Basic Construction Materials
Prof. Radhakrishnan G. Pillai
Department of Civil Engineering
Indian Institute of Technology, Madras

Module No # 11
Lecture No # 50
Wood and Wood Products Part- 2

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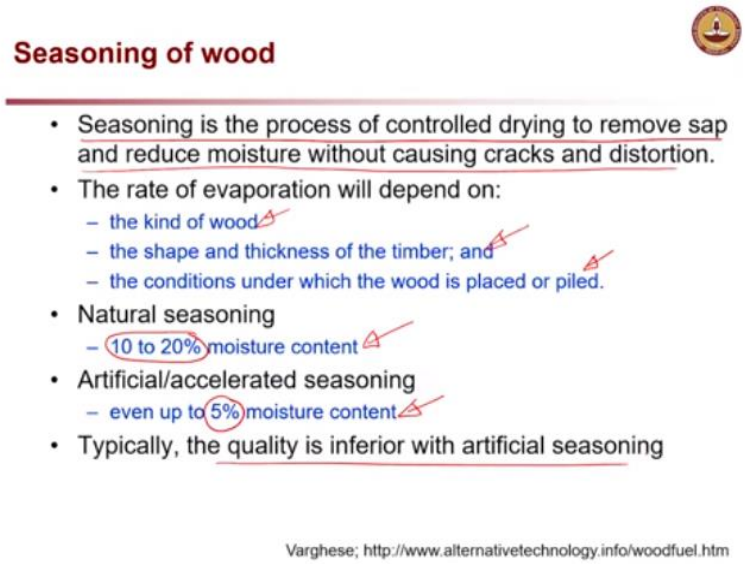

Now, what do we do or what can we do to avoid such problems. One is the seasoning of woods. So what is seasoning? Seasoning is the process of controlled drying, not just drying controlled drying to remove sap and reduce without causing cracks and distortion. So it is like we know that whether you dry it or not, it will happen right over a period of time. So it is better that we do it in a controlled way before we start making the structure with wood.

So that is what we call a seasoning, or you are preparing that wood to be used for the structure. So that once the structure is built, then there are no further deformations. So all the deformations which can happen because of shrinkage we are we are forcing that to happen before the structure is built, and that process is what we call seasoning and what is it? It is nothing but the removal of sap and moisture from the wood but not heavy drying. But in drying, make sure that during that process, there are a cracking or distortions happening on wood.

So we go for a slow process in general. Now the evaporation rate will depend on the type of wood which we use the shape and thickness of the wood, the volume mass to the surface to volume ratio etc., and the condition under which the wood will eventually be used. Now natural seasoning is one way, and another way is artificial or accelerated seasoning. So with natural seasoning, you can get above 80 to 90% moisture removed from the wood.

But it takes time now; in the case of artificial or accelerated seasoning, you can remove even above 95% of the moisture can be removed. So you can have only left moisture content is only 5% in the natural seasoning case; you can have about 10 to 20% of moisture content. So artificial or accelerated seasonings can remove more moisture than natural seasoning, but you know there are also disadvantages to that.

Because you have to see the other properties like you know whether it will be warping etc. And too much drying is not also probably it might affect the other properties of the wood. Now, so typically, the quality is inferior with artificial seasoning anyway, considering the demand for processed food etc. Nowadays, it is the artificial seasoning that becomes necessary for us to meet the market's demand.

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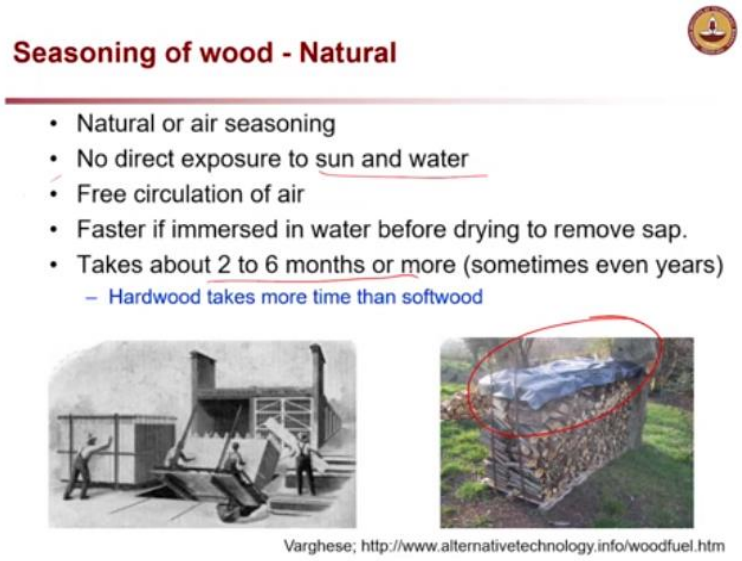

What is natural seasoning? It says natural or air seasoning, just leave the wood under the sun but not direct exposure to the sun. You can see the photograph on the right side where the wood is stacked, and then a sheet is kept on top so that it is not getting direct sunlight and no direct

moisture and air. Now free circulation of air is another thing and then faster if emerged in water before exposing to the sun.

