Building Materials and Construction
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Module - 13
Lecture - 2
Glass and Timber: Timber

To conclude our discussion on timber; let us look into some additional issues on structure of timber.

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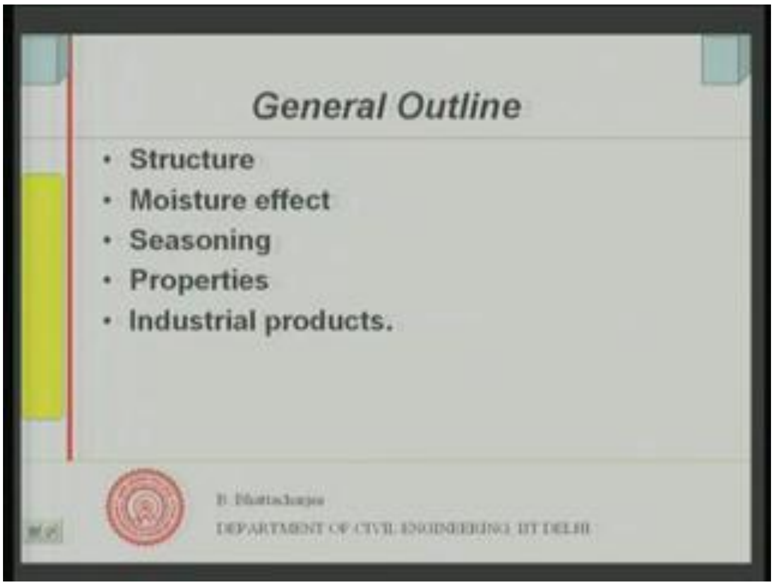

And we shall see moisture effect, seasoning, properties; some important properties. And you see timber today is in a large scale used as industrial product as boards and particle boards plywood's and so on. So, we will discuss more on them within our time limits, because additional discussion on actually timber as a product as a structural timber as a product; that is not being covered in this lecture, because of the paucity of the time. So, we will look into industrial products instead, because which are more definitely more efficient use of the timber.

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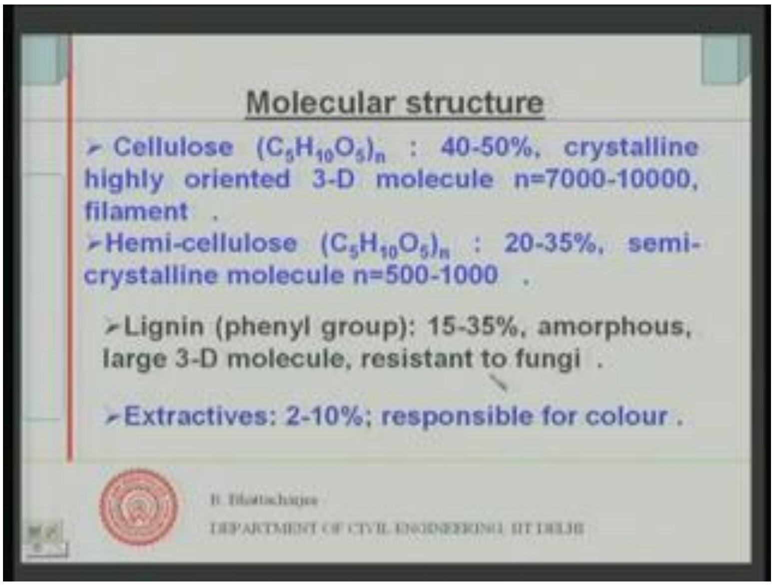

So, let us continue with our discussion on molecular structure. We did not talk about we just said that, you know it has what type of growth of the tree we looked into and we said talked about sap wood, the heart wood etcetera. And also we talked about conversion, but we did not talk about what the molecular structures of wood look like. Now, molecular structures of wood if you look at it; it is actually it is cellulose are the fibers right, this is the formula of cellulose is this that constitutes about 40 to 50 percent. And the crystalline cellulose actually it is crystalline highly oriented 3 D molecules right and its pol degree of polymerization or number of molecules in the chain could be 7000 to about 1000, the filament formation in form of filaments.

So, this is of kind of fibers which are there in the wood. Then the other same 1 hemi cellulose same formula, but that is semi crystalline and 20 to 35 percent. So, 40 to 50 percent is this, 20 to 35 percent is this and this; obviously, is much shorter chain length 500 to 1000 is the degree of polymerization. So, these are the 2 fibrous material those are present in the wood. And the other group which is present is the lignin phenyl group that forms by enlarge the matrix part of it 15 to 35 percent amorphous and large 3 D molecules, this is resistant to fungi.

So, this 3 are the main constituent chemical constituents of wood and other extractives are 2 to 10 percent, this are responsible for color as you get in the wood. For example teak wood has got it is or you know for that matter for example, mango wood which is yellowish in color. So, there are different brownish color wood let us say. Some woods are yellow color, some wood are reddish color. So, their extractives are responsible for the color of the wood right. So, that is the chemical structure of the wood.

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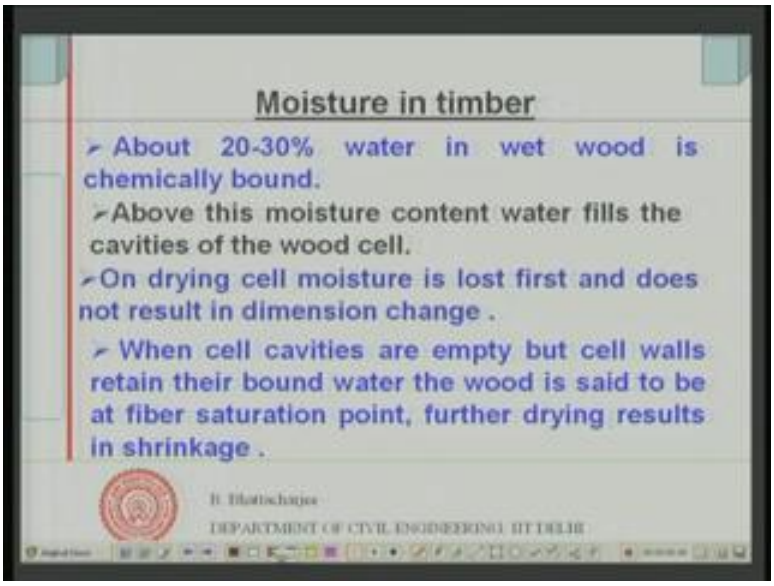

But most important is the moisture in the wood. About 20 to 30 percent water in wet wood is chemically bound. You see this water as we have discussed earlier also several times that, water can be bound chemically and physically absorbed water, then a capillary water etcetera and mechanically held water and so on. The same thing goes on in case of wood as well. So, about 20 to 30 percent water in wood is chemically bound. And there is about you know there is some moisture content which is about 27 percent. So, I will say this is about 27 percent moisture, content around 27 percent moisture right about 27 28 percent moisture content, 28 percent moisture content, cavities of wood cell remains filled.

Now, this is chemically or physically bound, actually chemically bound some amount of it is physically bound. And higher moisture content; they fill the cavities of the wood cell, higher moisture content fills the cavities of the wood cell. So, when you dry the wet wood, the cell moisture is lost fats, you know which are capillary water in larger cell cavities which are there, which are not chemically or physically bound, mechanically held or capillary bound; they would be actually removed fast right. And this does not result in any dimensional changes because; structure of the material has not changed.

If you remember, there is an analogy in case of concrete also; if you have you know capillary waters lost, there is no dimensional changes, but when you have physically absolved water is removed there can be dimensional changes. So, when cell cavities are empty, but cell walls are cell cavities are empty, but cell walls retain their bound water right, because the cell structure is such that it has got a cavity inside, then the boundaries have bound water. And this state is said to be fiber saturation point, this state is said to be fiber saturation point. And if you dry it further it will result in shrinkage.

So, so long you remove the capillary, you know capillary water or cavity cell cavity water there is no problem. But, the bound water the moment you start removing them; that can results in shrinkage. And water up to which you know drying up to that water does not result in shrinkage; that water we call as fiber saturation point fiber saturation point. So, fiber saturation point is what; it is the amount of water at which actually the cavity cells are empty, but the cell boundaries are you know cell boundaries have their bound water there. That is what we call it as fiber saturation point. This is an important aspect.

