Course Name: Building Materials as a Cornerstone to Sustainability

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Week: 08

Lecture 02

Carbon Sequestration

Hello everyone. In the last class, we saw an introduction of advanced building materials. Time and again we have been talking of carbon sequestration by various building materials. So, I thought this would be the right time for me to take a class on carbon sequestration by building materials exclusively for a small understanding about what this word goes on meaning. So, today we will explore this intriguing topic and an upcoming topic, carbon sequestration through building materials. As we delve into sustainable construction practices, we will discuss how our built environment can play a crucial role in mitigating climate change.

Carbon sequestration is the process of capturing and storing carbon dioxide to prevent its release into the atmosphere. So, today we will focus on how building materials contribute to this important process By understanding the significance of carbon sequestration, we can appreciate the impact of sustainable construction on mitigating climate change. So, carbon sequestration through building materials involves the use of construction materials that capture and store carbon dioxide from the atmosphere, helping to mitigate the impact of greenhouse gas emissions on climate change. The goal is to create a more sustainable and environmentally friendly construction industry.

is a small difference between carbon sequestration versus carbon storage. The active process of extracting carbon from the atmosphere in the form of carbon dioxide and converting it into building material is known as carbon sequestration. Whereas carbon storage describes the building material that, over time, retains carbon as part of its inherent self. So, if we look at carbon capture, during photosynthesis plants capture gaseous carbon from the atmosphere. That carbon is stored in plants themselves as well as in the soil.

So, plant-based building materials prevent this stored carbon from returning directly to the atmosphere, providing meaningful storage for the duration of the building's lifespan, and that is called total captured carbon. Now, let us look at the carbon footprint of the construction industry. The construction industry has a significant carbon footprint primarily due to the energy-intensive processes, material production, transportation, and construction activities involved in building infrastructure. The materials and processes involved in construction can leave a considerable carbon footprint. This emphasizes the urgency to adopt sustainable architecture alternatives in the construction sector to combat climate change.

Therefore, the built environment sector has a vital role to play in responding to the climate emergency, and addressing upfront carbon is a crucial and urgent focus. Towards the middle of the century, as the world's population approaches say 10 billion, the global building stock is expected to double in size. Carbon emissions released before the built asset is used, which is referred to as upfront carbon, will be responsible for half of the entire carbon footprint of the new construction between now and 2050. This can potentially threaten to consume a large part of our remaining carbon budget. As we already know, 39% of carbon emissions the building and construction industry is purely responsible for.

This is made up of 28% operational efficiency and 11% in embodied. In building and construction activities, they consume a large amount of carbon, out of which the building material and construction alone consume 11 percent of energy. So, this becomes very important for us to assess carbon sequestration by building materials. If we look at the role of building materials in carbon sequestration, some building materials have the ability to absorb and capture carbon dioxide during their production or overall their lifespan. This process involves using materials that naturally contain high levels of carbon or are derived from sources that have absorbed carbon dioxide during their growth.

The mechanisms in carbon sequestration by building materials can be seen like this. When classifying carbon-storing building materials, two processes for sequestering carbon are found. Cementitious carbonation and photosynthesis in plants. The process through which biobased materials, including harvested wood products, sequester carbon dioxide is known as photosynthesis. During a plant's growth, carbon dioxide is converted into biomass, which is then processed into a construction material.

Carbonation is the second mechanism involved in sequestering carbon. The process of carbon absorption in cementitious material, known as carbonation, is defined as the reaction between atmospheric carbon dioxide and hydration products to produce calcium carbonate. Let us look at harvested wood products. Harvested wood products refer to wood based materials and products which are derived from forests that have been sustainably managed and harvested for timber. These products play a role in both carbon sequestration and the broader sustainability of the forestry industry.

So, when trees are sustainably harvested, wood continues to store carbon in the thousands of products we use every day, from paper products to lumber to energy generation. Trees then regrow; repeat the cycle. When people use wood-based products in place of fossil fuel-intensive products like steel, concrete, or plastic, there is a permanent benefit to our atmospheric home. For example, buildings framed in wood Release 26% less carbon than steel framed buildings and 31% less than concrete framed buildings. Similarly, when people install wood floors instead of vinyl flooring, carbon emission can be much as 20 times lower.