I will show a picture on the next slide about that and then take about 2 to 6 months or more. For proper seasoning, sometimes even years, it will take depending on the type of food. Now it says hardwood takes more time than softwood.

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Now let us look at seasoning of wood artificial or accelerated way essentially here what we do is we immerse wood in water and then to air dry. So you can see the picture on the left side where you can see logs floating on the water body. And that is kind of immersion, or it can expose to water or sometimes in river water they use propel use you know tie logs into the river. Or sometimes let the wood float in the river itself during the transportation and all that helps or part of the seasoning causes and then eventually they will dry it.

So what happens is the strength also reduces due to the excessive loss of organic materials that are also concerned. But eventually, you get a better wood which will have more resistance against shrinkage etc.

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This is another example of artificial or accelerated seasoning. I can see here a clear picture of that define a modern-day kiln element where the timber is seasoned. So these kind of setups are necessary because the demand for wood is high in our today construction. So you cannot avoid artificial seasoning, and you cannot depend only on natural seasoning.

So you can pause here and look at different elements of this; they set up like this to ensure maximum air circulation because the whole idea of doing this is to remove moisture. So you increase the temperature so that water tries to evaporate and make sure that there is a good circulation of air so that the humid air inside the room can be taken out. So that more and more moisture from the wood is pulled out or is drone out and then eventually you have a dried or seasoned wood

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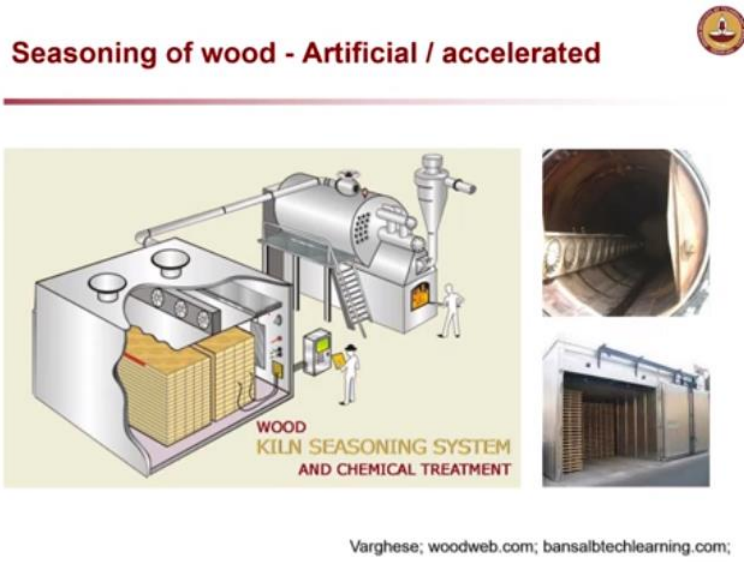

This is another example just to show some schematic, how things are. Some need to have a supply heat energy which would be that due to electrical sources or due to fuel or even due to solar cells all these are being used and then at the same time you need to have a very good supply very good circulation of air. So that the humid air inside the chamber is taken out and more and more moisture from the wood is removed, or it has been dried in a controlled manner.

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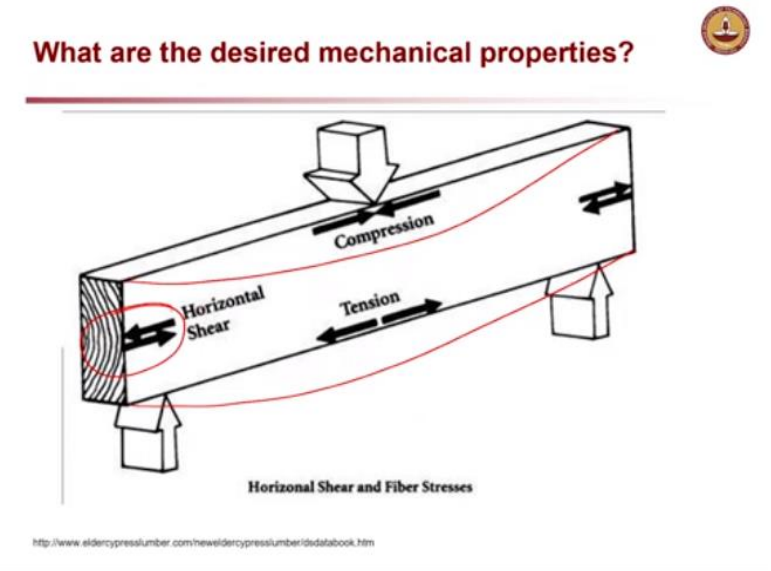

Now let us look at the desired mechanical properties. Now, this is an example of you know beam. You can see the example of a beam here simply supported beam you can see one support here another support here and the load is applied from the top. Now, look at this beam element

where which portion of the beam element is experiencing tension? Which portion is experiencing compression? And also,s which portion is experiencing sheer?

