Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 04

Innovative Building materials

So dear students, until last class we had seen alternative building materials. The first segment we saw traditional and vernacular building materials. Then in which we saw mud, straw, bamboo, stone etc. In the second segment we saw alternate building materials which are nothing but a combination of either traditional building materials with a conventional modern building material which results in a greener alternative. And under that we saw alternate aggregates and CLT and so on, phosphogypsum and all that. Now, we will look at innovative building materials.

We will look at what these materials are, what is the purpose of innovation in building materials. So, we will see the existing building materials, the impact of building materials on sustainability, what is the need for innovative building materials, what are these materials examples. We will look at some of these in brief and in further classes we will look at these in detail. So, we will look at permeable concrete or nanocellulose composite bricks, agro bricks, fab-brick and so on. We will also see the future trends and opportunities. Now what are innovative sustainable materials? So the rise of eco-friendly materials to meet growing environmental concerns has given rise to the need for innovative building materials which must be sustainable materials too. There must be technological integration which means there must be technological integration which means it must be incorporating smart technologies for enhanced building performance. Customization and design flexibility is very important to meet the varying aesthetic and functional requirements of modern architecture.

It must also have industry forecast. Which means the advanced building materials market is on a cusp of a significant growth caused by you and me, driven by a collective vision for sustainable, energy efficient and technologically advanced construction. This industry forecast indicates a positive trajectory offering substantial opportunities for innovation and market expansion. Now, what is the need for innovating building materials? Now, if you look at carbon dioxide emission by sector. You can see that the building sector including the operation and embodied energy comprises 35 to 39 percent of the total

energy consumption.

So, when the building sector consumes so much energy decarbonizing the construction industry is an important step towards achieving the net zero goals for almost all countries. The production process of conventional building materials consumes a high amount of energy which has a negative impact on the environment. The use of locally available materials and upgradation of traditional techniques can be a good option for sustainable development. The construction sector is consuming so much of energy 35 to 39 percent of total global energy and contributing to produce one third of the total greenhouse gas emissions. Therefore, the development of new green building materials with better properties is becoming increasingly important.

As the demand for housing increases exponentially, this further strains the construction industry as well as the production of conventional materials such as cement, steel, aluminum, and wood among others. Such production processes account for a high carbon footprint polluting air, land and water. Higher awareness on climate change is forcing companies to rethink their strategies in developing more sustainable construction materials. Now, let us look at what are innovative building materials and what are their characteristics. So, the use of sustainable building materials which is a way for the innovative materials taking into account all aspects of sustainability such as environmental, economic and social sustainability have many advantages.

They have a low environmental impact with low energetic production processes. Using agro-waste in developing construction materials either wholly or partly helps tackle the sustainability challenge while reducing pollution and adverse environmental effect. So, what must be the characteristics of innovative materials? The material must be energy efficient, So, the production of the material as well as when we use that material what it does to the operational energy both put together must be energy efficient. It should be a renewable building material that is it must not be a material which will perish it must be recyclable. Made into another form and it should be made from recycled material.

It should be non-toxic, should not cause poor IAQ, should be durable and easy to maintain, and should be cost effective as far as possible locally sourced because that will reduce the transportation cost of the embodied energy and must have enhanced durability. It should last long. These must be the characteristics of innovative building materials. What is the necessity to finding the innovative building materials we have seen? We will focus on concrete for now because concrete is supposed to be a material which is most consumed in the construction industry. So, concrete is highly used in the construction industry.

It comprises a mixture of cement, fine aggregate and coarse aggregate, all of which are derived from natural resources and on top of that cement is a highly energy consuming building material. Subsequently, as the demand for housing and buildings increases, there is significant pressure on non-renewable natural resources. As the demand for housing increases, significant pressure is mounted on non-renewable natural resources thereby sparking research on the alternatives for traditional concrete. Now, let us look at why there is necessity to find alternative for bricks. So, brick as a masonry component has been predominantly used in the construction industry since early centuries.

Traditionally, the brick making process involved three fundamental steps. Mixing the raw materials which is earth based materials such as clay and water. We need to mould the brick and dry it and finally firing them to obtain appropriate strength. Now, a significant shortcoming of this big brick production process results in the generation of substantial amount of greenhouse gases. The second disadvantage of the process stems from their excessive usage of non-renewable materials such as water and clay thereby facilitating the depletion of natural resources because this clay is fired unlike the mud that we saw in the first class where the blocks are not fired.

So, a more effective strategy regarding the transition to more sustainable brick making process is required. The processes incorporate agriculture waste products. We can add useful properties in the bricks and these can also help tackle waste disposal challenges associated with agricultural processing. So brick as a combination of clay and water is more eco-friendly than when you fire it. Also the kiln that is used for firing, the source of fuel increases the embodied energy of brick and therefore we need to find an alternative to brick.

So let us now look at permeable concrete. Permeable concrete is the concrete containing interconnected voids inside to allow air or water moving through it. The fundamental material characteristics of permeable concrete is its open pore structure, primarily the connected porosity and the large pore sizes which is caused by a gap creating coarse aggregates and little to minimal amounts of fine aggregates. Water is easy to percolate through paving matrix and the subsoil beneath when permeable concrete is utilized as paving material. If we look at where this can be applied, Permeable concrete is beneficial for conserving stormwater and recharging groundwater.