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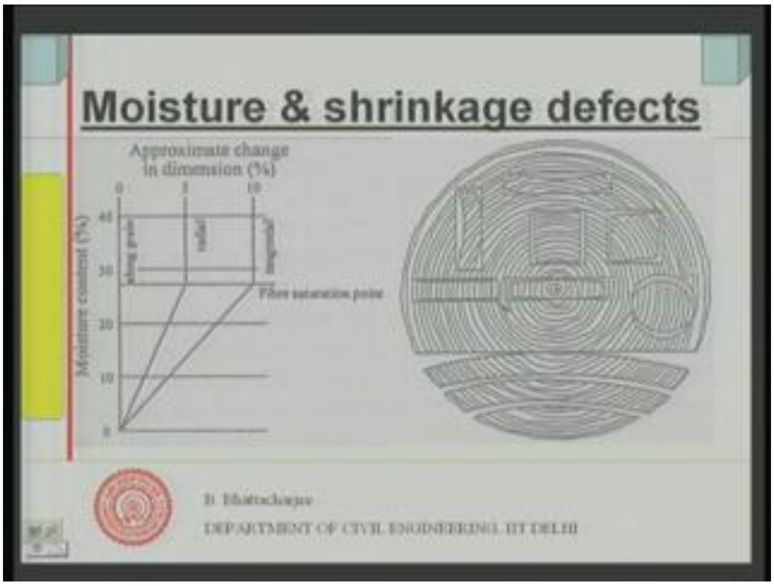

Now if you look at this diagram you see if I reduce my moisture content 40 percent here downwards, let us say if you reduce our moisture content right and you can see approximate of x axis is the dimensional change. So, this was my original dimension let us say and along the radial direction and also in the tangential direction. So, since I told you about the fact that wood is anisotropic; its properties could differ along the radial and tangential direction actually they differ. And, because growth in growth is along the radial direction and in tangential direction if you go at certain level, the molecular structures are different. That we have seen yesterday.

So, if we look at radial direction the moisture content or dimensional changes, if I as I change the moisture content from 40 percent to 30 to about 27 as I said, this is the fiber saturation point. So, as you reduce the water content you know there is no dimensional change till fiber saturation point, because what is happening; actually low you know bound weakly bound not strongly bound that is water which are there which are bound to the structure of the wood by weak bonds, very weak bonds capillary bonds are relatively weak so long, so you empty them easily, the cavity gets becomes emptied. So, when cavity becomes empty there is no change in the overall structure and therefore, upto this point; either radial or tangential, there is no change in the dimension.

But if you now start further drying right further drying and reduce down the moisture content much lower, then you find that that it shrinks, dimensional change in approximate change in dimension that much it will shrink. So, the shrinkages takes place and of course, this shrinkage is measured with reference to 0 moisture content. So, shrinkage takes place as I go down and this result in defects.

We will see this defects again in more details, because this can result in defects and we name this defects later on you know each of them will … So, this can result in formation of certain defects in the timber as it shrinks. We will see this defect in more details.

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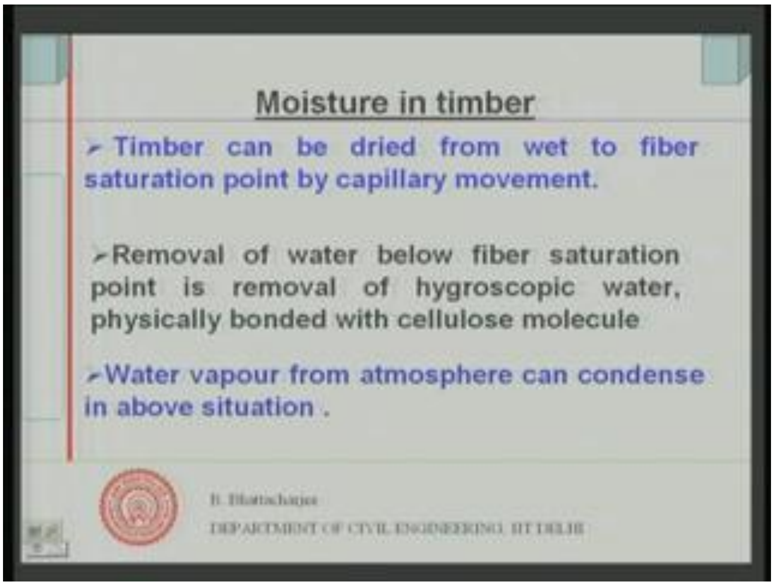

So, you can, but then you cannot use wet timber. You know wet timber cannot be used right. And you got to dry it from wet to fiber saturation by capillary movement simply. But beyond that you will actually require some heating right. So, actually what is happening till cavity you know the cell cavities of wood these are all capillary of water. Further removal of water is nothing, but physically bound or chemically bound. First physically bound hygroscopic water and then you know this chemically bound with cellulose material or cellulose fiber cellulose molecule. The water that is bound chemically with the cellulose molecule that is what you will be removing. Now this water is hygroscopic right.

So, if you want to remove them you have to give more energy that is number 1. And wood in actual structure or in this use it would be in conditions, where you know it would be the relative humility would not be 100 percent it will be much less. So, actually drying would take place in actual use the moisture content what is known as equilibrium moisture content with the atmosphere, depending upon the situation whatever is the relative humidity and the condition of the atmosphere; wood will go on losing its moisture. And it attains what is called a equilibrium moisture content with the surrounding that most of the material does.

So, this equilibrium moisture content; it should be such that, you know moisture content of the environment and the wood should be of the similar nature so that, it does not lose too much of moisture while in use. And if it loses too much of moisture, then that will be shrinkages in use. So, that is why we would like to ensure that it does not lose much water. But below fiber saturation point the moisture can be lost as vapor. And if there are vapor present in atmosphere it can condense in to the wood again.

So, moisture condition can go on changing depending upon the actual moisture content of the wood and the atmosphere surrounding atmosphere; relative humidity of the surrounding atmosphere below the fiber saturation point. So, when you have low let us say you have something like 20 percent moisture content in the wood and atmosphere is such that, it can absorb lot of wood the vapor pressure within the timber and outside is lower, then it would absorb some amount of the moisture vapor, atmosphere will absorb some amount of moisture vapor.

On the other hand if the atmosphere is dry I mean saturated and wood is relatively dry, there can be some amount of condensation within the wood. So, there could be transfer of moisture vapor from wood to the atmosphere and atmosphere to the wood if, there is there is differential exist if sufficiently large differential exist right. So, both this can take place. And therefore, we would like to maintain condition such that not much of moisture transfer takes place from wood to the atmosphere or atmosphere back to the wood, resulting in shrinkages right. So, that is that we do through what is known as seasoning. We will look into seasoning a little bit later. Let us see what are the effect of moisture on strength?

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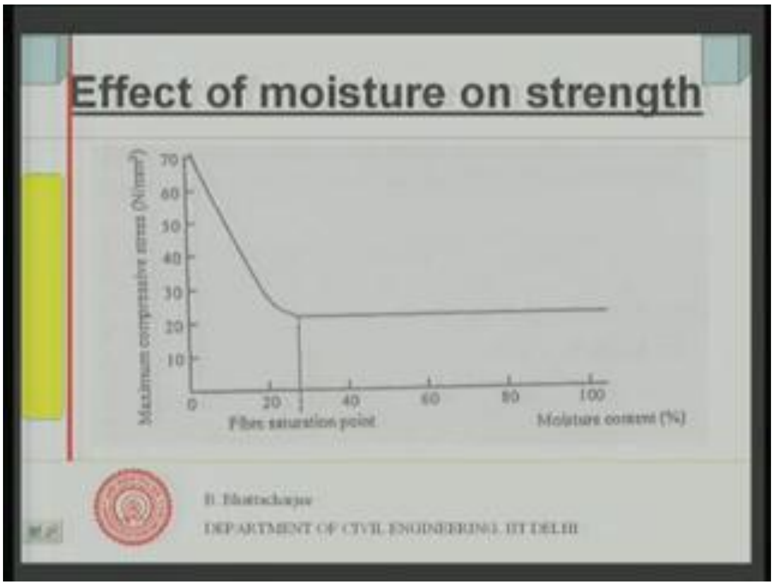

The effect of moisture on strength is something like this; you see this is my fiber saturation point, beyond this as I go on increasing moisture content; there is no change in the strength. But lower than fiber saturation point you know points, lower than fiber saturation point along here, because this diagram shows moisture content along this point, this is my fiber saturation point, this is my fiber saturation point and as I go down along this direction, my strength reduces, strength you know it reduce in strength is I mean strength is increasing. A drier material we know is stronger strength is increasing. And from here strength reduces and its is constant at your fiber saturation point right, because it is all saturated, no further moisture would affect any way.

But we know that when you have less moisture, there is a reduction in I mean increase in strength and this happens in all materials in connection with the basic phenomena, behind we have discussed in case of bricks as well bricks and concrete as well. So, as moisture content reduces, the strength increases and it can be sufficiently large of course, it can be sufficiently large in oven right condition; obviously, it will be very you know it will give high value of moisture I mean strength. Strength would be relatively high.