So you can see here when you have a simply supported beam like this will bend like this. This is a typical bending right. Now because of this so let me draw it again; this might bend something like this. That means the top portion is under compression at the center of the span, the top portion is under compression, and at the center of the span, the bottom portion is under tension.

This is another interesting feature here; you can see here that you know fibers are in the horizontal line right. So when this bending happens, the fibers will start trying to slide, which is why we have horizontal shear force also, because it is there are trying to slide each; other. So these are the different things different type of stresses which are generated when we apply load onto wood elements structural members.

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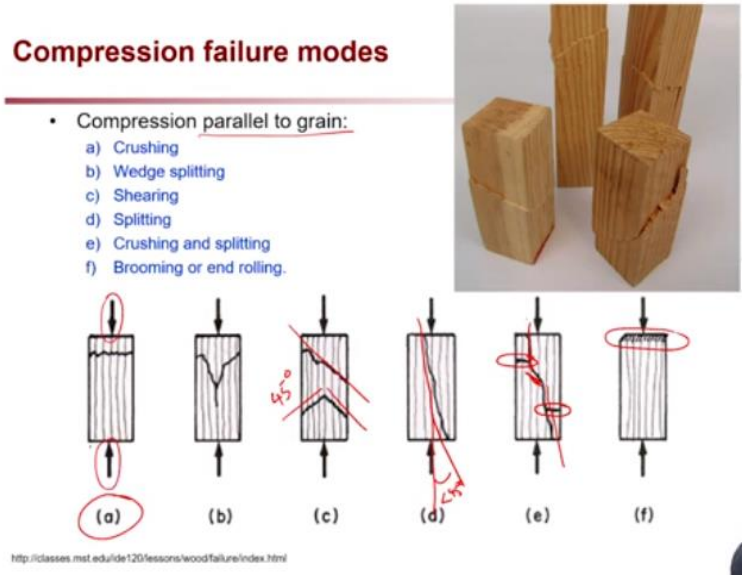

Now the failure modes compression failure, we already saw that there is a compression mode failure, possible tension failure possible, and shear failure possible in the previous slide. So let us look at its compression failure mode the picture on the top right are examples of the test specimen. And the sketch on the bottom indicates a different type of failure. This is crushing you can see here there is a crushing of the fibers happened.

So you can look at try to correlate with the, you know the picture photograph on the top right also. Now the second one is wedge; you can see a wedge shape forcing here, and then it is going into this so that kind of failure. The third one is the shear failure; you can see a shear action, and here also this much is under shear; this is under the shear plane. So these three things and then you have a splitting action here angle see in the case of shear the angle is almost 45 degree.

But in the case of splitting, you can see that the angle is not fortified but is more parallel into the grain, or you know this is the angle you are talking about. This is less than 45 degrees, so this angle is very small. So the angle between the failure plane and the grain direction is very small or acute angle. Now crushing in the case you have crushing and splitting. So it is not that if you take a timber, only these first four will be happening; you can also have a combination.

So this you look at here it is crushing this is crushing and then you have splitting in this direction here. And then here you have split and then maybe a little bit of shear failure also here. So this you have to look at and try to analyze, and then you have a case which is brooming or end rolling. You can see here deepening on one type of load was applied at the top, and probably there is a local failure or local crushing happening at the top surface itself.

So these are different ways by which the wood can fail when a compressive load is applied parallel to the grain. So you can see all these arrows on the top and bottom; they indicate like compressive force is applied in the direction parallel to the grain direction.

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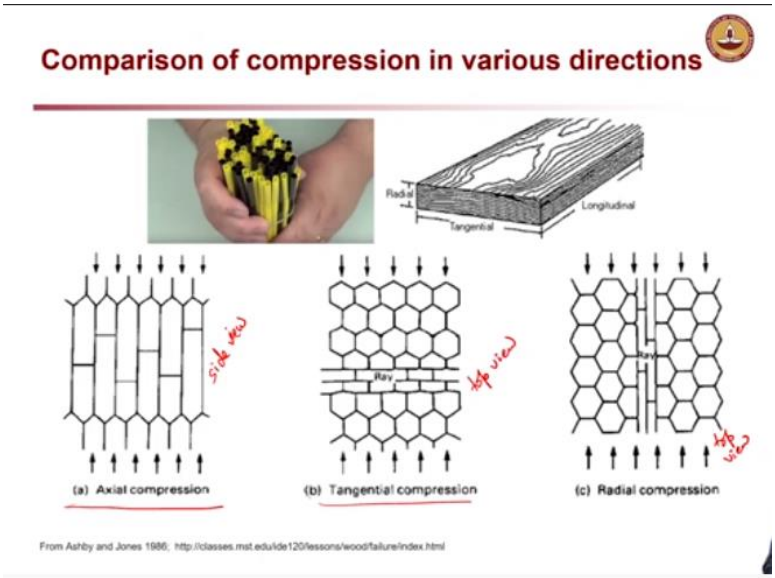

