Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 03

Bamboo

Hello everyone. So we had already seen about thatch as a building material. In this class we will look at bamboo as a building material. How this very versatile and a material that can be used in so many ways. It was used predominantly in traditional Indian architecture. It is a vernacular building material.

Let us look at all its strengths, weaknesses and how we can incorporate it in modern architecture. So, in this class we will see what are its characteristics, what are its properties and how bamboo as a building material can be used, some of its construction details, the advantages and limitations of using bamboo and whole lot of examples. Bamboo is one of the oldest traditional building materials used by mankind. They are the largest members of the grass family and are the fastest growing in the world.

Bamboos are of notable economic and cultural significance in South Asia, Southeast Asia and East Asia being used for building materials as a food source and also as a versatile raw product. Bamboo has a higher compressive strength than wood, brick or concrete and a tensile strength that rivals steel. This is a substitute building material which is renewable, environmentally friendly and widely available as the wood resources are diminishing and restrictions are imposed on felling of natural forests. Due to its rapid growth, its adaptability to most climatic conditions and due its properties, bamboo emerges as a very suitable alternative. Now, bamboo is functional for various intentions at different stages.

When it is less than 30 days, it is fit for consumption. Between 6 and 9 months, it can be used for weaving baskets. Between 2 to 3 years, it can be used for making ply boards or lamination. 3 to 6 years, it can be used for construction works. Greater than 6 years, bamboo slowly lacks its strength up to say 12 years old.

So, the bamboo market is segmented into species, application and region. By species, the market is categorized into Mosso bamboo, Bambusa vulgaris and others. On the basis of application, it is categorized into gardening, furniture, construction, industrial, food and

other uses. Region wise, the market is analyzed across North America, Europe, Asia-Pacific and Lamier. Asia-Pacific dominated the Bamboo's market share in 2021, accounting for the highest share and is anticipated to maintain this trend during the forecast period. This is attributed to increase in cultivation of bamboos in the region. So, in the industrial you can see that when it comes to application you can see that the industrial use of bamboo is highest and after that the construction industry. The projected trend as well as the current trend shows that there is extensive use of bamboo in this industry. Let us now look at the characteristics of bamboo.

It is the fastest growing renewable natural building material. The material is easily available and is eco-friendly. Bamboo is a viable alternative to steel in many places. Concrete and masonry as an independent building material. It is cost effective and easy to work.

We also know about bamboo reinforced concrete. So it can be used as an alternative to steel. It can be easily bent giving desired shape and can provide joints to suit the construction. Its enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes. Locally available material to some areas, which tries to carry the local tradition and vernacular architecture of that place.

The plant improves the environment in many significant ways including acting as an atmospheric and soil purifier. It is hardy, light and flexible. Thus, it is a good substitute for wood. In the hilly and mountainous areas as well as river banks, it protects the slopes from erosion as an effective soil binder. Let us now look at the properties of bamboo.

So, we classify these as the properties of bamboo. Its tensile strength, its compressive strength, its elastic modulus, its anisotropic properties, its shrinkage, fire resistant properties. So, when we look at the tensile strength, bamboo can withstand great stress than it can be compressed. Bamboo possesses axially oriented very elastic vascular bundles with strong tensile fibers. These fibers have a tensile strength greater than that of steel.

However, this strength cannot be transferred through construction. Additionally, thinner tubes are better in this regard. Axial parallel elastic fibers with a tensile strength of up to 400 newtons per millimeter square are present inside the silicate outer skin. In contrast, exceptionally robust wood fibers have a stress resistance of up to 50 newtons per millimeter square. When it comes to the compressive strength, slimmer tubes have a greater compressive strength rating relative to their cross section than larger ones because larger tubes contain a small amount of the outer skin which is very tension resistant.

The slimmer tubes have superior material qualities. The compressive strength is influenced by the amount of lignin present in the culms, whereas tensile and buckling strength are determined by the high cellulose content which serves as the structural component of bamboo fibres. When it comes to its elastic modulus, As with tension, shear and bending strength, the buildup of extremely strong fibers in the tubes, walls, outer regions positively correlates with the elastic modulus. The quality of the bamboo increases with its elastic modulus. It is extremely flexible, making it an excellent building material in seismically active places.

When we look at the anisotropic materials, its qualities, anisotropic materials are materials that exhibit different properties in different direction. Bamboo is a material that is anisotropic. The properties of the transverse and longitudinal directions are entirely different. The transverse direction contains lignin which is fragile and brittle and the longitudinal route contains strong stiff cellulose fibers. When it comes to shrinkage, when bamboo dries out, it shrinks more than wood.