This can be used to absorb the noise of vehicles and adjust the temperature and humidity of the earth's surface. It can provide protection from flood, drainage, can reduce noise and maintenance of the balance of urban soil ecological environment. Now let us look at another a brief of another innovative building material which is nano cellulose composite brick. Nano cellulose is a natural polymer and is a promising building block for preparing

eco-friendly composites. Its properties include the fact that it is renewable, it is biodegradable, it has high mechanical properties, it is low in density, it is thermally conducive and has the ability to compact the cement matrix.

Despite the numerous advantages of nanocellulose, the large scale isolation or production of nanocellulose from plant biomass is still relatively complicated and energy expensive. Now let us have a look at agro bricks. Agricultural wastes are the residues generated from the cultivation and processing of raw agricultural products such as crops, fruits, poultry, dairy products, etc. Incorporation of agricultural waste materials in brick production is an efficient method to diminish the environmental pollution, reduce the amount of generated waste and protect the raw materials from depletion. The disposal of solid waste generated from agricultural industries is another serious problem that is faced by developing countries like India.

The major quantities of waste generated from agricultural sources are sugarcane, bagasse, rice husk, jute fiber, coconut husk, cotton stock etc. Reuse of these wastes as a sustainable construction material appears to be a viable solution not only to pollution problem but also to the problem of the land filling and high cost of building materials. Agro-waste shows the potential to develop energy efficient brick materials that also had good thermo-mechanical behavior. The bricks that were produced incorporating the agro waste were observed to be cost effective, durable, lightweight and have low thermal conductivity and environmental friendly. Let us look at agro bricks from date palms.

Date palm is one of the high growing varieties Its mesh fibers also called trunk fibers or surface fibers, leaves, bunches, ratchets and petioles are some attractive date palm fibers that have been investigated as construction and building materials. Date palm fibers can be used in concrete and mortar to improve their properties and can be utilized to make bricks. An increase in fiber content beyond a certain limit results in a decrease in compressive strength and tensile strength. It has been proven that palm date fibres could be classified amongst the best construction materials in terms of their thermal insulation properties. Let us have a look at rice husk in agro bricks.

Rice is the main chain food of Asia and part of the Pacific Overseas. Over 90% of the world's rice is produced and consumed in the Asia Pacific region. Rice husk is an abundantly available waste material in all rice producing countries and it contains about 30 to 50% of organic carbon. Using rice husk to produce brick is an effective way of reducing agricultural waste and reduces the embodied energy of the material. Increasing percentage of rice husk beyond a certain limit decreases the compressive strength with high porosity resulting in low dry density.

What if we use rice husk ash? Rice husk ash is one of the ingredients that is often used as an environmentally friendly material. Rice husk ash is the product of the incineration of rice husk. The characteristics of the ash are dependent on number one composition of the rice husk, number two burning temperature and number three burning time. The results of the study indicate that the higher the percentage of rice husk ash, the higher the water absorption capacity. The increase in the percentage of rice husk ash causes a decrease in the compressive strength of the bricks.

And we will see fabric. This has something to do with the fabrics and textiles. So huge amounts of cotton and textile ash waste are disposed off by countries all over the world. The majority of cotton waste and textile ash waste is expelled in such a way as to cause serious environmental problems. Cotton and textile ash waste can be used to produce a composite building material. Cotton and textile ash waste bricks are lightweight.

The cotton and textile ash waste bricks fulfill compressive and flexural strength requirements. The cotton and textile ash waste bricks are superior to the concrete bricks for insulation. And using cotton and textile ash waste bricks with lower thermal conductivity coefficients will prevent energy loss from buildings. So, conceptually what does innovative building materials offer by integration in design? We can have high performance facades that are efficient building envelopes can enhance energy performance and indoor comfort. So, we can have innovating building materials not only in isolation, but we can look at these as part of design components.

Hence, we can have high performance facade, we can have green roofs and living walls. So, nature integrated designs for biodiversity, insulation and reduction of urban heat island, UHI. All of these instead of doing it with the conventional building materials, we can use innovative building materials and create innovative design components. Smart insulation solution. Innovative thermal materials for improved energy efficiency in various climates depending on the climate zone.

So, there is a need for innovative building materials in order to go sustainable. In order to be energy efficient, in order to ensure that we do not deplete the natural resources. These are also very much essential to create energy efficient indoors so that our dependence on energy intensive contraptions gets reduced. Also, when we use innovative building materials with raw materials that are from recycled products or waste products, we also reduce the load on non-renewable energy sources or non-renewable natural sources to make the building material. Besides incorporating the waste in the building also is very friendly to the environment.

If we are able to combine these innovative building materials with innovative building

components such as high performance facade, green roof and living walls, smart insulation solutions, we can create much more sustainable, environment friendly, energy efficient buildings and on a long run this is where the future lies. We cannot afford to keep on tapping the natural resources for buildings considering that almost 38 to 40 percent of the total energy globally is consumed by buildings. We must attempt to reduce the embodied energy as well as the operational energy. So, use of alternate materials or innovative building materials alone is not sufficient, but the performance of the materials is also equally important. So, with this thought I will close today's session on innovative building materials and introduction.

In the forthcoming classes, we will have a look at some of the innovative building materials before we move on to the next segment. So, with this we will close the class. Thank you.