Building Materials and Composites

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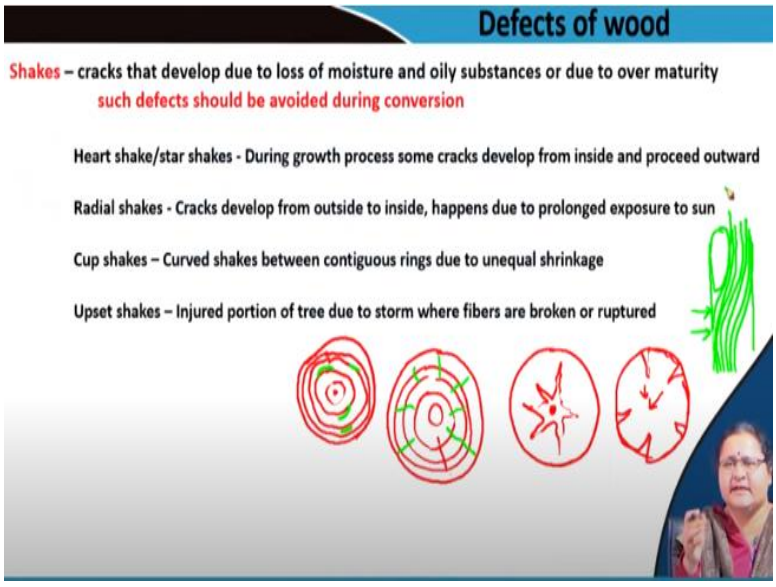
Lecture No. #08

Defects of Wood and Wood Joinery

Welcome to lecture 3 of Module 2. This time we are going to cover the defects of wood and wood joinery. In previous lectures we have understood wood and how to get it from tree. After getting it, we need to use it for our purpose. As a building material we need to know how to use wood but prior to knowing that, we need to know the defects that can happen or that can appear in these wood or timber, which we get for this purpose. Apart from knowing these defects, we will also know the different types of joints and I will give you a brief introduction of engineered wood. Through conversion we have come for the different types of wood and during conversion, if you are careful of the defects, if you can avoid the defects, then you will get good quality wood.

Procuring wood of good quality needs to be done after identifying the defects. We as architects need to know when we look for good wood, we should be able to understand if that wood contains any defect or not, because we may recommend it for some structural purpose or it may be framing a window or a door or a wooden truss. We must know how to identify the defects. Let us come to that.

First defect is shake. Different kinds of cracks that develop due to loss of moisture and the oily substances, which are natural and are naturally produced inside the timber gets lost due to maturity or over maturity. Such defects should be avoided when we are converting wood. As we have talked of different types of conversion, in some cases, we may be able to avoid such and in some cases we keep the defects along with it and we get inferior strength of the wood. There are different types of shakes: Heart shake, star shake, radial shake, cup shake, and upset shake. Let me try to show you few shakes.



When the shake within the cross-section starts from the center or the pith and propagates outward, these are fine cracks and are due to loss of adherence of one layer to the other and is called heart shake. It evolves from the heart wood and moves outside. Similarly, Star shakes form the same way when it is coming from outside to inside. This may be because of loss of moisture from the outside surface. So the cracks are from the outside and moving inward. Then you may find radial shakes where along the annual ring you will find cracks generating radially outward.