At the nodes, the canes may break apart. Bamboo shrinks to the wall thickness of 15-17% and a cross section of 10-16%. As a result, while using water as a building material, the appropriate precautions must be taken to avoid water loss. Let us now look at the fire resistance of bamboo. Because there is a lot of silicate acid present there is excellent fire resistance. When the water is within boiling it can withstand temperatures as high as 400 degree centigrade.

Let us now look at bamboo as a building material. Bamboo's high strength to weight ratio, ease of workability and availability makes it a highly adaptable material. Bamboo's poor natural durability necessitates chemical treatment. It can be utilized in a variety of ways for the roof structure such as manhole coverings, floorings, doors, windows, rafters and reapers.

Bamboo trusses are very popular. Bamboo strength is on par with that of saw and teak when it comes to trusses. To fix the roof a frame is constructed out of bamboo rafters, purlins etc. Bamboo roof skeletons are also very popular. It is made up of bamboo rafters or trusses that are covered with solid bamboo purlins that are fastened to the rafter using GI wire.

To cover the roof a mesh made of half baked bamboo is nailed to the purlins. here you can see the various bamboo trusses and bamboo strength is on par with that of sal and teak. So, that is why they are very popular when it comes to using bamboo as a truss. Bamboo roof skeleton - These are also very versatile and organic features or forms. These are made up of bamboo rafters or trusses that are covered with solid bamboo purlins that are fastened to the rafter using GI wire.

So, to cover the roof you need to make a mesh which is say of half baked bamboo and these are nailed to the purlins and you can get a number of hyperbolic structures too. Let us look at the use of bamboo for walling and sealing. Because bamboo is a very flexible material, it does not break as easily. It is a good choice for earthquake prone areas. If it does fall it can be simply re-erected with minimal effort and expense resulting in minimum loss of life and property.

Bamboo walls can be built in a variety of methods such as cutting the bamboo stem in half or nailing bamboo strips to one or both sides of the bamboo frame. Mud can be applied to both sides of split bamboo mats, which can also be weaved or attached to bamboo poles. For interior walling, bamboo strips are fastened to bamboo pillars or frames. For improved hygienic conditions and aesthetic appeal, the mud covering might be plastered with cement or lime. Here you can see how bamboo walls can be built in a variety of methods such as cutting the bamboo stem in half or nailing bamboo strip to one or both sides of the bamboo frame as can be seen here.

Then applying the mud on both sides of the bamboo. And for interior walling we can have bamboo strips that are fastened to bamboo pillars or frames. And for hygiene we can have mud covered or it can also be plastered with lime or cement. So, the easiest is woven bamboo wall. This can even be used for fences and the vertical half clumps these act a lot like insulation along with whole bamboo clumps.

So, the cavities in it act as insulation and the wattle and daub method again is a very popular method. Bamboo also finds its application in doors and windows. So bamboo doors they are very aesthetic because they have a natural appearance and unique slated composition which is visible on edges and frames. They have great stability and hardness and extremely sustainable building material with low emissions and which is carbon neutral. So, you can see the various scales in which bamboo is used for its for doors.

And let us look at bamboo flooring. Bamboo is a stylish flooring material that virtually instantaneously enhances the spaces charm. It has a unique look but resembles hardwood in both appearance and feel. Bamboo is a good material for customers who wish to live with a renewable resource or who prefer something unusual similar to cork flooring. Bamboo is most appropriate in modern environments but it can blend with practically any type of house and design. Let us now look at the advantages of bamboo.

Bamboo is a very environmentally friendly material. It is easily accessible to the poor. It is self-renewing resource to nature. So, every time you take down a bamboo, there is always a bamboo culm which is coming or we call as kid which comes next to it. It is

very fast growing, speedily grows, highly productive.

You do not have to do much. You need to plant a few bamboo and then automatically it reproduces and regenerates itself. It is a low cost material. It requires very less water also. It is a low cost material and is a sustainable and eco-friendly building material. Bamboo is an affordable and accessible building material.

It is sustainable because it is just a type of grass which can be grown easily. It is eco-friendly because it is 100% biodegradable. It is affordable because it can be cultivated en masse with very little water. Bamboo is versatile and adaptable to various building designs.

It has a good tensile strength. It has a higher tensile strength than steel because its fibers run axially. it comes to fire resistance it has the capability to resist fire to a very high extent and it can withstand temperature of up to 400 degree centigrade. This is due to the presence of high value of silicate acid and water. So, when boiling water is filled it can resist the temperature. Elasticity, bamboo is widely preferred in earthquake prone regions due to its elastic features.