Now comparison of compression in various directions, in the previous slide, we look that when compression is applied parallel to the grain direction that is axial compression case A. Imagine the straw which you have in your hand you can see the photograph. If you apply the load from top and bottom or ends of the straw, that is the axial compression case A. What will happen is if one stroke tries to buckle or something, then the other stroke will kind of give that lateral support.

So the whole system works perfectly. Now the second one is tangential compression, where you are trying to know this is the other view. So in the case of A, it is the side view. Case B is the top view. This case C is also top view. I am saying top view, side view, and top view of the bunch of straw in the hand. So now you can imagine how things are now in the second case B when a tangential compression or even in case C.

It is also radial compression; it is like your squeezing it. So what will happen is this the straw the walls of the straw will collapse. They will collapse, so the load-carrying capacity is much smaller in the lateral direction than in the axial direction. So you can easily imagine this thing.

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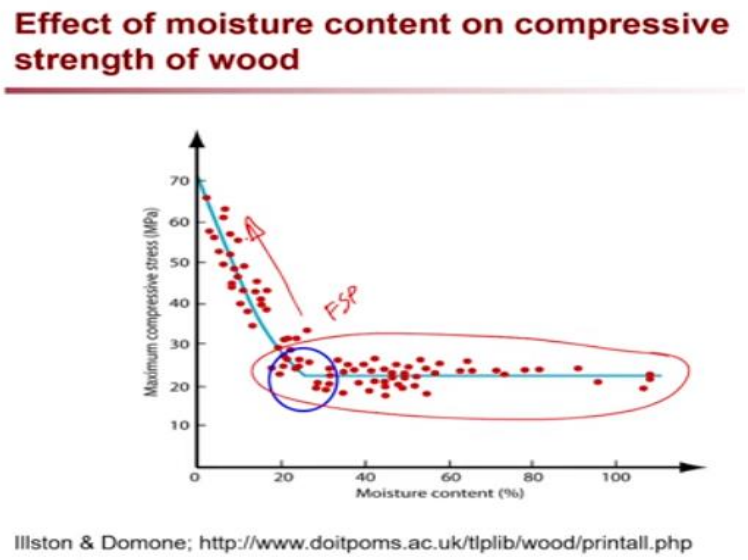

Now the effect of the moisture content on the compressive strength so you; can see the similar picture that I showed earlier about 100% till about 20 to 30% the load compressive. Earlier, we looked at shrinkage property, but this is more on the compressive strength. You can see that there is no much change in the compressive strength of the timber when moist. Until the moisture content is about fiber saturation point, or you know FSP until that point, there is not much change 20 to 30%.

But further drying, you know it leads to an increase in the compressive stress because your cell walls are very tightly packed air content inside the timber or wood is very less. So it can take really high strength.

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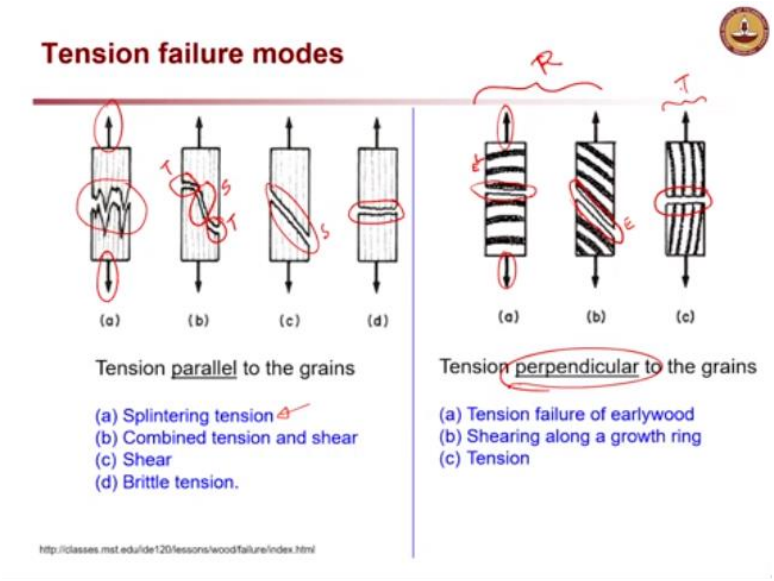

Now tension failure mode you can see here this arrow is going or showing tensile load and parallel to the grain direction. So how do they fail? They fail in splintering tension first option then that is this splinter you can see the splinters are formed, and the second one combined tension. So here it is tension failure and, the central region is a shear failure. So shear, tension now the third case you can see the pure and of shear failure.