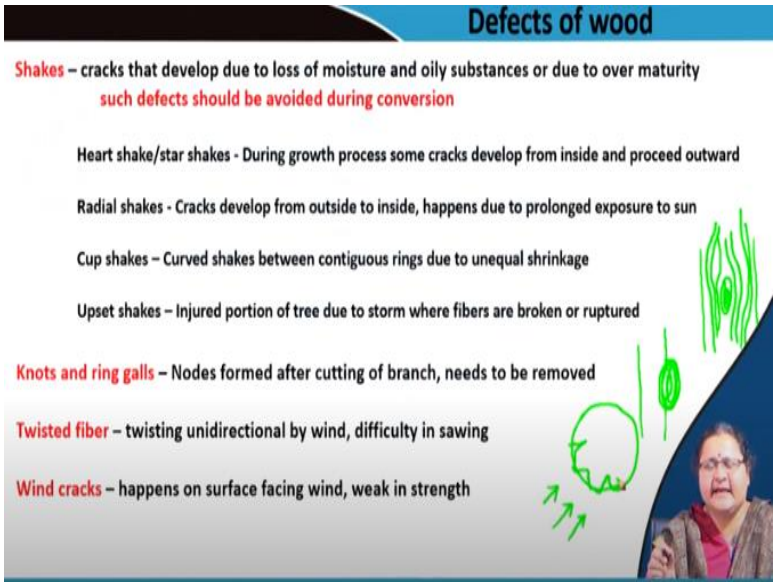
For all these cases, if you go for radial conversion you can maximize your good quality wood collect. Cup shake is happening in between layers. If you have annual rings you may have splits in between two annular annual rings. So you will have multiple such and during the process of conversion, you have to avoid such areas. These are weak areas these are having loss of adherence of one layer with other. Certain shakes happen due to injury. Say you cut down a portion of a branch. What will happen, the fibers will try to bend and move out to grow. Gradually what will happen? This portion from where some cutting had been done there all the fibers have twisted.

This may happen due to cutting of the branch. Also this may happen when a particular branch or a particular trunk is subjected to wind. Continuously there is a lateral force which is allowing it to bend in one particular direction. This gives rise to twisted shakes, so you can get the fibers twisted. What will happen? The strength will get lost and you cannot saw it, cutting will be very difficult.

Any ruptured part may lead to ruptured fibers which itself finds direction for growth or it is due to a continuous wind or continuous force in one particular direction, allowing the group of fibers, which are the xylems, the carriers of the water and the salt, to move with time in one particular direction. It has created the fibers in a different direction and are no longer perpendicular to the rest of the fibers. These areas become weak portions and these all are together called shakes. Shakes can occur because of loss of adherence or because of injury or because of continuous force of storm or wind in a particular direction, and the behaviour of the fibers or the pattern of the fibers get deformed. After this, we come to some more defects: knots and ring galls, twisted fiber and wind cracks.

Knots are the areas from where the branch has been chopped off. The fibers have moved and some fibers have cut. Again a set of fiber has grown beyond it, so that portion may not have bent but have got cut and there weakening has happened. Ring galls are formed after cutting such kind of branches or the branch has failed because of wind. There a lump kind of growth happens.

You can see, on a particular portion of a tree, there is a big growth or mass. These also try to disturb the fiber movement and that actually weakens this portion. So this ring galls, knots can be very well identified. Sometimes the cells get dead prior to maturity of the tree. These portions are weak portions.



The basic message is: in a branch of a piece of log, you can identify these by looking into it. You may find in a piece of wood, a knot and the fibers moving just like this. So you can see a dark patch here, which is the dead cell. By looking at the grain structure and the pattern, you can identify whether there was a knot, which is a dead part and that is the portion which needs to be avoided when we are proposing the use of this particular timber for a structural member.

Twisted fiber is a kind of shake because of twisting it is called twisted fiber. Wind cracks happen due to wind in particular direction of a tree trunk which may get multiple cracks, dried up. Again weakening in strength particularly the tensile strength is noted. There are another two types of defect.

Those are called rots. One is dry rot, the other is wet rot. When the decomposition of the wood brings in, on touching, it breaks and becomes a brown powder. This is not due to age of the tree, but due to fungal attack and this usually happens inside. Wet rot is happens mostly on the outside surface due to wet condition.

Damp and humidity helps in the formation of fungal growths and leads to rotten portions on the tree surface. These are called wet rots. Once you understand this, whenever you see a timber piece, from the grain alignment you can understand what the cross-section was like and what kind of conversion has happened. From the features on top of the grain side you can understand what kind of rots, what kind of shakes and what kind of knots are visible and this can give you a clue on the quality of the wood. When we need wood for building purpose, we may require 2 feet length or we can require 12 feet length. When it is subjected to tension or axial load, we may have a roof truss, it may have wooden members as long as 14 feet or 15 feet.