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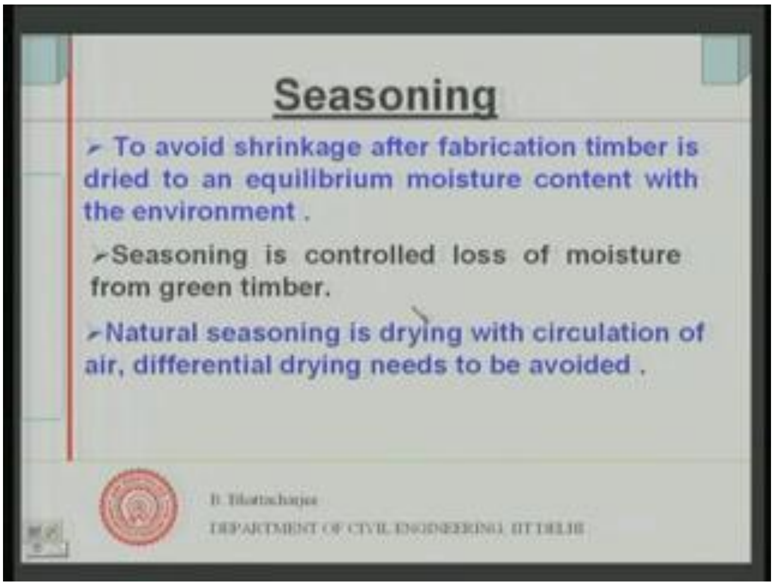

I mentioned to you something called seasoning. Now seasoning is to avoid shrinkage after fabrication of the timber, because timber when you dry timber, you know after even you dry it can shrink. So, if this shrinkage takes place after fabrication, after it is in use then; obviously, it would you know the functional performance of the timber; either as a structural member or as whatever we were using it that will be lost.

So, therefore, we do not want any shrinkage after fabrication. And it must be in close to the right to the equilibrium moisture content with the environment. So, we dry it dry it right in the beginning, before putting it to use to such moisture content, where it is likely to be in the equilibrium with the environment and that process we call as seasoning. Seasoning is basically controlled loss of moisture from green timber, green timber as it is taken again from the you know it is after felling of the tree as you get from the tree.

So, this seasoning is basically loss of moisture controlled loss of moisture. Natural seasoning is drying with circulation of air and 1 must have avoid differential drying, 1 must have avoid differential drying, because if the top surfaces is drying at a faster way and inside is drying at not drying at the same rate what will happen; there will be shrinkages at the top and the bottom would not shrink to that extent, it will resist that shrinkage and that will result in cracking or warping or some defects at the top surface. So, differential shrinkage you know drying is not desirable at the core and the surface must dry at the same rate.

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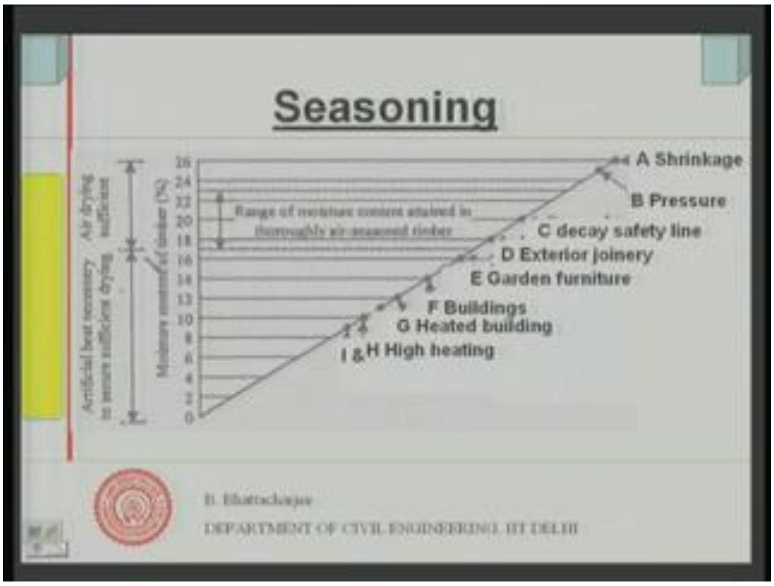

That is the idea right. And one can have natural seasoning or 1 can have heating, because up to certain point you can do natural seasoning, what is done is; after sawing of the timber the air is circulated you know they are stored and the air is circulated through them. And nature if you circulate the air at the normal temperature upto certain point of time the upto certain level of moisture content they will be actually dried, but below that moisture content you have to supply heat right.

So, we can say that this is up to this moisture content you see my fiber saturation point is here, fiber saturation point is here. So, till this point beyond this point the shrinkages takes place, above this point of course, it has you know above this point is of course, roughly about near you know above this point right. So, from these shrinkages takes place. So, what we do we is; we actually dry up to this point say about 18 percent moisture content or, so it is possible to dry with air right air drying. And below that of course, you need heat. So, hot air can be supplied, hot dry air can be supplied so that, you can reduce down the moisture control, content moisture content; you can dry it off.

But in a controlled manner the weight has to be searched that, the rate of drying of the surface should be nearly same as the rate of drying to the core. Or the amount of heat transferred from core to the surface or moisture transferred from core to the surface is same as the rate of moisture loss from the surface right. Now, you can see that, this is you know if you see this first of all let us see this is where you were likely to use the timber in area very close to the heat source; let us say then, the moisture content equilibrium moisture content will be very low.

Therefore, you should do the seasoning or drying up to this temperature. If it is kept again and not close to the source, but highly heated zone, then possibly this line 10 percent or so. Heated building could be about 12 percent right, normal building not much heated about 14 percent, garden furniture somewhere around 16 percent or so on right. So, this is similarly exterior joinery and so on, where you are expected to apply pressure decay up to this is, there will be no decay safety line below this you know upto this is decay safety line and above this there can be other kind of effects coming in.

So, you can see along in this diagram you can see in this diagram that, different conditions where as different moisture content to be there, for different environment a different moisture content to be there where, you expect that there will be no shrinkage, the atmospheric moisture content is about 26 percent or so you know you can leave it at 26 percent. But if it is likely to dry out at lower moisture content, lower moisture content then, you cannot keep it here because that will show a excessive shrinkage at that point. And you can see this range of moisture contents attain through air drying of timber. So, this is the range of moisture content which will attain through air drying and beyond this point of course, you need to have energy.

So, seasoning is essentially done, in order to attain especially control drying in order to attain in order to attain a moisture content you know equilibrium moisture content with the environment, where actually the timber is likely to be put in use put it in use. So, that is what it is seasoning. Now improper seasoning can results in various kind of defects.

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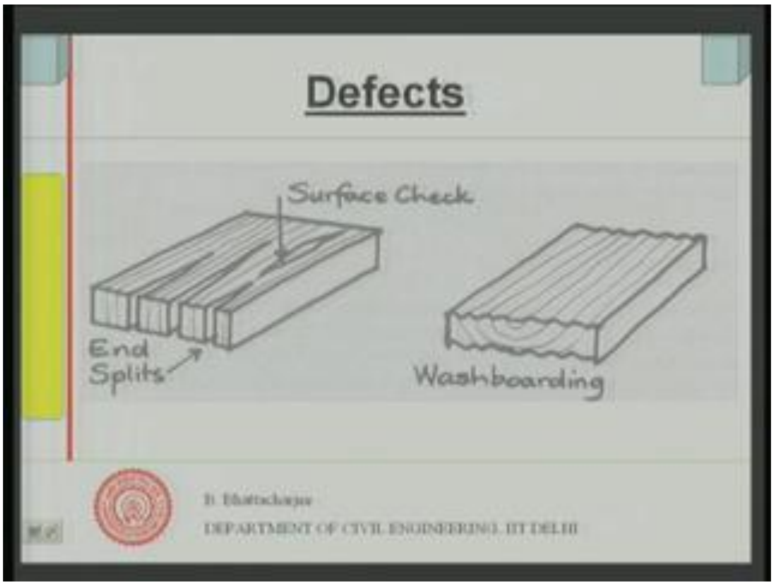

For example, end splits; you know like this 1 end splits, as shown surface cracks are forming, then this wash boarding something like this right.

