**Course Name: Building Materials as a Cornerstone to Sustainability**

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**Lecture 04**

Hempcrete

Hello everyone. So, last class we saw how construction demolition waste must be handled by segregation as well as by reuse into aggregates. Today we will have a look at another alternate building material which is hempcrete and papercrete. Now, a biocomposite material called hempcrete - This is sometimes known as hemp lime and is composed of puzolans, hemp shred and lime. It is employed in insulation and building. Amongst its others names, it is marketed as hempcrete, canosmos and also isohemp.

Compared to traditional lime combination, hemcrete is easier to work with and it acts as an insulator and moisture controller. Since it is not as brittle as concrete, expansion joints are not necessary. Combining thermal mass with insulation makes the material lightweight and appropriate for a wide range of conditions. It is a biocomposite material and therefore, it has natural fibers and natural particles in it.

And this matrix is derived from renewable resources which are also called as biopolymers. So, today we will look at a material at an alternate material which is a combination of a natural material along with conventional building material. How is hempcrete made? Hempcrete is made by mixing hemp shreds with a binder that has a lime base. Most of the lime based binder is composed of hydraulic lime either naturally occurring or hydrated. Hydrated lime which is made entirely of limestone solidifies when carbon dioxide is absorbed during the carbonation process.

When working with time constraints, hydraulic binders are used in conjunction with regular hydrated lime because hempcrete has a quicker set time than standard limes, approximately 2 weeks to a month to develop acceptable strength. For example, a little amount of cement and or pozzolonic binder is used to shorten the time required for setting. The combination created during the entire process solidifies into a durable lightweight product. So, hempcrete is termed as a strong yet lightweight and breathable product. It is an energy efficient product.

It has incredible insulation because it has hemp fiber embedded in it. It is made of a natural material hence it is non-toxic. It lasts long time. It is flame resistant, water resistant and pest resistant. It is made out of a combination of hemp plus lime plus water and is deemed to be a carbon negative material.

The production of hempcrete usually takes a few phases. Hemp is stored in a room and lime is kept in silos at the manufacturing plant. Following the addition of water to the hemp and lime combination, a machine shapes the material into blocks which are then moved along a conveyor belt to cure. After that, the blocks are separated into batches of 2 cubic meters and placed onto pallets for delivery to a building site. There they are fastened with polypropylene straps and wrapped in polyethylene packaging film.

Let us look at the applications of hempcrete. Hempcrete has been used to construct non-weight bearing insulating infill walls in France since the early 1990s and more recently in Canada. It is supported by the frame and lacks the requisite strength to be used as a foundation. Additionally, hempcrete was used in the renovation of historic stone and lime based buildings. France continues to utilize a lot of hempcrete and their need for it is growing every year.

Canada has followed France's lead in the field of organic building technology and hempcrete is currently a thriving invention in Ontario and Quebec. There are two primary building processes used in the use of hempcrete. Using forms, the first approach involves spraying or casting hempcrete directly onto the construction site. Like masonry construction, the second technique entails stacking prefabricated blocks that are transported to the project site. If we talk of the durability of the material, as mentioned previously, hempcrete concrete is thought to be resistant to mold and insects due to the lime's alkalinity.

Despite this, a lot of microorganisms can survive in an alkaline environment. Despite constant efforts to keep them moist, the bacteria frequently dried out and died over the 7-month testing period following inoculation. Two months after the first immunization, the bacteria died. None of the concrete showed any symptoms of degradation even after a large-scale inoculation of bacteria and multiple inoculations in response to population decrease. This is a result of either an unsuitable environment or a lack of readily available nutrients to support growth.

However, in India if hempcrete is to be used it can be used in places which are very dry and therefore would have no chance of algal and bacteria growth. Let us now look at the thermal properties. Compared to concrete which has an R value of 0.1 to 0.2 per square inch, hempcrete has an R value of 2.

4 to 4.8 per square inch. Hempcrete can also attain a greater R value than cotton and fiberglass bats whose respective R values are only 3.8 and 3.7 at best. Several factors such as the type of binder used, moisture concentration and density affects the thermal performance of concrete.

One of the most important aspects of study of a material for this course is its environmental impact. So, let us look at its environmental impact in detail. Let us look at its carbon storage capacity. Hempcrete is considered a carbon storing material as hemp plants absorb carbon dioxide during growth and this carbon is retained in the material throughout its life cycle. Hence, it acts as a package to store carbon.

When we look at its carbon uptake over the net life cycle of hempcrete, it is estimated to capture between 1.6 and minus 79 kg carbon dioxide equivalent per meter square with an increase in carbonate content as the block ages. Let us look at its binder impact. The environmental impact of hempcrete is primarily influenced by the manufacturing of the lime binder which involves calcination at high temperatures contributing to initial emissions. The carbonation process during hempcrete's life cycle can recover 18.

5 to 38.4% of the initial emissions produced during the manufacturing of binders. In the transportation phase, the transportation of materials including the binder contributes to the embodied energy footprint involving the consumption of diesel. Diesel consumption in the operation of machinery must also be considered and further this contributes to environmental footprint. Abiotic depletion, the production of electricity often involving lead and cadmium consumption contributes to abiotic depletion particularly in the company's production of hempcrete blocks. When we look at insulation, hempcrete provides excellent thermal and acoustic insulation creating a comfortable indoor environment.

There are some advantages of using hempcrete. Hempcrete is a non-toxic construction material. Since hempcrete requires fewer pesticides and herbicides than other building materials, less harm is done to the environment from the use of chemicals on the fields. As the building cools, heat is gradually released from the thermal mass of the hempcrete wall. The only construction material that can take carbon from the air is hemp.

