

Building Materials and Composites

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Lecture No. #10

Bamboo

So welcome everyone. We are in the last lecture of module 2. So we started with wood. In the previous lecture we tried to understand engineered wood. So these are all being used, readily available in the market and they are all acknowledged by our codes, standards. So all plywood what we discussed, MDF boards what we discussed have an ISI stamp. Wood also, particular types of wood have their stamps. They are recognized by Government of India. Across the country, if we move into the rural areas, we see most of the houses we use bamboo, particularly in this tropical climate, it is a grass. We have discussed bamboo also when we were doing the classification of trees. It was an exogenous tree sorry endogenous tree, it was endogenous plant.

It is a category of grass and it grows and at a particular rate on the upper side, on the longer side, vertical direction and every time it moves, there is an internode distance and then there is a node formation and then again a particular length, again a node formation and it grows longer and longer. This has been used traditionally for supporting roofs. It has been used as wall supports.

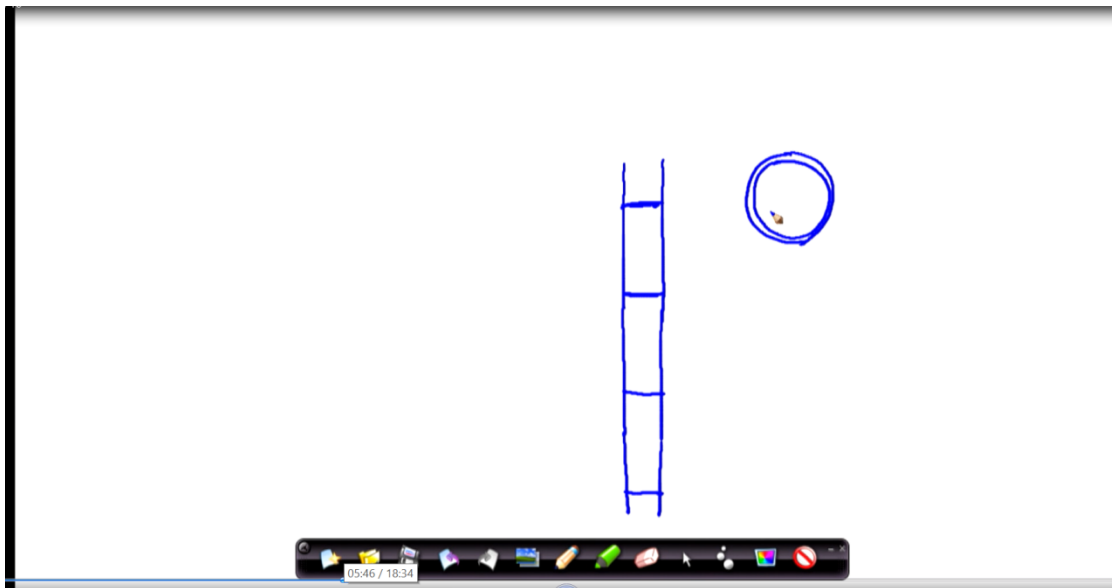
It is used as a support in scaffoldings of any urban scape, any urban construction. You can see use of bamboos as props, supports to hold the plywood in position when it is a roof casting, when it is a concrete casting. So structurally, strength wise it is very usable, people are confident in using it. But even then it takes a long process to enter into the code. Yes, as a structural member, it is now being included in NBC National Building Code 2016, SP 7 includes it. So we will go through its advantages, limitations and some applications.

In China, in Malaysia, in such tropical weather conditions it is being used for construction purposes. So it is a secondary member in our building industry. So it is a low cost temporary material and is used majorly as a supporting construction system. But recently it is being used, it is being explored, it is being researched and it is getting its popularity gaining its popularity.

Though the durability, lack of structural design data, lack of proper joineries has restricted its further use. So when Sbamboo member crosses one bamboo member, it is not cut. So there is no joinery as we had in case of wood. So there are certain limitations. One does not make the joint weak and at the same time it is temporary. it may not happen in the same position next time. So why to cut it?

If you cut it, what should be the way to cut it? So those things are now getting into the code and it is gradually becoming popular and getting into practice. So what does it have?