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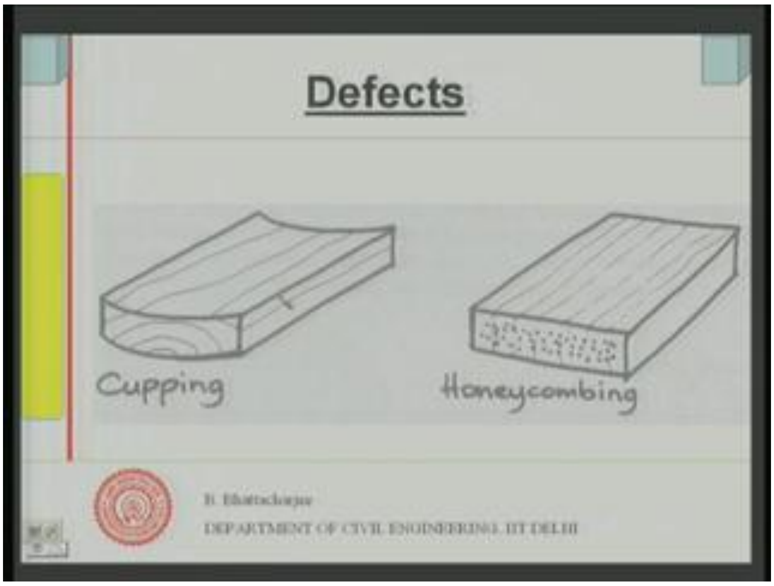

Various kind of defects that can come; this is called cupping and honey combing there are gaps here, while this can come from you know cupping can results from season seasoning defect.

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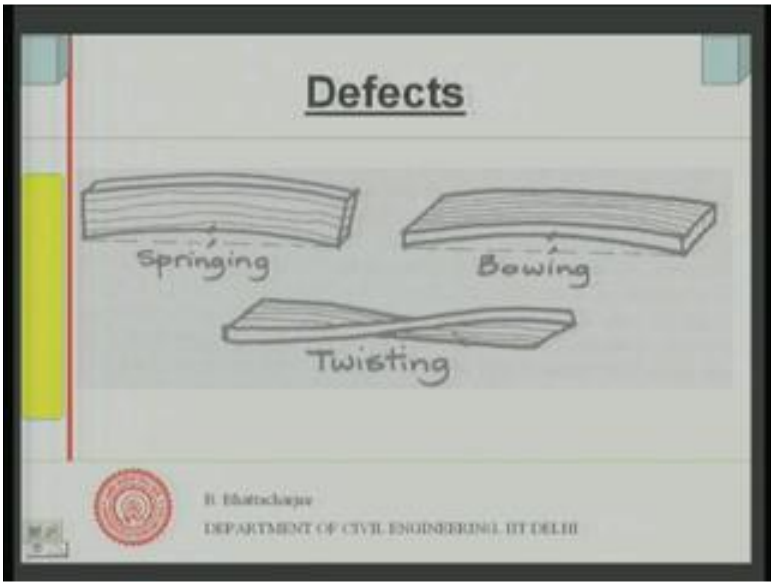

And other defects are twisting, bowing, springing; all these defects are possible in timber after sawing and seasoning.

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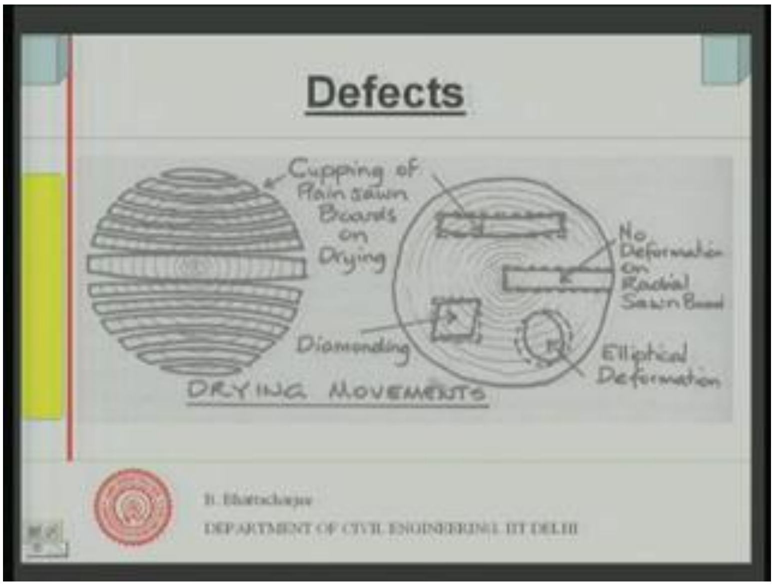

And if you see the seasoning defect drying you know basically cupping is this 1. We showed it earlier, we looked it we had similar diagram earlier also, we had similar diagram earlier also; cupping is you know rain sawn boards on drying, it would show you that, if you just dry it not proper seasoning, then this is cupping this is cupping. And this is diamonding actually its original was this, after drying shrinkages it is diamond shape. Then elliptical deformation a circular 1 turn in to an ellipse of course, here there are no deformation on radials on board, but this is cupping, it is again cupping. So, this kind of defects one can see in case of timber after seasoning. Now, what about the properties of the timber?

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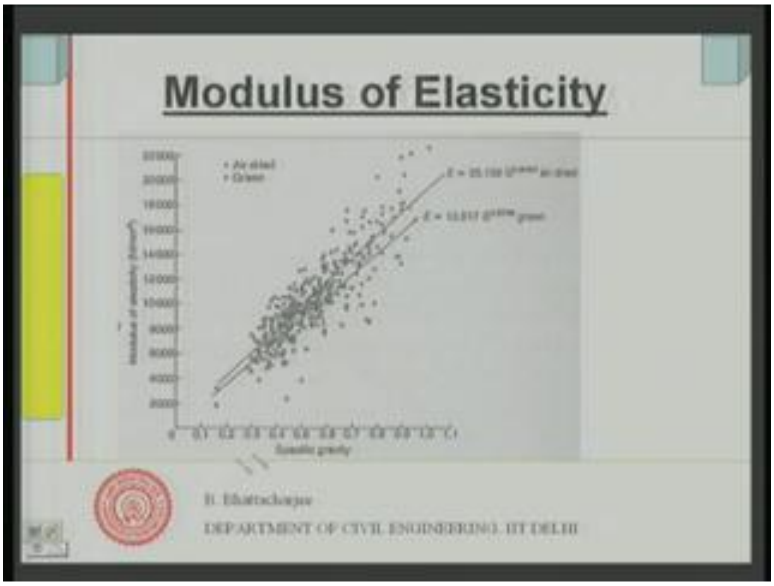

They can be related to specific gravity. Now 1 thing first of all we can see the values of this specific gravity, which are you know this x axis is specific gravity. And this values as you can see are order of about 0.1 to1.1 which means that the density would be varying from about 100 kg per meter cube to 1100 kg per meter cube, which is fairly small compared to the other materials that we have looked into so far and their densities specific gravity are densities were much higher.

So, this relatively light material, this relatively light material. And its modulus of elasticity you can see that in air dried and green condition that is before drying, the modulus of elasticity falls into a kind of a band and you can therefore, relate it to the specific gravity in this manner, you know it is simply a linear specific gravity you can relate it in this manner, something sort of exponential form 1 can relate to right. And this 1 air dried situation which is higher 1 can relate to this. So, modulus of elasticity could be related to this.

Now timber is a very resilient material as you know and their stress strains diagram its almost brittle straight brittle, depending upon of course, whether it is along the grain or perpendicular to the grain. When it is actually pulled and under tension or compression along the direction of the grain, if you try to pull it off course, this will be a fiber breakage, if you try to compress it along the you know parallel to the grain, the grain failure do take place, but when you are trying to compress it perpendicular to the grain, actually it compresses and it does not break; it just simply compresses up to certain level.

So, actually failures are defined accordingly depending upon the rate of deformation or total deformation etcetera wherever appropriately they are defined in terms of those, wherever required. Now in any case it can absorb a lot of elastic energy, it is resilient. And therefore, where you have shot an impact and they were earlier used very much, when timbers were available in plenty. Today of course, timbers are not available as much and we do not know its use is restricted from the environment point of view. However it has got it is a high resilient material, it can with stand absorb a lot of energy within elastic range and it has got good elastic recovery. So, any way this is modulus of elasticity.

