Course Name: Building Materials as a Cornerstone to Sustainability

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

Week: 12

Lecture 04

Concluding Lecture

Dear students, we come to the end of this course and today's class will be more of a recap and conclusion. Today we will see what all we have learnt in all these weeks. High-carbon materials, low-carbon materials, the need for alternate building materials and advanced building materials, smart building materials. When a material is carbon neutral, it indicates that the quantity of carbon dioxide it releases into the atmosphere is equal to the amount it takes out. A product is considered carbon negative if it absorbs more carbon dioxide than it emits. Utilizing building materials and technologies that effectively remove carbon dioxide from the atmosphere can reduce the building sector's carbon emissions and is known as a carbon-negative building system.

This can be accomplished by utilizing a mix of these. Renewable energy sources, energy conserving design, Technology for capturing carbon The value of carbon-neutral construction materials is now imperative to prevent the rise in global temperatures. If not, the effects of climate change will have to be felt more severely on the planet. This is where switching to construction materials that are carbon negative becomes significant.

In addition to being sustainable, they provide significant financial benefits. For example, utilizing energy efficient engineering and renewable power sources may lead to cheaper energy costs for builders and tenants. Even more astonishingly but surprisingly easily, current carbon negative building materials can produce carbon credits through their capacity to sequester carbon. So, what are carbon credits? Units of carbon credits are obtained by the removal or reduction of carbon from the atmosphere. One ton of carbon avoided or eliminated is represented by each credit.

By producing carbon credits, it is possible to sell the credits for money. It becomes important to identify building materials that have the lowest carbon footprint to receive the most credits. In actuality, it relies on a variety of factors, including the raw materials utilized, energy consumption, technology, and method of processing the resource or product. Recall what we studied in the embodied carbon. Because it is inexpensive and simple to produce, concrete is a popular building material worldwide.

However, that comes at the expense of 7% of global carbon emissions and the health of the planet. What are high carbon material, especially concrete? Concrete accounts for more than 7% of yearly global anthropogenic carbon dioxide emissions and is the second most utilized material worldwide after water. The majority of this concrete is used in the built environment which includes infrastructure, buildings and landscapes. It is accountable for more than twice the emissions produced by the aviation sector. By planning our constructions to make better use of each cubic unit of concrete, we can cut demand and emissions by 22%.

The most effective technique to lower concrete's carbon footprint is to use less cement. Aggregate and binder are the ingredients of concrete. More than 90% of the emissions from concrete are caused by the binder. Klimker, which is produced by heating limestone and clay to 1450 degrees Celsius, which makes up 91.4% of cement's material component, is the source of about 95% of the material's emission.

Three quarters of the emissions, approximately 35% from concrete comes from energy used to heat the kilns. Large volumes of carbon dioxide are released during the calcination process, accounting for 53% of the emissions from concrete. The industry must reduce its clinker impact in order to decarbonize. The amount of cement used in cement and concrete can be changed to achieve this. Reducing the impact of clinker is key to decarbonizing the sector.

There is yet another high-carbon material, which is steel. Steel product is responsible for about 12% of all carbon dioxide emissions in India. Ore, a raw primary material, and scrap steel, a recycled commodity, are combined to make steel. Primary steel is made by processing ore in a furnace at 1300 degrees Celsius. CO_2 emissions due to crude steel production are approximately 2.

55 tons of carbon dioxide per ton of crude steel in India. Primary steel can have an embodied carbon footprint that is up to five times greater than high recycled content steel. Here you can see India consumes 6.65% of steel, and you can see that the construction sector consumes 43% of the total steel. Recycling steel.

Secondary steel is made using electric arc furnace to melt existing steel scrap and recycle it into new steel. Two advantages of secondary steel related to energy use and emissions are, first is much less energy is required per unit steel and since EAFs are powered fully by electricity, The process can be completed using 100% renewable energy. Primary steel can have an embodied carbon footprint that is up to 5 times greater than high-recycled steel. Now strategies for reducing carbon emissions are like this. India has to switch from coal-based steel production to cleaner technologies.

Otherwise, the sector's carbon dioxide emissions will also double from the current levels. This will hinder the emission target set by India at COP26 in Glasgow in 2021. The projection is thus. Today, India has a coal-based production and steel production of 92%. And that is causing 114 megatons.

In 2030, India must slow down and step down its steel production from coal to 70%. And in 2050, it should step down to 29%. And then by 2070, India will not be coal dependent for its steel production. Now let us look at low-carbon materials.

First is straw bale. In addition to storing carbon in the soil, straw also naturally sequesters carbon in the grain stock. The type of straw, its growth conditions, harvesting techniques, and other factors all affect how much carbon is sequestered. When straw is used as a raw material, it is entirely the waste of another industry, which is the agriculture industry, and is frequently burned, which pollutes the air and releases carbon back into the sky. By using straw bale, we actually sequester that carbon. Straw bale has several advantages.