It has internodes transverse direction, which actually acts as stiffener. So at a regular interval, it is having a stiffener kind of thing, which actually gives it support. So if you see the bamboo like this it, will be inside here you cannot penetrate further. So this is closing this is connecting. So otherwise it is a hollow section, in section it is hollow. But at these points: these are like ridges.



So bamboo culm is this tubular structure consisting essentially of its nodes and internodes. That is called a bamboo culm. In the internodes the cells are axially oriented similar to wood fibre. You see the fibres are in the longitudinal direction and the nodes are preventing it in the transverse direction. The disposition of the nodes and the wall thickness that is the thickness of the bamboo are significant in imparting the strength to bamboo against bending and crushing. Hence it is suitable as a spanning material. It can be used for bamboo as a truss. Bamboo for roof holding, framework, tiled roof, bamboo can go as a continuous beam member in foundation and by splitting it you can make it usable for giving strength.

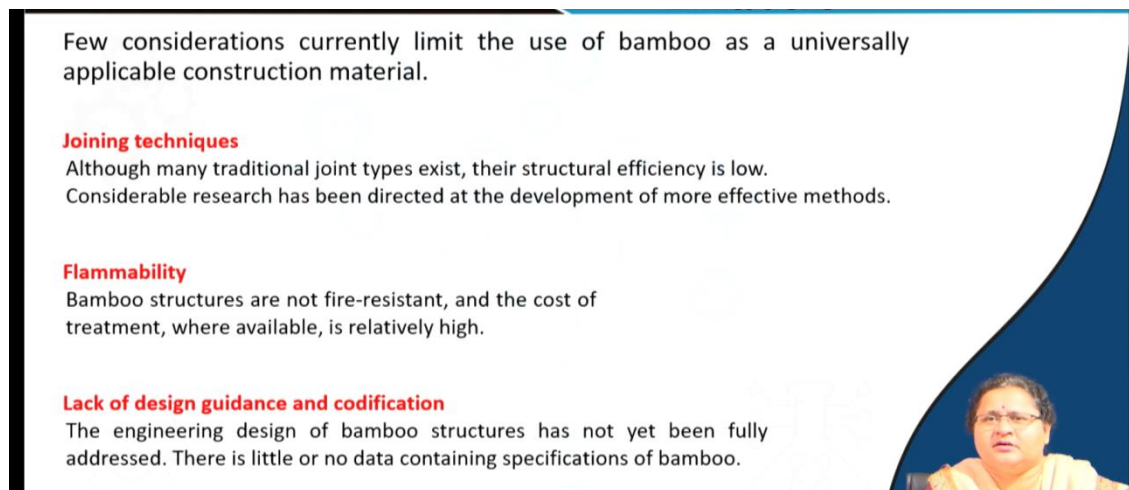
So bamboo splits half culms, you can split it in the longitudinal direction so it needs proper workmanship. So you can actually slice it into two halves, I will come to some picture. And you can slice it further to get slivers. Those are also quite rigid, quite strong and they can bend. You can make wall with it, the support system within a wall with it. These are called bamboo slivers.

So after knowing these terminologies, let us see what are the advantages of it. As I told you, it grows in the longer direction. It is a fast growing grass. It grows 30 centimeter that means one foot to one meter in one day, extremely strong, natural fiber. Obviously being natural, it

has all the disadvantages like wood that is it may be affected by termites. It can absorb water and you have to check those. It is at par with hard woods. And the strongest parts are those nodes where the transverse supports are there and it is so close, it gives it the entire strength and stability. A large number of species are found. And mostly as I told you, it is used for scaffolding, but bamboo is highly flexible too. You see this particular picture where the bamboo has grown in a trained way. So if you want to make a bamboo arch, you can actually make it by training it.

You can create such kind of arch just by giving it a way to grow in this direction and allow it to grow in this direction; after it gets matured you can cut it and use it for your purpose. So walls, arches can be made with help of trained bamboo. It is a shock absorber, particularly useful for our earthquake prone areas. And finally the most advantage is, it is a tropical grass, it grows much in number, light in weight. Hence it is cost effective. You see any kind of temporary structure which till date crops up is all made of bamboo. Any festival pandals, any fair kiosks you will see the extensive use of bamboo. As it is light in weight you can carry it for distances by human carts and they can be transported. You use it as props, for holding as scaffolding. So these are the major advantages of it.