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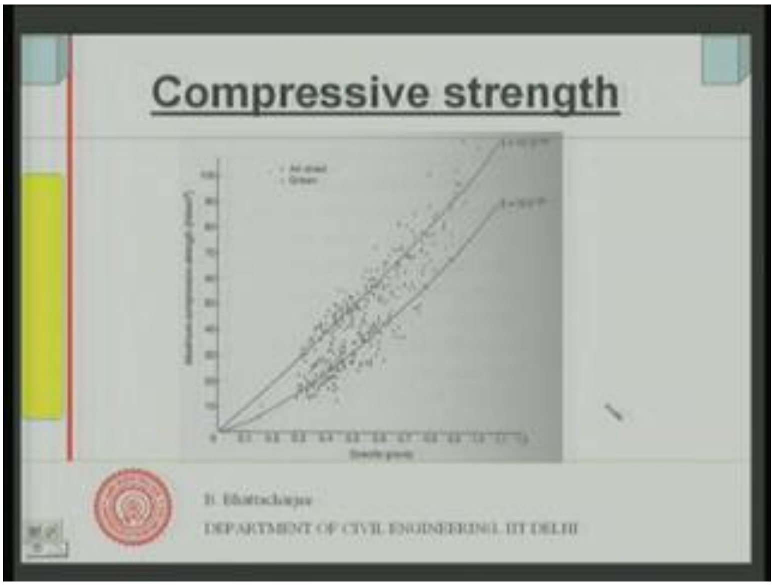

If we look at strength; strength can also be related to the specific gravity very easily. You know this axis is again specific gravity, this axis is specific gravity and this axis is compression compressive strength, you know this axis is compressive strength. And you can see then these are also related to the specific gravity g, these are also can be related this can be related to specific gravity g. And as density increases or specific gravity increases strength increases; this is well known to us. So, strength increase as specific gravity and specific gravity and increase this is well known to us. So, this is what the properties of timbers are.

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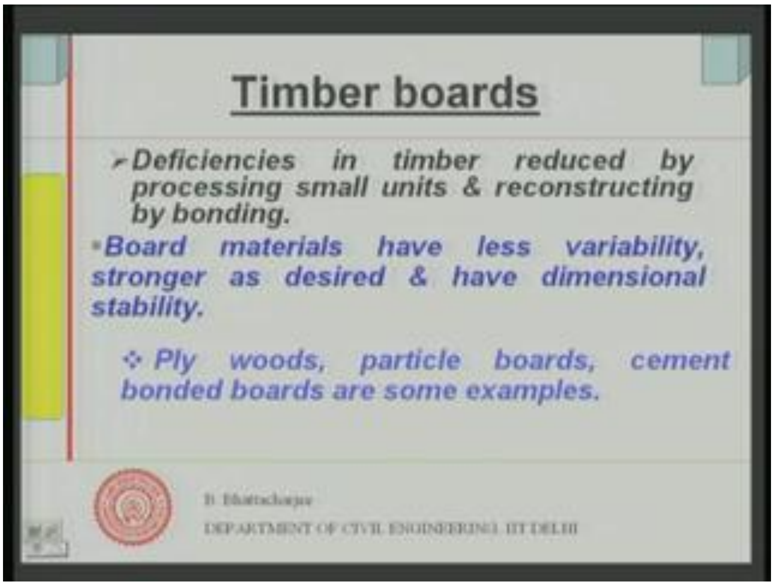

Now of course, there are gradation of timbers in terms of soft wood and hard wood. Soft wood are generally weaker ones, hard wood are the stronger ones. And structural gradation is available in the Indian standard code for various types of timbers to be used in structural situations. But more importantly today in fact, we do not use the timber as it is, you rather use it as kind of industrial product, because use of timber directly is not very efficient. As we could see there are lots of varieties of defects those are possible. There can be lot of wastages, first of all the wastages in conversion itself and then defects in terms of the inherent defect in the tree like knot, you know actually grains are no longer parallel, but they form a kind of a knot as this called. And therefore, these are weaker points in the timber.

So, there are lots of wastages and its properties differ from, because its anisotropic properties differ properties in the perpendicular and to the direction of the grain and perpendicular to it they differ. So, what one can do; one can actually make use of you know make use of small timber pieces or process them at a small level and then join them, reconstruct them together to get more efficient system.

For example deficiencies in timber reduce you know reduce by processing small units. So, we process small units and you know they can be by enlarge defect free and then you can design them. And then reconstruct the whole thing by some sort of bonding, because today you have lot of bonding material available. So, we can use reconstruct them using bonding. For example, you can bond the way you like. So, you can design this material. So, this timber boards are those kinds of products, which are actually produced by processing small units and reconstructing them by bonding.

The boards will have much less variability, stronger as we desire and will not shrink, because we are using pieces very small pieces or they are bonding them gluing them right. We will see some of them. What do you use; like we know the ply woods for example, you know ply woods, you know particle boards or cement bonded boards and some these are the some examples. We will look into some of them at the moment. We will just look into some of them right.

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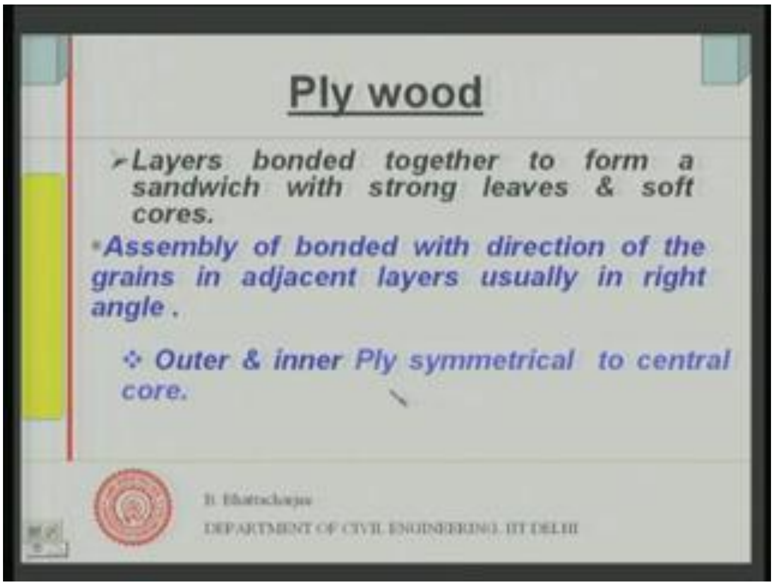

In case of you know you can bond layers you can bond layers to form a sandwich with strong leaves and soft cores. Now if you remember we talked about sandwich construction; something like this you have possibly a leaf and you have possibly you have possibly another leaf, you have a leaf; you have a 1 leaf and another leaf and in between you have some other core material. Now remember when you talking of polymers; we are talking of such sandwich material. Now such sandwich material when you apply transverse loading say load along this direction, load along this direction, when you apply transverse loading; the bending is stresses are maximum at this point, we know that bending stress are maximum here and here, because the maximum compression will be here maximum tension will be here.

And the core is suppose to transfer the, is a shear connector basically transfer the load from 1 leaf to the other through shear, because this will bend this will bend right and get a shape its dimension will be shortened. If you see the next layer which is bonded to it, it will be shortened relatively less and so on so forth. And at the center the neutral axis we know that it does not actually, there is no change in the dimension. That is what we assume in linear elastic theory. And as we go below this that is each 5 each layer will be actually longer than their original dimension.

So, in the process therefore, if there is bond this is how it will get transferred; from the top layer would try to shortened the next layer and next layer will try to shortened the next layer till the neutral axis. And below the neutral axis it will actually cause elongation of those layers. So, therefore, purpose of this code is to transfer shear transfer and we know the shear stress is maximum in case of bending, bending shear is minimum here and it increases in a parabolic manner and maximum is here, shear stress is maximum, as some where bending stresses we know is thing like this, bending stresses we know is thing like this. You know maximum at the top compression and maximum tension at the bottom, so this we know.

Now, therefore, shear stresses are maximum here. The core should be withstanding with maximum shear and the leaf outer leaf and the bottom leaf should be withstanding the tension in the compression. Now, this same idea can be used here also. So, we can make a kind of sandwich structure, sandwich structure with strong leaves and soft cores. So, strong leaves can withstand the forces, bending forces and core should transmit the shear. It should transfer shear transfer and also might give other properties improvement in kind of other properties.

So, assembly of bonded you know assembly of bonded with direction of the grains in adjacent layer usually at right angles. So, this assembly of this one is layers are bonded with direction of the grains in adjacent layer usually at right angles. Now why is this basically; if you have you know if it is in 1 directional the forces we will get in mean the properties we will get is directional. It is making see if they are perpendicular to each other, if the directions of the grain are perpendicular to each other, then the strength will be same in both the direction so both in horizontal x and y direction.

In z direction if you apply the load, let us say a ply wood board something like this which we shall see later on; it will have it has got a sandwich construction at top layer at bottom layer and the core. In the core you will have you have actually sort of pieces or small pieces with such that, the grains are perpendicular you know grains in adjacent layers are perpendicular such that, the strength will not be directional, it will be both directional. So, outer inner plys are symmetrical to the central core and that is how they can withstand lot of load.