It has environmental advantage. So, using straw bales instead of wood in single family homes can reduce the need to clear old growth forests for lumber, protecting ecosystems vital to wildlife habitat, air quality and soil stability. It is durable when constructed and maintained correctly. Straw bales can last for a minimum of a century. For instance, in the late 1800s, homesteaders on the Great Plains began constructing using bales, and many of these buildings still survive today.

They are very economical and less expensive. They are equivalent to other thick walled construction methods. They are fire resistant too. So a straw bale wall assembly coated in lime plaster has undergone testing to obtain a 2-hour fire rating. Bamboo is another low-carbon variety.

Although there are over 1,600 varieties of bamboo and a wide range in the amounts of carbon sequestered by each species, bamboo forests perform comparably to other types of timber forests in terms of carbon sequestration. More so, bamboo, the species that is primarily utilized to make building materials, has a carbon sequestration capacity of roughly 102 to 289 tons. Bamboo's tensile strength is quite well known. It is a carbon-smart substitute for steel rebar or steel structural elements because, according to some research, its fibers run axially or along the length of the pole, giving it a stronger tensile strength than steel.

Bamboo is very flexible. It is strong because of its tissue structure just like wood. Nonetheless, bamboo's fibers are many times longer than those of wood, and practically all of them extend the whole length. the whole length of the culm, enabling it to bend without breaking or deforming in adverse weather conditions like strong winds and earthquakes. As a result, properly constructed engineered bamboo structural components, including bamboo nail laminated timber systems, can be used as a carbon sink in areas that are vulnerable to earthquakes.

Bamboo grows very quickly. It grows three times faster than most other tree species and yields 20 times more fiber than trees, making it one of the fastest-growing plants in the world. A type of bamboo known as timber moso can grow two feet a day and reach heights of 80 feet in just two months. This allows for shorter crop rotation cycles and the sustainable harvesting of more product without the need for replanting. Besides, bamboo resists flames. Bamboo poles can withstand temperatures of up to 400 degrees Celsius because of their naturally high silica content and insect treatment with boric acid, which is frequently used as a fire retardant.

Typically engineered bamboo items are bonded using a resin, which makes them extremely fire-resistant as well. So, in this course, we have seen vernacular building materials that are low-carbon materials. We have seen mud, stone, thatch, and bamboo. Since they are low carbon, why can't we continue using these materials? We simply can't because the type of buildings required today are very different from the type of buildings that were built using the vernacular building materials. Today we need large span structures, big office buildings and so on which is not prevalent during older times.

Hence, we need to look at fly ash as an alternative building material. So, what are the alternate building materials? Alternate building materials are nothing but materials that use vernacular building materials in conjunction with the prevalent contemporary building materials such as brick, steel, and so on, concrete. And by doing so, we lower the embodied carbon of the contemporary prevalent building materials such as brick, concrete, steel, glass, etc. So, what are the alternate building materials we have studied? we have studied use of fly ash, furnace slag, cross laminated timber and construction demolition waste as alternate building materials. Then further what happens is we need to have building materials that perform better, which perform differently, and at the same time they are low carbon.

We have classified those materials as innovative building materials. Under these, we studied so many materials like bioluminescent paints, milk paints, etc. Then there is a need for advanced building materials that are carbon sensitive, which means they are not high in carbon, and they have certain very unique properties along with being sensitive to the climate and to greenhouse gas emissions. We saw fab ash, which is made out of fabric, light-emitting concrete, and fiber-reinforced concrete. So, light-emitting concrete is a response to a different need.

Which means you need to have light in areas that are extremely dark. But the intensity need not be that high. Then we saw mycelium composite bricks, geopolymer concrete, living bricks, etc. Then one very important upcoming building material classification, which is smart materials. We had a look at many smart materials, such as smart windows, photochromics, thermochromics, electrochromics, etc.

Now, in vernacular buildings, when we saw vernacular buildings, alternate building materials, innovative building materials, advanced building materials, etc., we were able to give good building examples. Slowly, as we came towards advanced building materials, the applications were what we studied more than the buildings themselves built using advanced building materials. Similar with smart building materials, we saw the concept of these building materials and how we could likely use them. But we were not able to see many case studies.

The reason is that these are all upcoming materials. These are materials that have a lot of scope. The idea of this course is to bring it out to you that there is a lot of scope of use for these building materials. However, a lot of research is needed on applying these building materials in architecture because more research for application is needed. That is where you all can pitch in as researchers and experiment with the application of innovative building materials and smart building materials in architecture.

So, you have two fold responsibility. One is to do a lot of research and bring out the application of these materials in architecture, and the second is to have propaganda to apply these materials in architecture. So, in this course, I have tried to tell you that there are these various types of building materials that are non-conventional. These are not building materials that we use normally. Some of these materials are carbon negative, some of these materials are carbon neutral, and in order to meet the demands of the country, which says that we will lower our carbon emissions.

We will go carbon neutral by 2070. It is important that we as architects and designers know about these building materials so that we create awareness and, in the future,, we are able to apply these materials to buildings and create a carbon-neutral world. With this, I conclude this course on building materials as a cornerstone to sustainability. I wish you all the best and I wish you apply whatever you have learnt here in this course into the architecture, in the designs that you do and in the architecture that you do. Thank you.