Now let us come to the limitations. You can see the red bullet points: Joining techniques, flammability, lack of design guidance and codification. So traditional joints exist, but they are structurally not efficient and that is why they are not put into code because who takes the responsibility. So proper joining techniques are to be developed were to be developed which are now being developed or researched.



Few considerations currently limit the use of bamboo as a universally applicable construction material.

Joining techniques
Although many traditional joint types exist, their structural efficiency is low. Considerable research has been directed at the development of more effective methods.

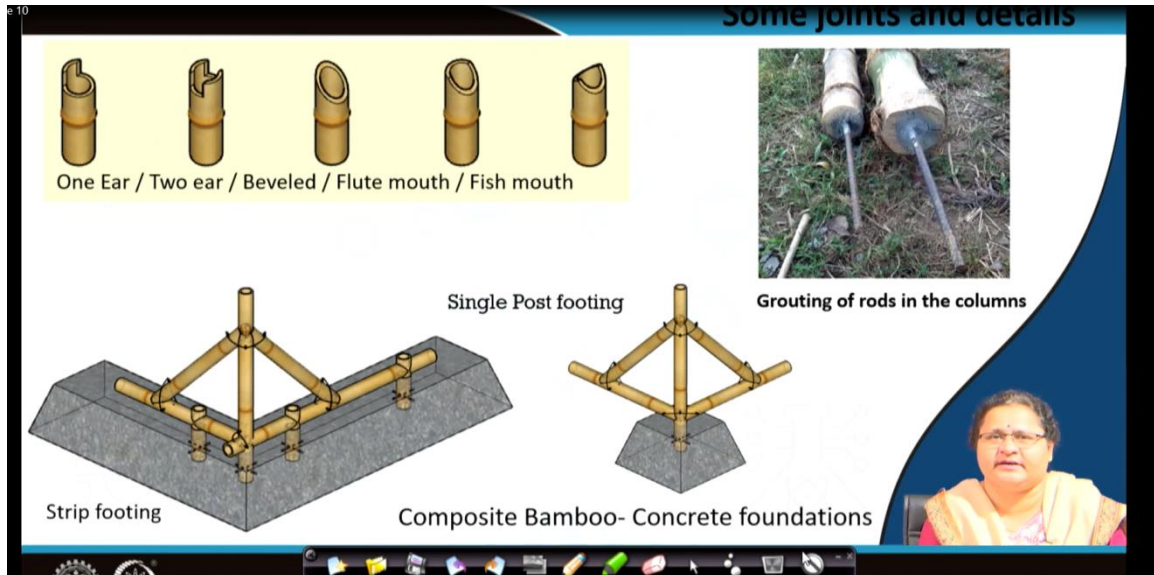
Flammability
Bamboo structures are not fire-resistant, and the cost of treatment, where available, is relatively high.

Lack of design guidance and codification
The engineering design of bamboo structures has not yet been fully addressed. There is little or no data containing specifications of bamboo.

Flammability, yes similar to wood. Bamboo is also not fire resistant, they are highly flammable, and you have to either treat it with proper paint or you have to embed it so that it is not exposed to fire and then only you can use it. And coming to the last point it does not have proper codes to be followed as a structural member. Though it has lot of or equivalent to wood, it has not come so much into the codes because there is not much design guidance.