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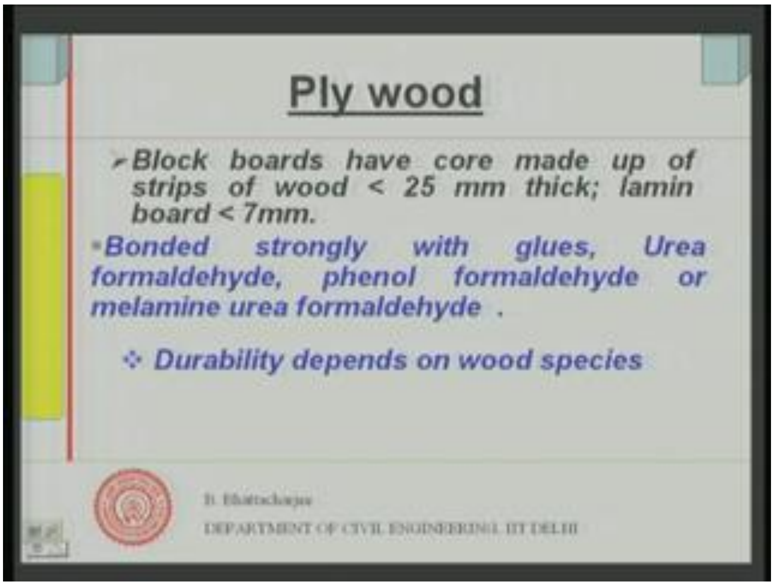

There are different names of the similar kind of materials; the block boards have core made up of strips of wood, you can make them up of strips of wood less than 25 millimeter thick. And lamin board have less than 7 millimeter thick woods, as we shall see. These are bonded with the glues, now you have polymeric glues for example, glues we have discussed about the adhesives like urea formaldehyde or phenol formaldehyde or melamine urea formaldehyde glues. So, these glues are used to bond with and once you bond them you get right kind of property. Durability of course, of the wood depend upon the wood species itself, durability will depend upon the wood species itself right.

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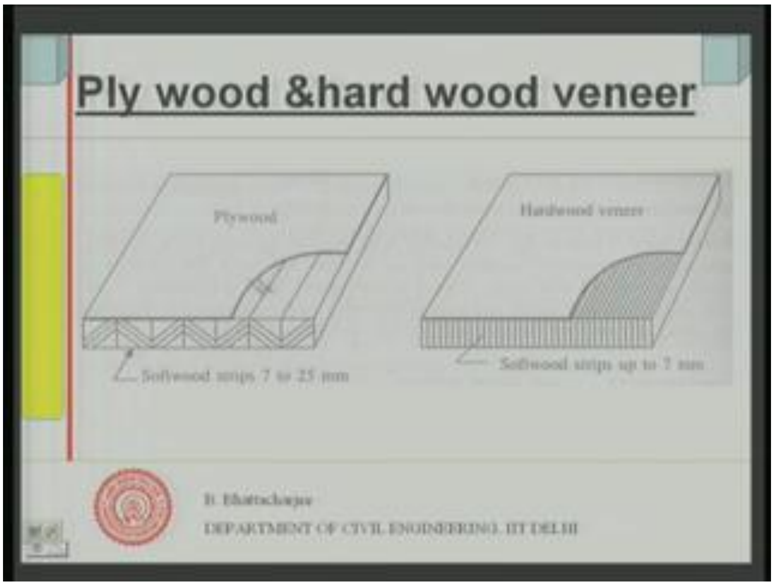

For example, this you can see is the plywood. Now, you can see this is a soft this you can use. So, you can make use of soft wood and you know soft and hard kind and this ply again could be bonded you know bonded with glue could be bonded with glue fiber board's basically. Now, here you can see this, this is the grain direction. So, they are perpendicular to each other. For example, if the grain direction was all in the same direction. So, it will have strength only you know if you have, in this direction the strength would have been all in the same direction; let us say all in the same direction. Then strength would have been higher along this direction, along the direction of the grains and low along the perpendicular to it.

But making some grains along this direction and some other grains along this direction, it is actually properties along this x and y direction are made equally good. And you can see this is the, this is the soft wood strip, this is another softwood strip, another softwood strip and so on and this softwood since it is un not expected to take too much of the load, you know this the transverse load when I apply load like this, the load will be taken by the bending stresses would be taken by this outer leaf and the bottom outer leaf. And this would only transfer it will be ensuring shear transfer and shear you know shear transfer is ensured like this.

So, therefore, this leaves are meant for taking transverse load and this board. So, we can use strong this board, but soft wood can be used here. Similarly the lamin board as I said this soft strips this is 7 to 25 millimeter, 1 of them we said block board. So, this is a block board and lamin board are the 1 I said. So, there is a strip simple strips along this direction; strips of simple softwood strips along this direction and you have a hard wood veneer right. So, it is again a kind of a board basically a strong board. So, this is this forms the leaf; the bottom 1 forms the leaf. And all this are joint by glues, this ones are joined by glues and this 1 is also joined by glues, and therefore it gives you the requisite kind of strength that you desire.

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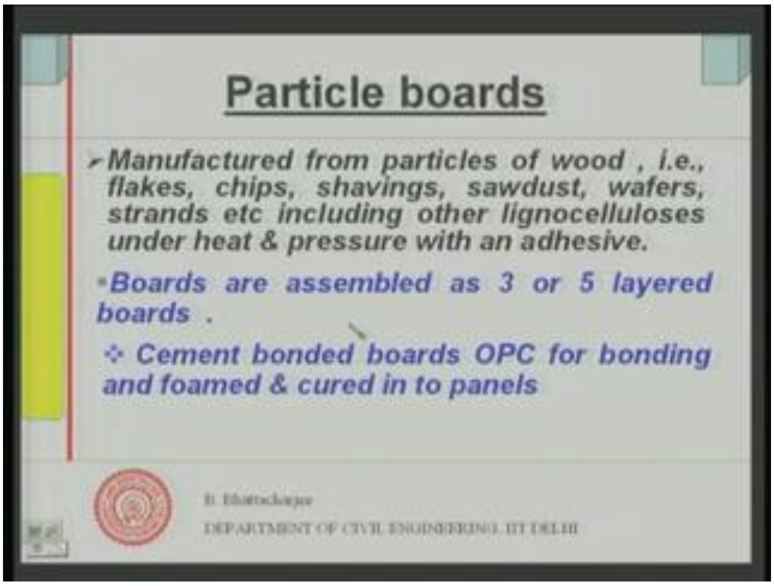

Then there are particle boards. So, one thing is used in a previous case, plywoods basically you are using small pieces of wood. You are using small pieces of wood and you can see that, this otherwise you know may not have been used. For example, the softwood pieces which you have used; they are not very strong, but you have used them efficiently by reengineering the whole thing. Or rather, you know kind of reconstructing the whole thing. And it is a definitely more efficient use than using direct using the direct timber just you know as it is or after conversion straight away after conversion.

So, other kind of another kind of very efficient uses particle board. Now this particle boards are manufactured from you know particles of wood flakes. So, if when you actually polish the wood, you get shavings wood shavings right with a file, you know you polish the wood with files, then you will get shavings, you will get flakes. The chips would be there when you cut it into cut let us say, when you are actually cuts it into some sizes. Then saw dust would be available after sawing and this saw dust would be available after sawing, wafers are available at certain places, strands can be made available while processing the wood.

So, all this comes from processes in woods and normally they would have gone as waste So, this materials can be used together with some sort of adhesive glues and use heat and pressure to form boards. They can be used efficiently for various purposes. Now not only this you can use other lignocelluloses, all lignocelluloses products other than cellulose products under heat and pressure with adhesive to get this particle boards.

You can make them layered boards. In fact, coming you know considering that plywood earlier, 1 can think in terms of layers even there like something like this; is 1 layer right, this is 1 layer of the material, 1 layer first layer, there the orientation of the fiber would be like this. The second layer could be orientation of the fiber could be along this direction. So, those where even in plywoods there can be several layers or boards various kind of boards, where there can be more layer. Now here these are this are boards can be assembled in 3 or 5 layered boards. They can be assembled in 3 or 5 layers and you can have also other kind of boards such as; cement bonded boards with you know usually say such kind of materials as the wood shavings, chips, saw dust, wafers, etcetera, strengths and other kind of material, together with this you can bond with cement.

So, it is something similar what we have done in case of let us say. And here in here in case of many of them, we use polymeric bonding agent and some other cases you can use cement bonding agent right and they can foam them. Now foaming means what basically you can make them light weight so that, you can it can be used for various kind of insulation purposes.