If we need a chair where I need to sit, it has to take one human load with its 1 feet or 1.5 feet height foot, the support. So it has to experience compression. These small pieces need to get assembled to form a chair. At the same time, you can get small pieces for the chair by cutting.

But if you need a 12 feet member, you may not get in a continuous length of wood, you need to join it. Now how to join with minimum loss of strength because weak portions are to be taken out? So you may eventually need two or three joints to make a long piece.

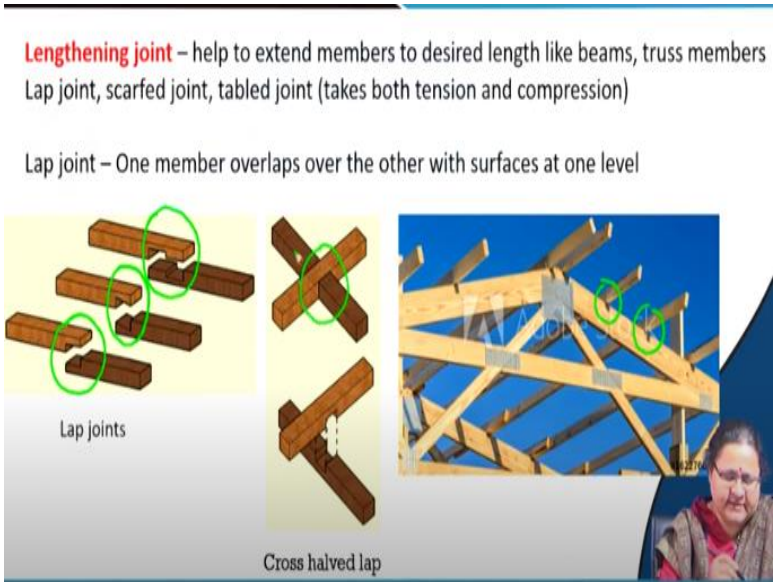
This brings in the process of joinery, which is woodworking that involves joining together pieces of wood or similar kind means wood or wood equivalent to produce more complex items. If you can get one long piece you are very fortunate but usually you cannot get such long pieces. Now you have to join two pieces together maybe in right angle or maybe in an oblique direction. You may require joining two pieces or two members in right angle. As seen in the diagram, in case of a chair, you may have framing in such a way so you have these as taking the load in the tension, these as taking the load in the compression. So this forms the main structure. Similarly, you may have a wooden truss to be made, where you may need to make supports in oblique direction.

Here you need to have joints with one member and the other in oblique direction. You may further strengthen the joint by use of adhesives, fasteners, binders, nuts and bolts. You can loosen it and take it out and you can refix it. If you eventually have a rotten wooden member, you can replace it. This joinery has a beautiful way of adding wood one after the other to make a complex item of it and you can replace individual members if required.

You have to remember some points when you are doing wood joinery. You remember the xylems and phloems flowing. Whichever direction they are in, the vertical or in the horizontal when it is tension member they should be in the horizontal horizontal direction. Whenever they are subjected to compression, the xylems and phloems should be in the vertical direction.

They ensure the strength of the member. Some joinery may be helped to lengthen members, some may be required to widen members and some joinery may be for bearing loads. What do I mean by widening? When you need a table top, you are adding one member with the other in such a way that it gradually forms a surface which can become a table top. Lengthening member is required when you have a beam. A small piece is joined together to get a big beam, spanning between two ends, maybe walls or maybe two other wooden members, which is where you need lengthening and load bearing is when you are subjecting it to load. So let us move to the lengthening joints.

To extend members to desired length like beams, truss members, lap joint is the simplest one. So a portion of one member is taken out and on top of it the other member is sitting as you can see in this drawing here. To maintain the thickness continuity half of one member has been taken out and half of other member has been taken out and in the opposite direction they are placed to form together one member. Now who is holding it? Either you have to put a nut or bolt or you have to strap it by a metal plate. Otherwise they can separate out. See the little more complex picture where a beveled cut has been given. So it is a little more slanting. Here the grip is further better, but even they can move apart.