This is all shear failure then fourth is tension pure tension. So pure tension, pure shear, splintering, and a combination of tension and shear. So these are the four different ways by which wood can fail when you apply a load in the direction parallel to the fibers. Now, if the tension is applied perpendicular to the fibers, this one is perpendicular to the fiber. Then you can see how it is so you can see the rings here. Lightwood and earlywood you can see there right.

So this is light wood this is lighter color is the earlywood you can see that there. Now, what happens when you apply the tensile load in this direction? So is it like another bunch of straws, and you are pulling your hand in the opposite direction like such tension failure of earlywood can happen. You can see here the earlywood is failing; the white region is failing; this is the white region that is failing.

And again, in the case of B, you can see shear failure happening again in the white region, making the wood fail early. And then in the third case, you have again failure, which is in the pulled in the other direction because you can look at the ring direction also changing there. So

they have a pure tension failure, both, you know, cross-cutting through both earlywood and the light. So these two, you can think these are probably tangential you know direct sorry these are the radial direction, and this one is of a tangential direction.

The tension force is applied in the tangential direction in the first two A and B the tension force is applied in the radial direction.

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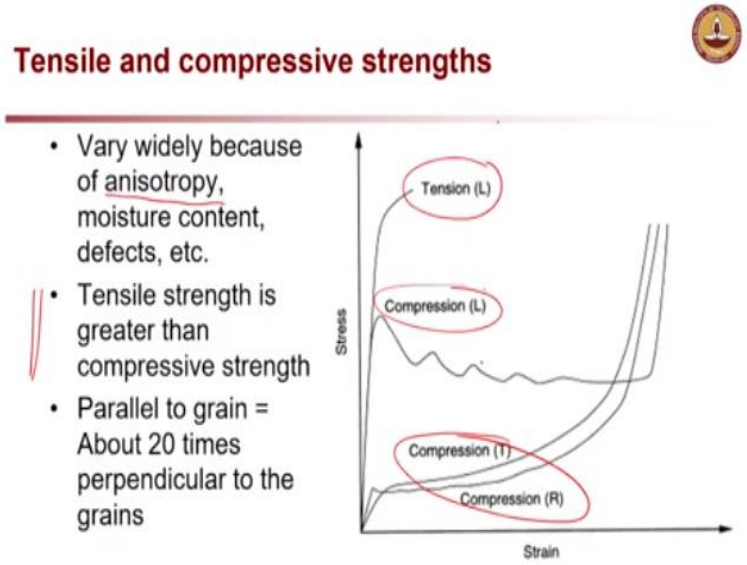

Now, look at how these tension and compressive strengths of the same timber are in different directions. We know that very widely because of the anisotropic nature of wood and the presence of moisture and other defects. And it is a natural product that is the most important thing you know it naturally has that controls how the fiber should be? Where should the defects be or not etc.

You do not have much control. Now tensile strength is greater; this is very important is greater than compressive strength. I can see here that the tensile strength is much more than the compressive strength and also, when you look at the direction parallel to the grain is about 20 times more than the perpendicular to the train. So this is tension, and you can look at the compressive force also, this is the longitudinal direction, and then this is tangential and radial, which is lateral, we can say.

So this longitudinal direction, the force the strength is much higher than the other direction. That is the key message from this so parallel to the grain that both the tension and compression can take more than in the other direction.

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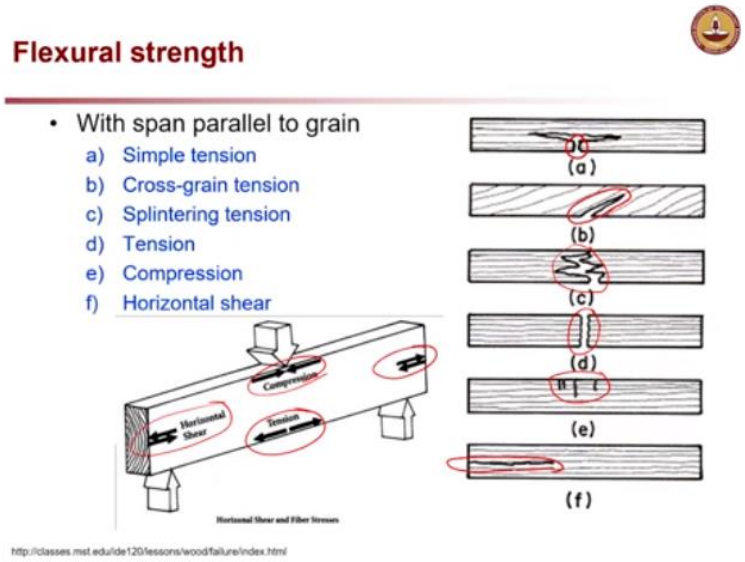