So when you open a window all of your heat won't escape immediately. Other insulating options including fiberglass have a high carbon footprint. There are certain limitations of this hempcrete. A lot of fertilizer must be used on the crop which could harm our ecosystem. There aren't many architects or builders who have knowledge about this product.

Besides, hempcrete can increase a home's total cost by 8 to 12% upfront. It's not always as easily available as conventional building materials like concrete or steel. Now let us look at papercrete as a material. Now how is papercrete made? Portland cement and white lime or sand is combined to create papercrete along with the paper slurry. This becomes a composite or a hybrid material.

Paper trash of any kind may be disposed of appropriately. Just add it to a basin of water and let it soak for a full day. Included waste paper in a waste basin. After that use a mixer to stir the slurry for 10 minutes.

Then drain any extra water. A ratio of 1 is to 0.5 is to 4 is advised for Portland cement, white lime and paper sludge. As necessary add water to the mixture to make it workable. This is not suitable for projects involving structures or structural members. It has been discovered that walls that are not used for support offer superior sound absorption and lower thermal conductivity.

Let us look at the manufacture. Cardboard, newspapers, magazines, books, junk mails are commonly used and may be added dry or pre-soaked depending on the mixing equipment being used. Aggregate, either coarse or fine, typically sand is used depending on the required strength. Cement or clay is used to bind the mix together providing strength and rigidity. Water is used in appropriate proportions. The mixing process uses a device with a sharp blade to chop the waste paper and combine it with water and the binding agent which is cement or clay.

Many individuals create their own machinery for efficient mixing. Once successfully combined, the slurry is formed and the resultant slurry can be pumped into slip forms or added to molds. The molding blocks can be leveled off and smooth the mixture within the molds to form building blocks. The blocks must be kept in the mould for approximately 30 minutes to allow excess water to drain. These blocks must be cured for 3 to 4 days and this curing process is crucial for the blocks to gain strength and stability.

Let us look at the properties of papercrete. Papercrete has good insulation properties and they have superior qualities to work as thermal insulants. The material is insulated against heat transfer by the air pockets the paper fibers form. These are extremely lightweight products as compared to conventional concrete. So, papercrete is substantially lighter and it is simpler to handle, simpler to move and simpler to operate when it has this feature throughout the building.

It is a low density material as a result of its composition and this can be helpful in

earthquake zones and is good for lowering the overall weight of these structures. Papercrete is fire resistant in the sense it has intrinsic fire resistant qualities although not being able to be completely fire proof. The material gains its fire resistance from the cement component of the paper crate. Paper kit can be easily worked with and is pliable. It can be utilized for a variety of building purposes and molded into different shapes.

It's a very sustainable material. So, papercrete is an environmentally friendly alternative because it contains recycled paper in its combination. It reduces the environmental impact of paper disposal by making use of waste paper. Papercrete has good insulation properties. Because its composition also offers good sound absorption. It has the potential to effectively lessen noise transmission inside a building.

It is resistant to mold. Compared to conventional building materials, it has better resistance. Portland cement's alkalinity prevents the growth of mold and fungi. Because papercrete is permeable to vaporized moisture, buildings can breathe and this can help control the amount of humidity in the building. Papercrete is customizable as its composition can be changed to obtain various qualities. Strength and durable properties for instance can be altered by including more fibres or chemicals.

It also has load bearing capacity. Paper creates comparatively low compressive strength limits. Its usage in some structural applications is as a load bearing material. There are certain pros and cons of using this material. The raw material needed to make papercrete is abundant and inexpensive. And that is a huge advantage we have because there is no dearth of raw materials.

You don't need any specialist equipment. To produce the mix and form blocks. They can be easily done in your own way. Papercrete has excellent heat and sound insulating properties. It is very lightweight and it is far lighter than concrete.

It has high compressive strength. Fasteners such as screws are generally able to be used without the risk of cracking the structures. The material is very malleable and can easily be formed to make blocks, sheets and panels. Paper clay does not catch fire that easily and when it does, it tends to smolder for hours together when compared to say wood. The spread of papercrete fires tends to be confined to a smaller area and less damaging. Adding more cement and mineral material increases its fire resistance.

Let us look at its limitations. As expected from a paper based material, papercrete offers poor moisture resistance. If exposed to water for prolonged periods, it can begin to break down. It can easily act as a wick to extract moisture from the ground across the building structure. Mould can develop if the material remains warm and moist at the same time. It

can easily expand and contract leading to cracks and buckling.

It offers poor tensile strength. Over doors and windows additional and more traditional support is often needed in the form of wood or concrete. Let us compare it with respect to other building materials. As compared to concrete or brick, it is a lightweight and insulating material whereas concrete is a dense and poor insulating material. Brick is a heavy and moderate insulating material. Papercrete requires less energy. A high carbon footprint is a concrete material.

Brick again is a high energy for production material. Papercrete is eco-friendly and sustainable whereas concrete is extremely carbon intensive and environmentally taxing. Brick again is an energy intensive production. These two pictures you see here are made with papercrete on an experimental basis. So, these are hempcrete and papercrete buildings. So, today we saw in this class- how material which we take for granted which is hempcrete and papercrete which is abundantly available.

Paper is abundantly available. Hemp is also an organic material. We can have alternate building materials made with these organic products and these are all environmentally friendly and good enough for many purposes. Let us try to incorporate these materials in architecture and promote a healthy planet. With this, we stop this class and we will take yet another alternative material in the coming class. Thank you.