The weight of bamboo is due to their very organic structure and therefore it is not at all heavy. So, it can be easily displaced or installed making it very easy for transportation and handling during construction unlike many other building materials like cement or asbestos. Also, bamboo does not pose any health hazard to people being a type of grass and organic material. So, these are the major advantages of bamboo.

Bamboo also has its own limitation. It requires a lot of preservation because it is shaped by nature. The durability of bamboo is questionable when left untreated because bamboo is subjected to fungal attacks and insects. Therefore, bamboo is viewed as temporary with expected life of about 5 years unless otherwise it is replaced or taken care of. Although many jointing techniques are available, their structural efficiency is low and hence jointing in bamboo needs to be strengthened.

There is lack of design guidance and codes. Bamboo is prone to catch fire very fast due to friction of cones during winds. So, in these two pictures you can see the jointing that is being done despite so much of advanced efforts in jointing still a lot of work needs to be done to strengthen it. And in this third picture you can see how bamboo can easily be joined by even tying it. So, there need not be a very complex method to join the bamboo cones. Let us now look at some of the case studies of bamboo structures.

The first we will look at is floating bamboo house by HNP architects. So, this is in

Vietnam and Vietnam is one of the hardest hit countries in the world by climate change. As forecast, 47% of the Mekong Delta area and 13% of the Red River Delta area will be submerged by the sea level rise of 1 meter, directly affecting somewhere from 20 to 30 million people. In this context, this floating bamboo house is believed to provide a useful alternative for millions of poor households because as soon as possible, It will create a stable and safe accommodation for the people and adapt to the worst scenario of responding to climate change. Floating bamboo house is a housing model for Vietnamese locals whose livelihoods are river based, especially those in the Mekong Delta.

It is a new type of three compartment house made of solid cored bamboo with a diameter of about three to four and a half centimeters and which is say three to six meters long. These are joined together simply with latches and ties. to create a structure like this. The house is covered outside and partitioned inside with light materials such as compressed weaved bamboo sheets, leaves, corrugated iron, bamboo screens, etc. The partition is entirely up to the designer, but it has to be lightweight.

And it has a large roof to collect rainwater and harness solar energy. The door systems that can open and close flexibly helps make the house sturdy enough in adverse weather events while creating a typical identity like flowers amidst floating waters. The floating bamboo house can remain floating on water thanks to its plastic drum system which is tied to the floor beneath. In the center of the house is freshwater storage tank and septic tanks. It has a square ground which is about 6 meters by 6 meters with two levels which can be extended to increase the area of use.

When the second floor panels are removed, the house becomes much more spacious, functioning as a communal house, a classroom or a library, a reminiscence of the wrong house. So, it is long lasting typical place of Vietnamese people which can be on the ground and which can function itself as a floating house when an adversity arises especially because Vietnam is prone to climate change more than any other country. The next one case study we will see is the wind and water bar. Now, this wind and water bar is designed to be surrounded by an artificial lake. It has a dome measuring 10 meter high and 15 meters in diameter and it is topped with an oculus of 1.

5 meters in diameter that ensures the release of hot air from the bar cooled by the adiabatic evaporation of the perimeter water. Now, the wind and water bar is an incredible venue designed by Vietnamese architect Vo Trong that is made entirely of bamboo bound together and covered in a local bush plant without the use of any nail. Surroundings in the middle of the lake, this is designed to be surrounded completely by water. So, you can see that this building has a lot of ties. So, the architect has used bamboo exhibits as a combination of cultural Vietnamese background and the

architectural education that he has got from Japan.

It is a lightweight flexible material. And he has used this prominently to construct the sturdy, environmentally friendly space and simultaneously offer an eye-catching facade that reflects its natural surroundings in the middle of the lake in Vietnam. It stands at 10 meters high and 15 meters wide. The venue offers an accommodating space for visitors that include natural light and air ventilation through the use of wind power, allowing hot air to naturally rise and escape through a circular opening in the ceiling. With 48 fabricated units of bound bamboo structures carefully pieced together, this architecture boasts an intricately assembled frame with an aesthetically pleasant pattern.

So, with this we come to an end of use of bamboo in architecture. And in this class we have seen how bamboo can be used in contemporary architecture to the extent that the designers have made us feel that bamboo was a irreplaceable material in the last two contemporary examples we saw. So, highly vernacular and traditional building material, but which is so versatile that it can be used in the modern context in whichever way possible either as reinforcement like how some of the Kerala houses have bamboo reinforced house or houses made completely out of bamboo. The last example being one where not even nails are used, but bamboos are just tied. So, such a versatile material is entirely in our hands to use. So, with this I end today's class and we will meet again in the next class with yet another vernacular building material. Thank you.