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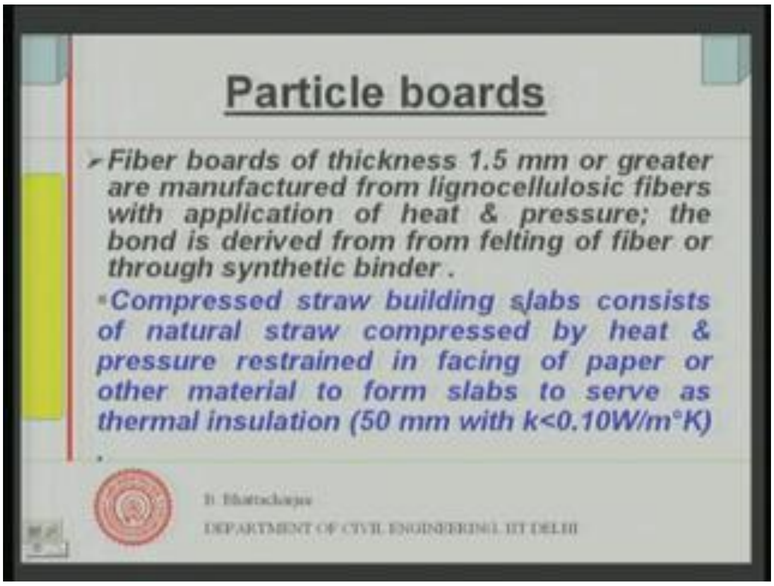

Fiber board's: fiber boards are they have thickness about 1.5 millimeter or greater and their manual manufactured from this fibers. So, earlier what we have seen; we have seen plywood's actually uses the small pieces of wood themselves, they glued together. Plywood uses the small pieces of wood themselves they glued together right. And in case of um particle board, the wood wastes of various forms we are gluing them together. So, first 1 is the wood itself is being glued together pieces of woods; second 1 is where we are actually the waste finer ones, fine waste we are gluing them together and now we are trying to look at the fiber themselves.

So, supposing this cellulosic fiber we take them right or any other form of lignocellulosic fiber, we take them. And then under heat and pressure we join them either using a synthetic binder like urea formaldehyde binder some sort of glue. So, we bind them together and then compress them right under pressure or heat them up. Or use this material fiber themselves so that, they bond themselves right. They bond them you know they themselves bond by felting you know. So, you bind they become a form a felt when you compress them under pressure and heat them up. So, by felting they bond themselves; let us say it is 1 thing.

And second case could be used a synthetic fiber. So, what you get is a fiber board. The thickness of all are small 1.5 millimeter or greater. And these fibers again can be used as leaves outer leaves or outer leaves for you know other kind of sandwich construction right. Then there are compress straw boards; straw can be used as a material and compress straw boards you can make slabs actually straw building slabs right. Now here you use straw, you compress it by heat and pressures actually we join them. You compress it by heat and pressure and join them right, by putting papers bonding papers with it and you form a kind of slab. So, papers and straw compress to the level papers at the top bonded together and this kind of thing you can form into slabs.

Now this will be very, very light weight and as you know light weight material forms good thermal insulation, light weight lot of porosity straws are very very porous and when you actually put the paper as the restraining and bonding material bonding you know bonding bond with the paper. So, this forms a very light weight material. And its thermal conductivity should be less than 0.1 watt per meter centigrade and you can have thickness of 50 millimeter or so. Now, this would form good insulation material, this can form good insulation material. So, particle boards and then straw buildings slabs are something like this.

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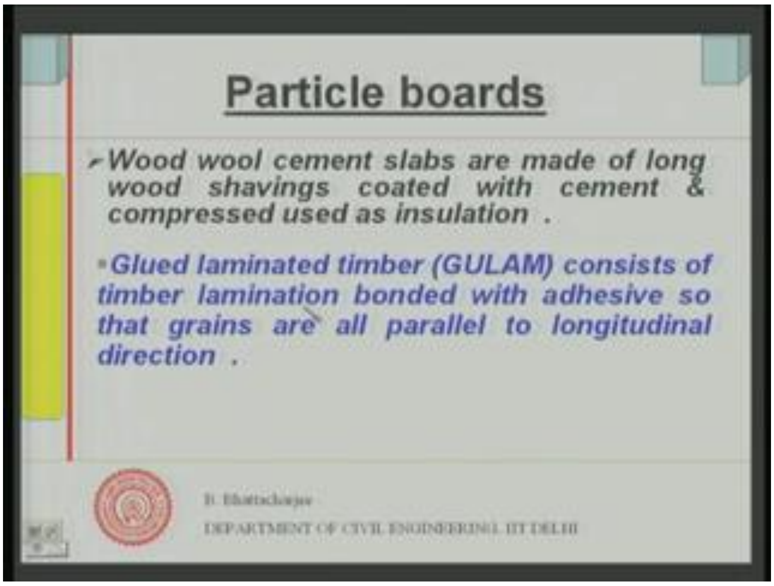

I said that cement is cement can be used for bonding purposes like particle boards can be manufactured with cement So, we have same cement you know in sort of cement mortar preparation, you essentially use sand. Now instead of sand supposing I am using wood shavings wood sawdust and all that. Therefore I can get the I can make it you know in something of the kind of board or a slab, which will be fairly light weight and can be used as good insulation.

Now, wood wool cement slabs are made from long wood shavings. So, you take wood shavings, which would come from processing of the wood and then actually they are embedded in cement or coated with cement as we are calling. And then you compress them and then they can be used as insulation. Now wood itself you see the insulation essentially have very low thermal conductivity and which is a function of porosity; in other words inversely proportional to the density. So, should have in normal temperature we are talking of the thermal properties or even insulation wood you know like acoustic insulation. Or such boards can be used as absorbers acoustic in acoustic for acoustic purposes of spaces. They can be used as absorbers, because in the pores when you have in the, you know sound absorption you need porous material. 1 of the technique to increase absorption is to have porosity pores into the surfaces right.

So, when you have pores in the surfaces what happens; the longitudinal sound wave actually would impinge to this and due to friction of the surfaces, some little amount of energy is converted into heat. So, there is an absorption porous absorbers are there they are very concrete. And boards such as wood wool cement slab or you know the straw board that I was talking about just now; they can be used at good absorbers for sound as well, because there will be lot of losses.

And you need absorption sound absorption when you want to control the you know sound we generated within the rooms. For example a sound is generated within the room and you want to control its control the acoustics of the rooms itself and noise is also or the sound is generated within the room itself, you would need lot of absorbers at certain places, because many a times you may not like the reflected sound to come back. Most of situations like in auditorium in certain locations you do not like do not want sound to reflect back into the auditorium especially from its rear portion, which causes some sort of defects in the acoustic effects.

So, absorbers are used and this material can serve as good thermal and good acoustic insulation. So, wood wool cement slabs are made of long wood shavings coated with cements and compressed using compressed and they are compressed under pressure and they can be used as insulation. So, this materials can be you know they can all this material therefore, the straws slab I talked of and similar other kind of particle boards, which are generally light weight in nature and have lot of pores in the system foamed cement particle board, they can be used at good thermal insulation in or say in partition walls, they can be sandwiched between harder leaves, in order to make them make it good thermal insulation. So, construction can use them.

Then this is glued laminated timber, consist of timber laminations bonded with adhesives so that, grains are all parallel or longitudinal to longitudinal direction. So, you can now choose the timber pieces and then glue them together in such a manner that, in a given direction all are all grains are parallel to a given direction, which what you do then in a sense, you are making it strong in 1 given direction. So, properties are utilized in a given direction. So, this is called glued laminated timber in short form it is called GULAM and consist of timber lamination bonded with adhesives so that, grains are all parallel to longitudinal direction right. So, this is this is another product.

Now with this kind of products now available, there are various kind of flash doors available right. And just as an example there are similar sort of products which are used in buildings and constructions from timber of course, use of timber will use of timber as such although, it has become less popular now because of its availability, but it has been extensively used in areas, where timbers are grown as you know as for example, in cross in roof cross.

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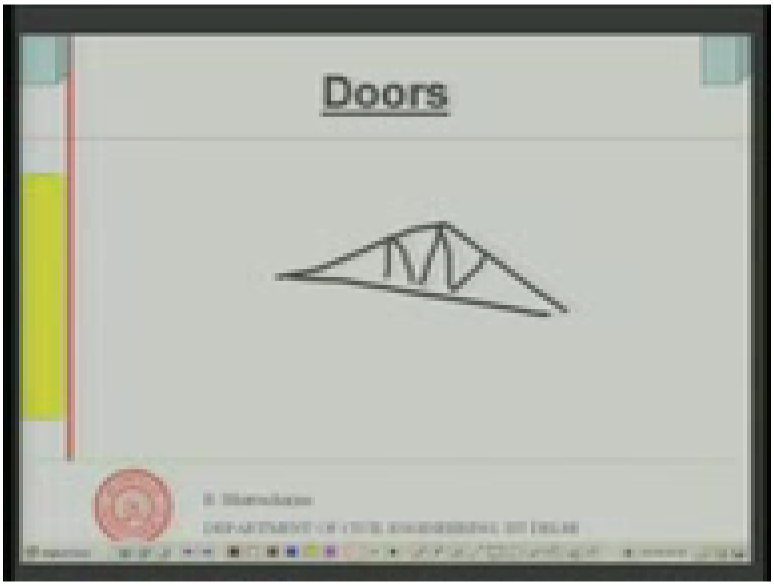

So, cross roof timber roofs are very, very common in many places. Timber you know roofing system, I mean timber frame or timber cross; they will be used for building construction for many, many years earlier, but now their usage is reduced because of the availability of timber. Similarly, the columns in particularly in north eastern part in India or let us say Himalayan areas, people would have used timber very much and even floors of timber floors have been used in cold areas of Meghalaya for example.

