack of confidence in performance of new technologies. Higher cost of EE technologies. Asymmetry in sharing of costs and benefits, especially in building sector.

Tips for Architects and Developers are - Select an organization/ consultant with expertise and experience in performing building energy simulation. Always inquire for key input parameters

and output reports, eg: thermal specifications of wall, glazing and roof elements, load and system summary reports. Ask simulation consultant to perform parametric studies to evaluate - relative cost and benefits of selecting key components and technologies (glazing and lighting) and sizing of HVAC system.