Let us take another example of hempcrete. Hemp's rapid growth, dense canopy, and ability to grow in nutrient-poor soils make the plant more efficient than trees at sequestering carbon. In construction, hemp is combined with lime based binder to create hempcrete which we have already seen. This is a carbon-negative biodecomposite that can sequester even up to 100 kilograms of carbon dioxide per square meter. Hempcrete is not only healthy and non-toxic, but it is also resistant to fire, pets, pests, mold, and mildew.

Specific benefits of hempcrete are that it sequesters carbon. It is superior thermal resistance. It is energy efficient. It is naturally non-toxic. It gives improved indoor air quality.

Although hempcrete can be cast like concrete, it isn't a substitute. The lightweight material lacks the structural integrity needed for load bearing. It can, however, be used in place of traditional drywall, insulation, and siding, where its high thermal mass offers energy-saving benefits by reducing the need for heating and cooling. Let us look at the, which is bamboo. With the growing trends in environmental awareness, bamboo has cropped up as a green alternative to other woody raw materials.

Bamboo has been one of the oldest and most versatile building materials, with many applications in the field of construction, particularly in developing countries. Lauded in environmental circles for its quick growth and the fact that it can be harvested without harming the plant, bamboo seems a perfect way for promoting green economy. As wood becomes more scarce, bamboo construction will hold more and more value when the benefits of its use have been known for millennia. Bamboo being extremely lightweight thus building with bamboo can be accomplished faster with simple tools than building with other materials. As such, bamboo constructions are easy to build and resilient to wind and even earthquake forces.

Thus, the major qualities that make bamboo an ideal material for green buildings include strength and durability. The third example, which we saw a couple of classes before, is mycelium. Now mycelium are thin root-like fibers from the fungal that run underneath the ground. When dried, it can be used as a super strong water, mold, and fire-resistant building material that can be grown into specific forms, thus reducing the processing requirements. By using mycelium, there is a huge reduction in the reliance on fossil fuels.

the embodied energy required for fabrication and a massive reduction in the building waste that is left at the end of the product's life as the mycelium product is 100 percent biodegradable and can be used as soil. Although in the construction industry, the use of mycelium is still experimental. Its development indicates a desire within the industry to create and foster a more cradle-to-cradle attitude towards building, with people aiming to reduce the embodied energy of the products while also aiming for as little net waste as possible at the end of their lives. In the future, this product holds the possibility of being very integral in the construction industry, being used for things like insulation in place of traditional masonry. There are many other materials that are used for carbon sequestration.

straw is used. So, straw bale construction and use of agro-based construction have been very prevalent because straw stores 60 times more carbon than is used to grow. Now, the transportation to building sites within the region also makes embodied energy through transportation very less. Apart from traditional straw bale construction, which uses the bale itself, there are many products that utilize straw, such as compressed straw, agriboard, compressed straw board, straw sheet products, straw panelized systems, prefabricated straw bale wall panels, and light straw clay insulation in film. The straw bale is approximately 40 percent carbon by weight. With regenerative agricultural practices that aim to regenerate topsoil and increase biodiversity, the amount of carbon sequestered in straw can be more than doubled.

Here you can see the comparison of straw without sequestration and with sequestration. And you can see how straw is one of the most sequestered carbon sequestered materials compared to engineered timber, brick-clad timber, rendered masonry, and brick masonry. Just a small, brief case study. The use of straw in construction, particularly in the form of straw bales, makes it a very sustainable material. But what if the built material could be a solution to the climate crisis rather than part of the problem? What if buildings could act like trees, capture carbon, purify the air, and regenerate the environment? So, there has been a theoretical attempt where the use, the concept for building and the urban context to absorb carbon at an unprecedented rate has been proposed.

So, SOM, Skidmore, Owings and Merrill had developed the first step towards achieving this goal on a broad scale with a design for a high-rise building that can be built today. The nature-based strategies behind the high-rise can be applied to buildings of all sizes and types. Each building type uses carbon sequestering materials like timber and bioconcrete to reduce embodied carbon emissions and advanced technologies such as energy-generating solar glass to lower operational carbon emissions. So, are we saying that we have to use straw bale and bamboo as advanced building materials? No. What we are trying to say is in the forthcoming classes we will see advanced building materials which will tap the benefit of all these materials we saw in its environmental advantage and yet they would be relevant to the context of modern architecture.

That is what we will call as advanced building materials and that is the benefit of using advanced building materials. So, with this introduction of carbon sequestration in buildings, I will stop this class, and we will meet in the forthcoming classes with the advanced building materials also trying to reduce carbon dioxide emissions.