Now flexural strength, you can see the same image which I showed you earlier where you see a simply supported beam. Now let us look at this a, b, c, d, e, f six drawings on the right side how they are the failure mechanism. As I said, look at this is a tension region this is a compression region this is the horizontal shear region, so these regions we look. First, let us look at the tension region, and then you can see in case A, you have a failure like this which is a simple tension.

So you can say this failure these, fiber here are failing in tension and then you have cross grain failures. So you can see here a cross-grain failure in a latewood earlywood region; there is a shear, not only shear; it just gets pulled apart. That is why we call it cross-grain tension, not the failure along the length of the fiber; these individual fibers get separated. That is what is happening in case 2.

The third case is again splintering, and the fourth case is pure tension; the fifth case is a compression failure at the top of the element, and then you have a horizontal shear failure near the support. Where here you have the tendency of sliding of the fibers So, these are the ways by

which the timber or wood would fail. When you go see structures, you should look for these failures. What type of failure it is and all that you can look for.

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Now, generally, as you know, in any structure, joints are very important. So, here also in case the wood structures joints and connections have a significant influence on their overall performance. So look at the picture on the top left you can very clearly see that this join has failed. So it has broken at the joint. And the second picture on the top right shows that there is a failure here, and this joint is actually failing.

So there is a movement at the joint, and if you also look very carefully at this point, here is actually a moisture attack is there probably. Because the joint the plate is holding and giving more moisture, that location near the joint is getting exposed to more moisture and then getting weaker. Now in the bottom left image, you can see a joint that is not designed well; if you tighten the screws too much, then it causes a shear action in this plane.

Imagine the direction of the screw; as you push the screw further to the left, there is a shear failure along the periphery of the screws. So here also you can see a small crack happening so you should not over tight and all. So you have to see what this wood is capable of? What is the strength? What is its strength? So this positioning spacing etc., where the screw should be placed?

All these are very important; otherwise, the system as a whole will not work. So here also you can see there is a failure in the joint because the connections are not correctly designed, and here also you can see there is a failure here this joint is not correctly made. So all these are very important it is not only the size of the wooden element how the multiple elements are put together or joined together, or we call it connection? So that how that connection behaves is also very important when we think about woods.

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Also, there is a lot of bacterial, fungal insect might attack etc. So you know we will not go deeper into this, but this is also something you have to worry about while talking about wood structures. And you have to provide proper protection against all these before you start using the structure. So in house construction, you know if you look at any construction going on, you see that they will apply some coating at the backside.

For example, the wooden door-frame they apply some coating on the backside of the door frame which comes in contact with the concrete. So that there is no attack of these biological elements you know or the insects fungus bacteria etc., cannot attack the wood directly. So some kind of protection is very much essential; otherwise, they will separate, and we will replace the wood directly. So some kind of protection is very much essential otherwise they will degrade and then you will have to replace the wood.

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So one way by which you know these things can be protected is by providing some treatment chemical treatment. So one thing which is widely adopted is that I already mentioned applying a coating, but this is another chemical treatment given to the entire wood as a bulk itself. So it is done by penetrating some liquid into the wood by pressurizing them at high-temperature heat. So you know impress or impregnate some chemical into the wood structure

So, structural members need to be fabricated as much as possible before treatment in order to expose untreated wood by cutting, drilling, holes etc. So what we essentially do is cut the wood and pass them through some chemicals or let them have some chemical treatment and then only use it for real structural application. So that damage after the structure is made is very less.

So you can see here very contrasting you know behavior one on the left side in this photograph one on the right side in this photograph the one on the right side is treated wood. Same dimension one on the left side also has the same dimension but after some time because of various mechanisms. So the chemical treatment helps in enhancing the resistance against biological attack.

And the main thing is to keep the wood dry and keep it above from ground if possible. These are the ways by which you can protect the timber from getting damage.