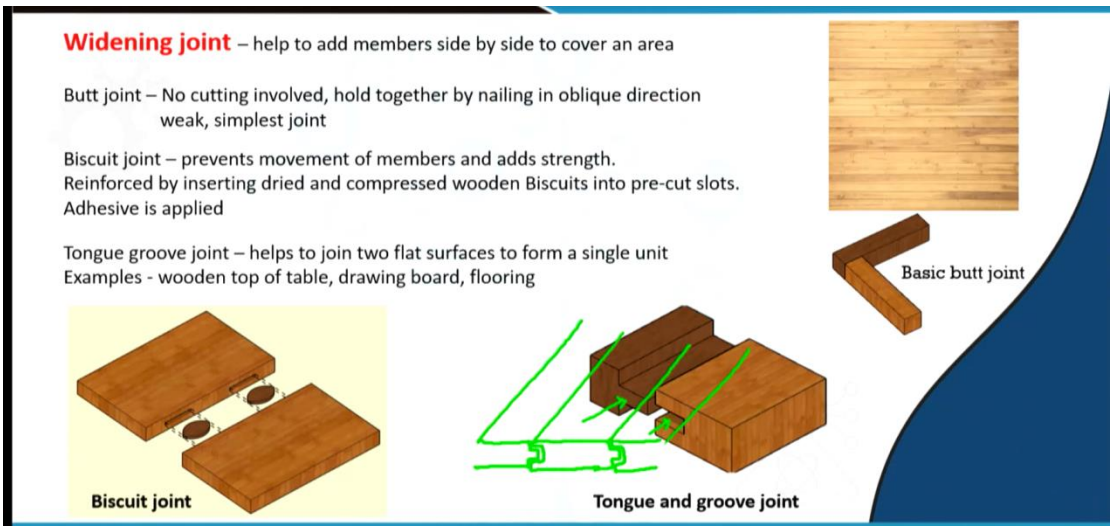
Look at the third one which is the tabled joint where you see they can move out but they are sitting holding each other. Here you may not strap it or you may not nail it. It will remain in its position but even then you need to strengthen it or to strap it. This is called tabled joint.

They can take both tension as well as compression and they help in joining. You may require crossing one member because it is long as you can see in the picture. Here these are not sitting on it, but they are going to get inserted inside it to a small length. Whatever will be the requirement, based on that you can have cross half lap joint. You can see this detail here.

Let us move to widening joints. You need to make flooring. You all have drawing boards. If you see the edge you will see planks joined one after the other. Butt joint is the simplest where no cutting is involved. One sits beside other and they may be held just by nailing. This can happen only when the surface is supported by some supporting member at the edge.

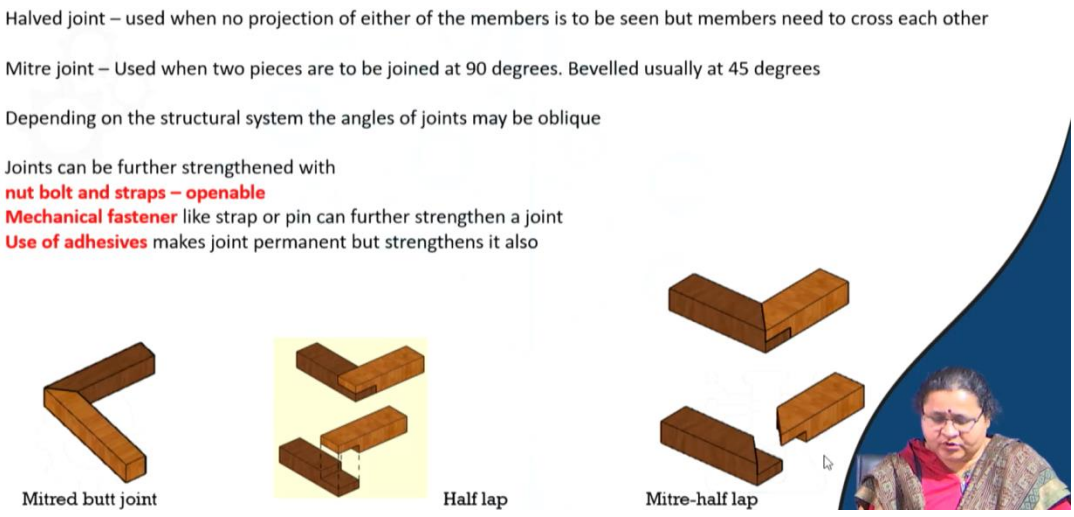
If you have a support here and here you can keep on placing members one after the other if you have another support here and here. You can place wooden pieces or planks one after the other and you can create a surface or you can widen the joint. So there is no basic joinery involved here. This can happen when you have a connector to a river bridge.