2 advantages, because they are light weight, can take a lot of they are resilient, can absorb a lot of energy. So, therefore, from traditional point of view they have been used extensively from consideration of you know those earthquake those areas happens to be also earthquake prone. So, timber structures where very popular in those areas earlier, but now availability of this timber directly has reduced significantly. But industrial uses of from this products, because we use less amount of timber would be used less. So, we have to use it more efficiently in case of doors and doors and similar structures ply woods and other kind of boards that we talked about they are being used. They are being used extensively and they are still quite popular.

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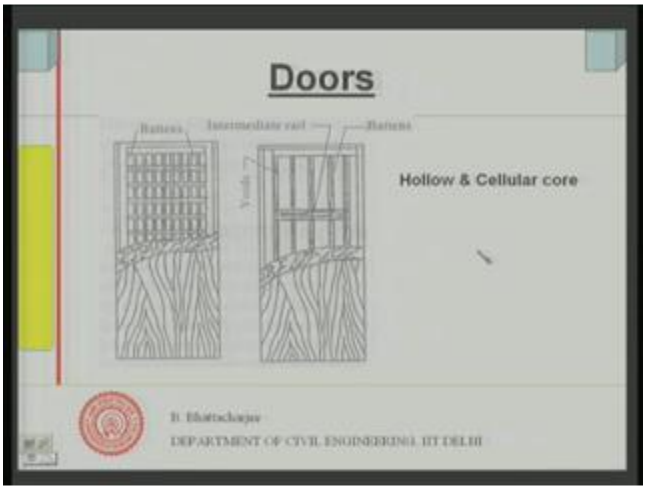

So, some of those flash doors which are available; they look like this. For example, this is a this has got hollow and cellular core. This has got hollow and cellular core this has small batons here right and this core is actually you know this is voids should be there in between. So, there will be voids here batons and then batons and they will be in between voids. And you have 1 leaf there be maybe there is another layer inside and here in this case you say you have got again the rails intermediate rails and batons this are rail and this is the baton. And in between you have got voids actually in between you have got voids.

So, it is a hollow and cellular core definitely would be light weight, mainly meant for doors definitely would be light weight and you know it will be definitely would be light weight and also sufficiently strong, because you have got the leaves here now the door essentially is likely to you know encounter loads transverse loads. And therefore, this leaves which not only gives aesthetic look, but also provides strength required strength in the given under given mode of action of load right. Inside you do not need much strength and therefore, you can make it hollow and therefore, this is 1 type of waste. So, hollow and cellulose core type of door has been is that is 1 of the types.

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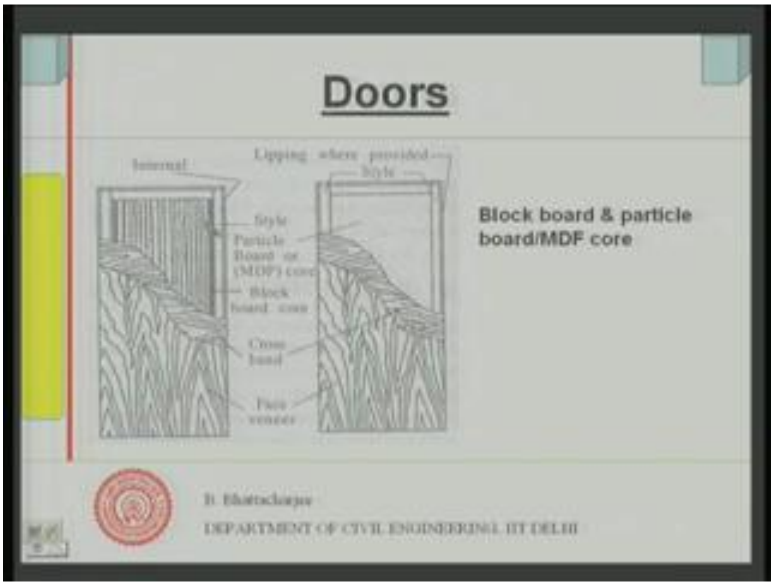

If you look at this 1 block board and particle board; in this case you have you know again this first of all the outer phase; the veneer outer phase the veneer, then you have got cross band right internal another layer. Then you have got block board block board core. So, this are block board actually block board form core here. And in this case you have got a particle board or you know macro de-factory sort of cores and this forms a door structure.

So, you should it is actually a composite, composite with core being of some kind of board particle board or some sort of 1 type of formation, the leaf being layers of leaf being different and you can have actually combinations and design them in design them I mean according to your requirement. So, this sort of industrial timber product; they have become very very popular, because they are efficient more efficient in use. You know user efficiency in use is much higher than direct use of timber right.

Now certain other aspects of timber that usage you have covered, but certain aspects other aspects of timber for example, they are durability and detoriation; this we have not covered. 1 of the major cause of detoriation of course, is the fungal attack; attack by fungus because fungus this is a material, where you know those insects can grow fungus can grow and therefore, its detoriation is in fungus effect of fungus is 1 where important issue related to decay and detoriation of timber. Now, that is why it is you cover them up with paints and varnishes and preservation and as you call it that is what we do.

But however, at the end I would like to add a preservation and details of this preservation and detoriation process in timber of course, we cannot cover them, because the time that is available to us. Now use of timber has really has become much limited than you know much less than what it used to earlier days, from the simple concern of environmental concern so much. So, that certain organization does not recommend use of timber directly. So, only process timber we can use and efficient use of timber is very much necessary, because you know deforestation is an major environmental concern. And therefore, timber; all those natural product was used away, I mean this was available very easily, now it has not as popular as used to be. And materials like other materials of the kind that is available to us, many of this partially man made or fully man made material; that has become much popular. So, I think this is our discussion on timber.

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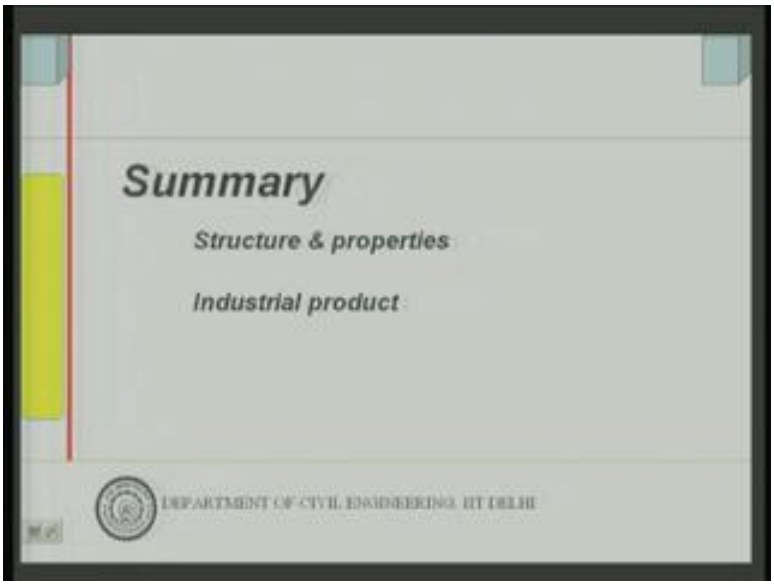

So, we can summarize our discussion. From the beginning what you have discussed; we have looked into we have gone in a of course, we could not discuss in great details about timbers whatever was possible. What we did is; first we discussed about the growth of the tree and you know from where actually timber comes from. Then we looked into some of those processing namely conversion. Then also we have looked into its chemical nature of timber. The other issues related to molecular structure or structure of timber not molecular structure, but general structure of timber, which we really not look into. And then we looked into we looked into importance of moisture content, because this is 1 major issue related to timber and moisture content is issue of moisture content that is very important.

Then we looked into seasoning; how we control the moisture. And then some of the uses sort of industrial products timber products, say direct timber products of course, we did not look into. So, I think that should summarize our discussion. We have looked into structure and properties. And then we looked into mainly into industrial product. So, with that we our discussion on timber and module 13 concludes. In the last module, we will discuss about different types of you know something about roofs and floors.

Thank you. Bye.