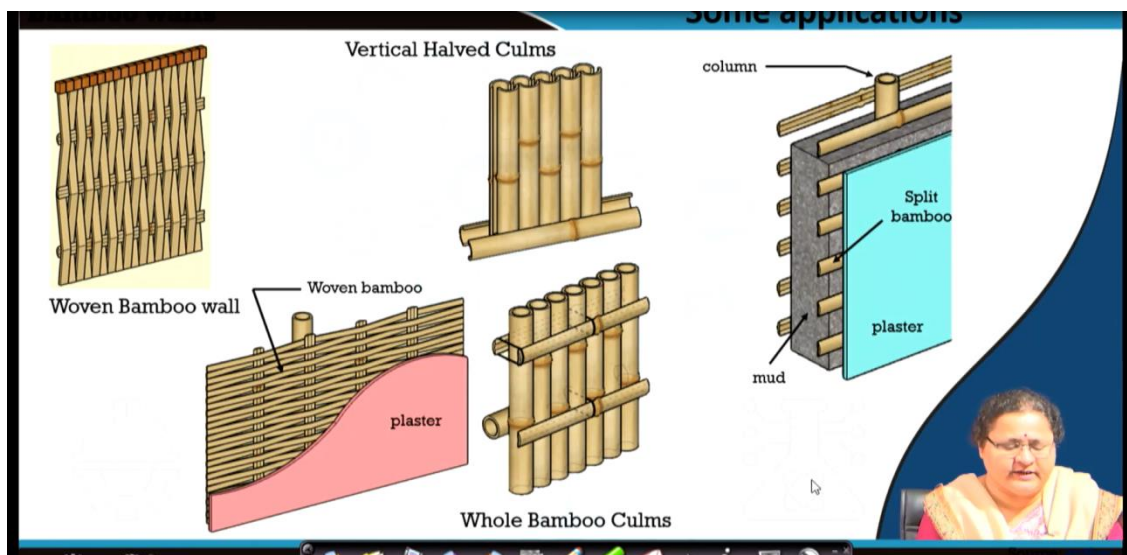
Lot of embedded that is bamboo as a reinforcement has been started nowadays. Researches are being made. It is being embedded to replace iron rods. Yes, the span may be limited, you

cannot go longer. So lack of guidance has restricted for its codification. But yes, researchers are working on it to bring it to the forefront of forefront of building construction. So let us see some joints. These are some cuttings. You can see on the upper side you see a number of cuttings; one ear, two ear, bevelled that is splayed at 45 degree, flute like. So one side is half is at the same level that is a horizontal level and part of it is bevelled. And this one is the most useful which is called fish mouth. So this is giving a circular profile, which you can see which can sit on top of another member.



So these are composite bamboo concrete foundations. This is a single foundation and this is a strip footing. So this is a continuous footing that is in the foundation. You can see at the edge or the corner where it is going to take the load here it is strengthened by more members. So this is the continuous member and you see the cuttings are being done. Now how to fix it? You see the grouting of rods in the column.

You can see reinforcement rod here that can actually be there, go and get embedded inside embedded inside the concrete. So these are details being developed. Architect Laurent Fournier works in Kolkata area where he has developed this kind of grouting methods. He has made cold storage in the rural area with bamboo. So experimentations are being done. Let us see some more.



Here you see the slivers, the bamboo slivers which are woven to form the bamboo wall. Now what has happened? After making this wall, it has lots of holes. So it would not give the protection for which a building is being made. Air will pass through, privacy will be disturbed, it will allow water inside, it will decay. So now you put a plaster on top of it, mud plaster: rural areas.

You see in between you are strengthening it with means of full bamboo culms. So these are put inside and the woven bamboo matrix is passing on top of which you are plastering. So you are not allowing air, visibility, water to touch this bamboo sliver wall. You can see another interesting way of making a wall is with half culms. Now how are they joined?

If you can recall putting the tiles, over tile and under tile. See they have cut it and they are actually pushing, supporting one within the other, again strengthening it with half culms at intermediate distances as you can see here also. They are protecting it. They are fastening it from this end to that end, by straps so that they do not move and then they can cover it with mud or they can keep it such like that to give it an aesthetic appeal, give it a rural setting.

So you can use such kind of details for making a boundary wall of a say rural tourist centre. Here you can see this is a bajareque wall where the inside is mud and to strengthen that mud wall, you are intermediately putting bamboo splits, split bamboo, not as thin as the slivers, but something in between half culm and the sliver. So these are split bamboos, which are placed to reinforce the mud wall.

So after putting, they are again covered with plaster to keep it protected from the weather. Inside at intermediate locations through the mud wall you can even put columns of bamboo. So in all these cases, you can see bamboo has been protected by a layer of plaster. It may be mud plaster, but it is keeping it protected from the moisture and also termite attacks.

Other way is if the bamboo goes underground, you can put coal tar. That gives it an impervious layer, water does not penetrate inside it. So with this, we can say that yes in the future, we as architects can also experiment or can go or recommend bamboo as a building material even if it is low cost construction, it should be having proper tests and it should be within our code.

So let me come to the end of this particular module. And I leave you with some assignments, which actually is considering all the five lectures. Some are from wood. As you can see, few of the questions are from wood; few of the questions are from plywood, engineered wood and the bamboo part. So you can try all these. Hopefully you can answer all these and any questions can be raised in the portal. Thank you.