Planks are supported on steel members one after the other inside a groove. So they will move out and it creates a surface for people to walk. Let us see another kind of butt joint which is called biscuit joint. In this, two members are placed side by side but in each of them grooves are made and is connected by a supporting wooden piece which holds the two pieces together in position.



They reinforce the joint. This is called biscuit joint and it adds strength to the joint. They usually do not slide and you cannot separate them. Adhesives may be applied to further fix it in position. In tongue and groove joint, as you can see in your drawing boards, if you look at the cross-section of the drawing board, you may see something like this. This projection continues to form the board and the projection is called the tongue and this is the groove inside which one gets into the other and forms a uniform flat surface that are called widening joint. So you get a continuous surface by putting one after the other through tongue and groove joint.

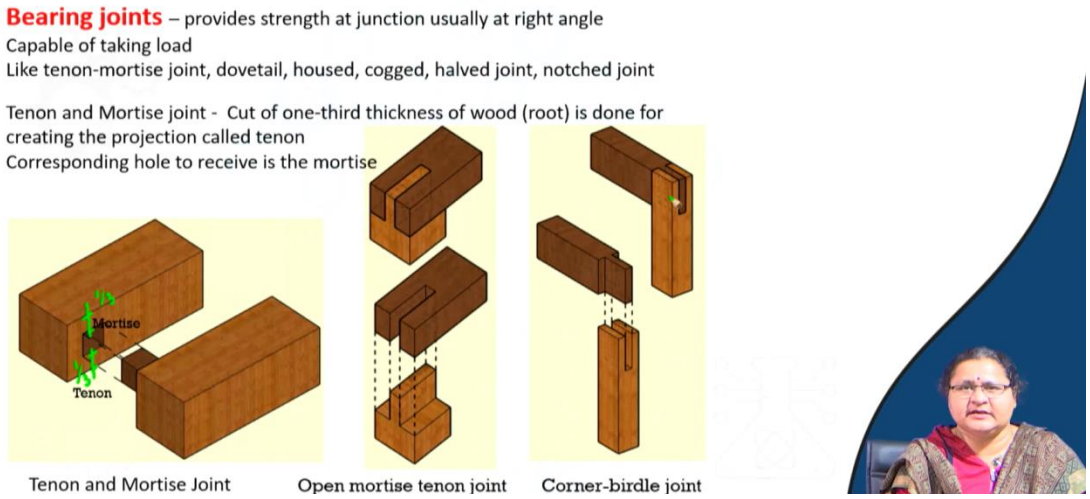
Now we come to some more joints, which is mitred butt joint which is a bevel joint, half lap joint. Depending on the structural system the angle of the joints may be oblique. They may be at 45 degrees. Nuts, bolts, straps, mechanical fasteners, adhesives are added to strengthen joints. Let us see some more type of joint that is the bearing joint.



In bearing joint we have we try to minimize the loss of strength. So they are usually provided at junctions mostly at right angles and are capable of taking load. Tenon and mortise joint is one such. Dovetail is another joint. Housing one inside the other is called housed joint. So