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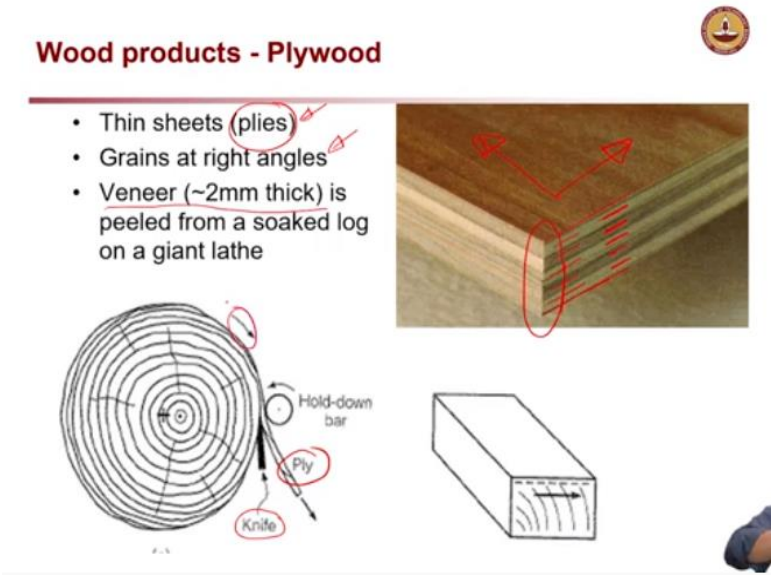

Now let us look at a couple of wood products; plywood is widely used in many constructions we use plywood. We have thin sheets used for this. So that is why we call it plies. Then grains are arranged at the right angle in different layers. So you can see here this is a cross-section you can see layer 1. There is an outer layer; guess some sheet and layer 1, 2, 3, 4, 5 so you can see here there are five layers, and then there is a small cosmetic layer on the top.

So the longer layer which is drawn is the cosmetic layer, then other others are the main layers of the plywood. So always, most of the time, you will see that **plywood will have this odd number layer that is mainly because of making sure that it has the same direction for the look.** Anyway, the point is the anisotropic nature of wood is changed when you make plywood. In the case of plywood, you will have similar properties in both the direction whether you take it in this direction or in this direction you will have similar properties.

Because the grains in these individual layers are arranged 90 degrees in the opposite direction, the properties in both directions become more or less similar. Now how is it mean? You can see the picture on the bottom left where you have a log, a stem of a tree etc. And then, we cut about 2mm thick veneers, cut or peel off from the log. In the next slide, I will show a picture before showing it here.

So this is one-ply, and then this is the cutting tool or knife, and then you kind of peel of your let this thing rotate this log is rotated, and then you take the layers.

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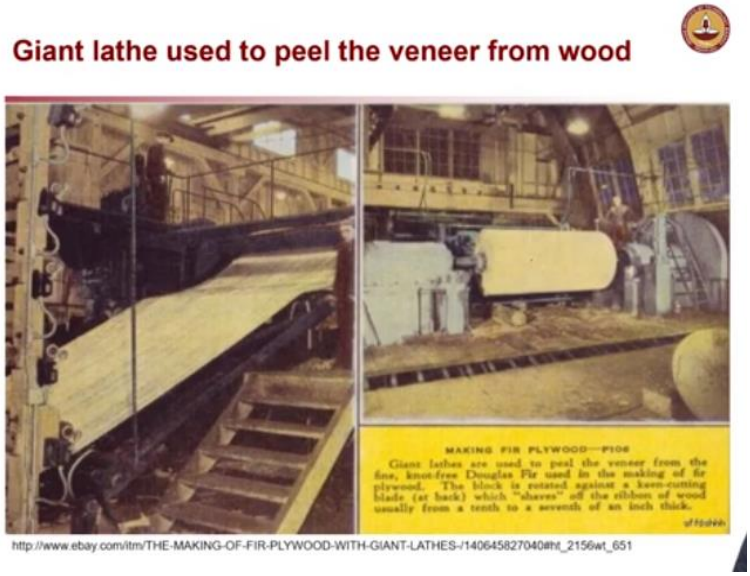

Actually, you can see it here: the real, you know, photos from a factory where you can see this from the logs. So the log is rotated, and then these veneers of layers of wood are peeled off and then used for making plywood. So the giant lathe machine here cuts the wood and then has these layers of thin sheets of veneer.

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And then, they are put together to form the plywood. Now other types of product which are recently coming into the market are you know. Because in the wood industry, there is a lot of this waste being generated because of the cutting action etc. So what they do is instead of throwing

them as waste we try to use them to produce more products which can be useful. So the waste is of different sizes and shapes. So, for example, you can have sawdust very fine powder.

Then you can also have chips slightly larger, you know, sawdust are slightly larger pieces which could be mm size and then chips and strands where it could be several millimeters maybe even a centimeter in the lateral direction and then longer pieces. You can see here the three pictures on the right side, which kind of show you the difference between sawdust, a chip and chip, and strands.

Then these materials are put together, glued, and compressed to form sheets similar to plywood. They are compressed, so these are all waste materials; remember that scrap material they are put together mix together and processed, and then glued together. Typically using a resin and then compressed to form sheets which can be used as either particleboard or chipboard or oriented strand board.