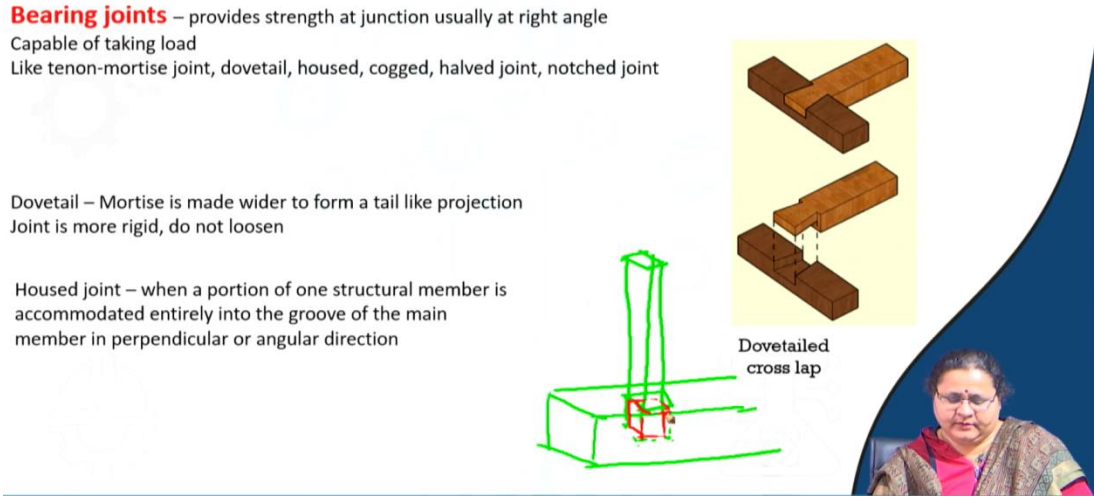
one member may be very heavy and a new member sits inside. That is called housed joint. Another types of joint are birdmouth joint, notched joint and half joint.There are several, but what is to be put in mind is that in bearing joints the weakening of the joint cannot be allowed. So let us see some bearing joints. In tenon and mortise joint, the tenon is a projection, whereas mortise is a chase. Chase means a cutout. And if you see this picture, you can see that one-third of it has been retained on this site, and one-third of it has been used for the chase.

So this tenon is similarly made with the extra piece of wood and that can go and sit together to form the tenon-mortise joint. Now this can happen in right angles as you can see. This is a kind of open mortise tenon joint. This is corner joint but the principle remains the same. It is open tenon and mortise joint.



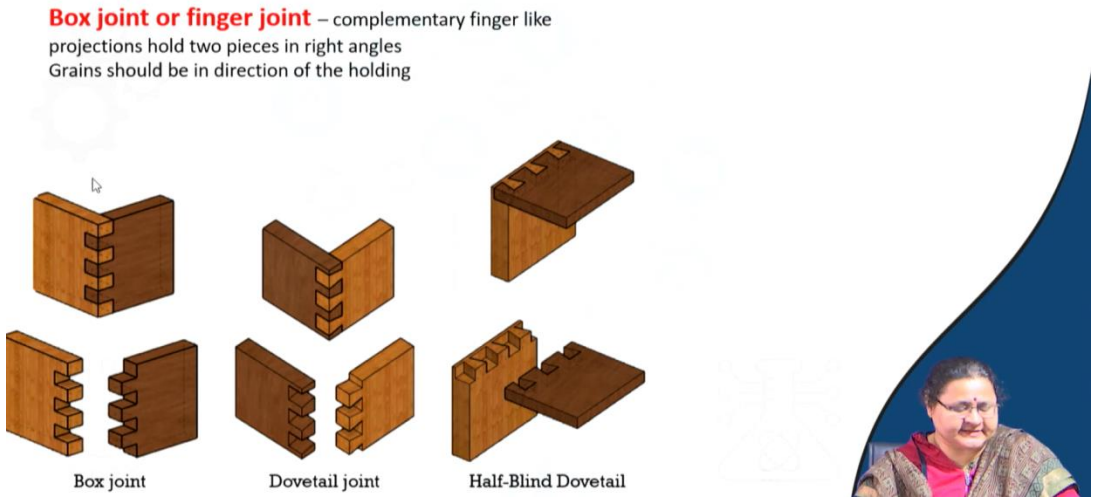
Now we see dovetail joint. Here instead of the tenon, which was uniform or perpendicular in the edges, here you see the projection has fanned out. It has come out like this- splayed. Similarly the receiving part has also got splayed to receive the tenon, the projection. So this mortise is made wider to form the form a tail like projection and hence it is called dovetail. This joint is more rigid considering tenon and mortise. In tenon and mortise you can pull it out, but in dovetail you cannot pull it out because it is wider at the end and smaller at the point from which it has to come out. So you have to entirely open the assemblies to get it out.