So the based on the type of raw material, these names are evolved. So the photographs on the bottom also you can see very clearly, and these are widely used today for furniture making. Many furniture today comes with compressed wood that is the familiar name which we call in the market compressed wood. So they are not natural wood, but they are artificial, and you know made by using the waste of wood industry itself.

And it is not equal to plywood, it is slightly different; in the case of plywood, you put layers of veneer, and you make the plywood, here it is compressed wood is slightly different.

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Now there is some danger associate or the deterioration mechanism you can see even in your furniture at home if it is compressed wood. You will notice that the corners etc., where there is a possibility, let us say use drop a little bit of coffee or something when moisture gets in, and it starts swelling. So you can see here on the top left a typical which you might have seen where moisture it is. So this is the one major problem with this kind of products is that they are not much

I mean, you have to ask for moisture resistance; otherwise, you know the typical product which you get they have a lot of air void inside. So there is a tendency for it to absorb the moisture, and once it absorbs, the wood will swell; why will it swell? You can see the moisture picture on the right side of the black image, a microstructure image. You can see the cavities are all filled with moisture, and then it swells. So all these small cavities which; you see in this black micrograph.

You can see that cavities can get filled with moisture, and then it will swell. So how much can the swelling be? You can see the picture on the bottom left, which indicates how much the swelling can be? So you can have significant damage to this kind of product if you do not protect them from moisture attacks. So when you use compressed wood or these artificial products, make sure that it is well protected against moisture.

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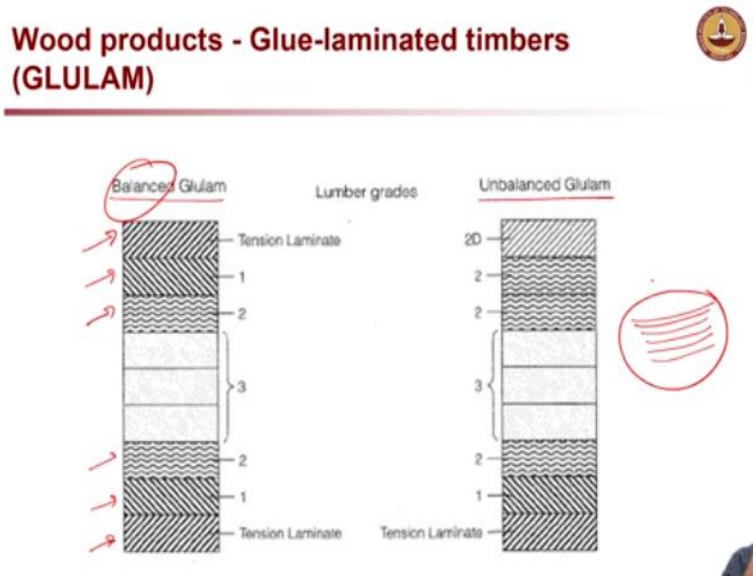

Another product used for structural applications is glue-laminated timbers; it is essentially a beam made out of (32:57). So you can see on the left side balanced glulam on the right side is unbalanced glulam. Essentially like plywood, we have different layers here also; you have different layers. The first layer, the second layer, third layer, and symmetry are followed here: top 3 and bottom 3 are the mirror image.

If you look carefully at the balanced glulam on the unbalanced glulam, it is not necessarily a mirror image, but it is not a mirror image, but you still have good property. So the point for you to note here is that if you want a deep beam which is like, you know, 1 feet deep and let us say half a feet wide. And you do not have to cut a large tree for that. What you can do is, You can get smaller tree stems or wooden pieces and glue them together to make the large piece.

That is the whole idea instead of cutting large trees, and we can get small wooden pieces and then glue them together. If you remember in vehicles and all that you know the axial there are these plates like this you know. Suppose you look on the train or anywhere. So this is essentially, you know, laminated wooden element or wooden beam.

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So these are the examples of this glulam you can see here multiple applications where you know here you have multiple layers of wood. So, for example, here, these are multiple layers; it is not just one timber. These are all multiple layers or laminates of wood to form a beam structure. These are all beam-columns and beams you can see on the left structure.

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Now other you know wide application or wood is nowadays into use as floor joists for constructions even farm work is you know a lot of farm work. Because these are all something you have to handle at the construction site, and if you have a lighter element, it is always preferable for the workers to use.

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So this is I think with this I will stop the lecture today. So covered the various uses of the wood. And what are the different properties and different types of wood we covered? We looked at the seasoning, and we looked at how the shrinkage properties? We looked at the structure physical and chemical structure of wood. And then, we also talked about the different mechanical properties and different.

You know which products are available and the concerns moisture stack, and how we should be careful while using such products? I think with that. I will close this lecture on wood. Thank you.