In housed joint, one portion is a structural member, so if I draw it like this, say this is a member cross-section which is quite heavy piece will have the notch or the groove which will go inside up to a given distance and the member which will come out of it will totally be housed inside it. This member is no way getting weak and this member actually sits inside this groove. So what has eventually happened? This member is not having any weakened point. So in that case, this member has to be sufficiently deep and wide. This is called housed joint.

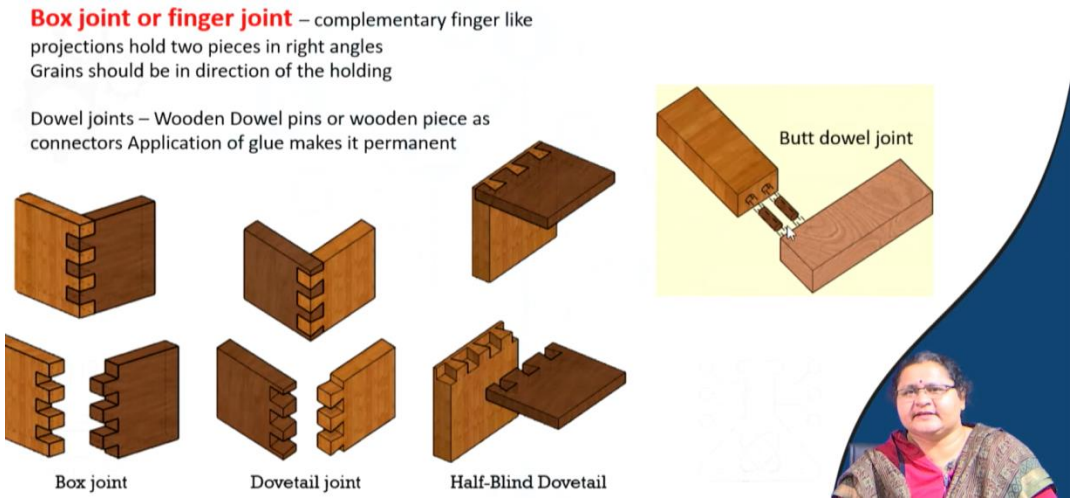


There are some more joints, which you can use for wood as well as I told you wood like. We will come to engineered wood just after this lecture. We see box joints or finger joints. You see so many projections are there and these projections have just complimentary receiving members and grooves. When they are set together, it forms a joint. So this is the simplest box joint and then again you can have dovetail on it. So corresponding cuts to be made.

These can be nowadays machine made. You see here the joint has formed. Similarly, you can see half-blind dovetail, a portion of it has been retained to give a neat finish to the outside surface. So this surface you see there is no joint but at the same time it is supporting something. So that means you can actually make beautiful finishes, neat finishes without showing the joint you can even create such kind of joinery. These are called half-blind dovetail joints.



Again as the biscuit joint you had seen you can also use dowels in which part of it will go in one member and part of it will go and sit into the other member. So these dowels can strengthen the entire joint. Whatever the kind of joint it is, you can insert dowels and actually make it a very strong joint. So these dowels can even be metal.



So how can we conclude the chapter of wood? Wood is obtained from naturally growing trees and may have defects due to various causes. Defects are to be avoided before putting it to use. Joinery helps in connecting two or more members and creating a usable item. It should be remembered that joints should be made along the fiber and not across the fiber. Before moving to the next lecture I would like to summarize that wood is a naturally occurring material. We can use wood, but at the same time, we also need to look into what are the alternatives or engineered wood, which we can use from wood and what are the good points of it in place of using wood. As you understood that during the process of conversion, there are losses up to 40% of wood.

What happens to that unused wood? Does it go waste? Does it get burnt and become fuel? Can we not use it for our purpose? What happens if the defects can be avoided by engineering the wood? So in next lecture we will go for engineered wood and we will try to see how the defects or the problems which we have encountered in using wood have been taken care and we will see that nowadays we are using more of engineered wood rather than wood. Thank you.