# Building Materials and Composites

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**Lecture - 35**
**Composites**

So welcome everyone to the last lecture of module 7, that is lecture 5 and yes, it was mainly titled as damp proofing and insulation. Here I have included composites which are a combination of two or more materials. So as you had seen in the case of thermal insulators, those were not single items, but they were within a system.

They were applied within a system, within a framing and then it was covered with something. So that is why I thought of putting the composites in this particular section.

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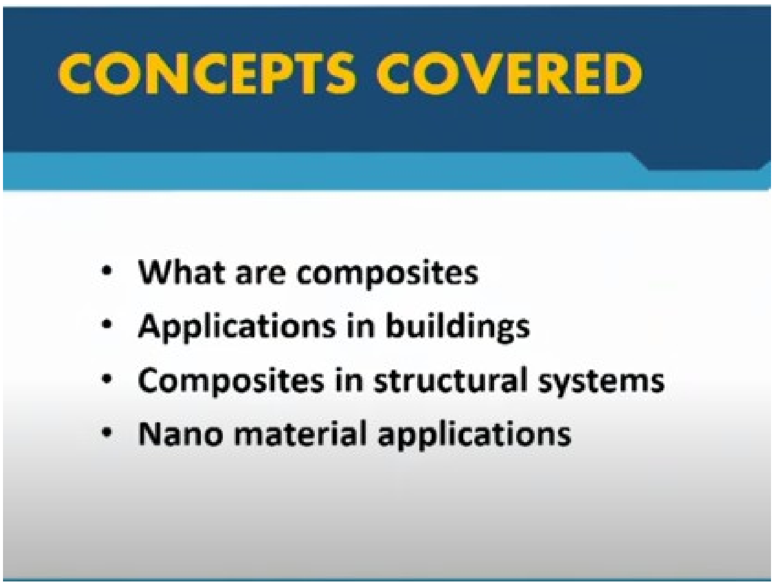


We have come across a number of composites by this time, but it is just to reiterate that what are composites, its application in buildings, its application in structural systems and again some nano material applications which are also added to items to make it work and function in a better way. So we will come to each of them.

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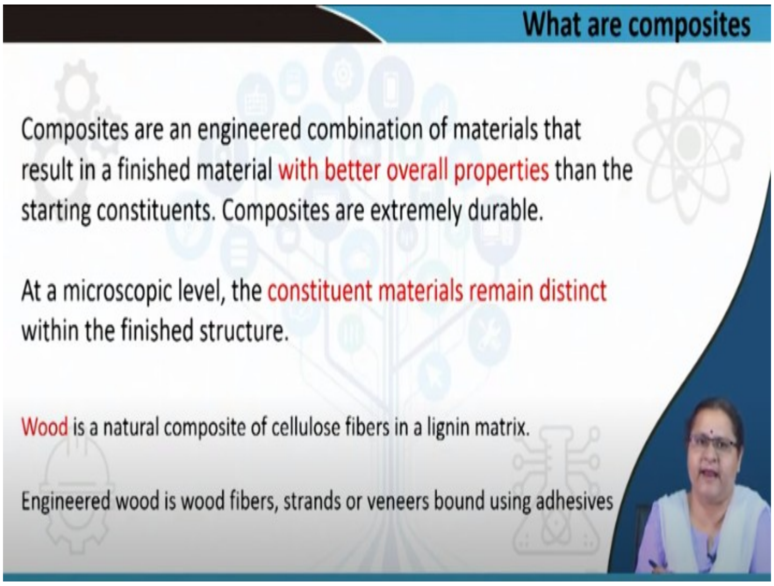


So composites are engineered combination of materials that result in a finished material, with better overall properties. We had individually seen sand, cement, and coarse aggregates in the previous modules, but when three of them were mixed in right proportions, concrete was formed which we called as manmade composite.

When we had done glass fiber reinforced gypsum, we have seen that as glass fibers laid inside gypsum so nicely that it gives strength etc., thereby enhancing overall properties. Hence they are termed as composites. If you see at a microscopic level, each of the constituents remains distinct. So there is no chemical reaction happening.

When sand, cement all these things bound together with water, a gel was formed which could bind together all the materials, but the materials did not change property. Again wood is a composite which grows naturally, it has the cellulose fibers in the lignin matrix. So lignin is holding the cellulose fibers together to give it strength.

When we talk of engineered wood, they are small pieces of wood are being or strands or veneers, in case of plywood, all are added using adhesive. So adhesive becomes the binder and the fibers or the members or the pieces, those are the wood pieces. So that is the engineered wood is a manmade composite whereas wood is naturally occurring composite.

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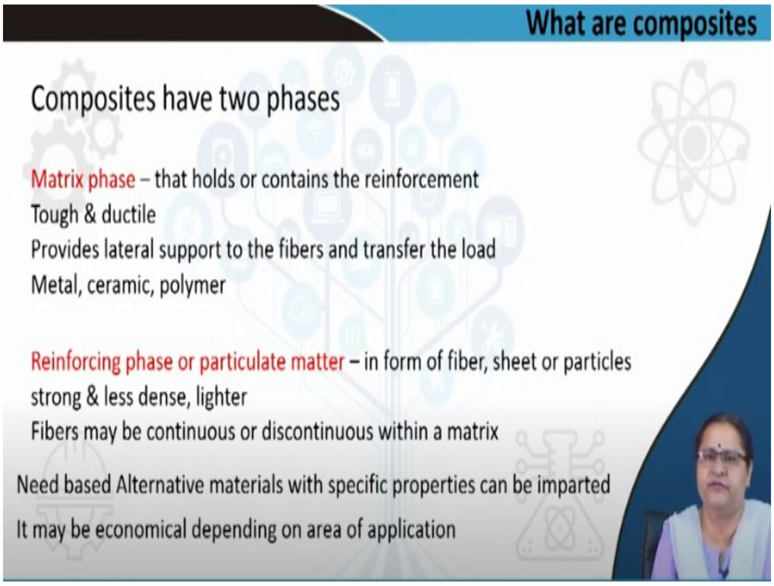


If we see very precisely or deeply in composites, we will see it has two phases. The first is the Matrix phase that is something which it holds onto. What does it hold? It holds the reinforcement. The particles help the reinforcements to become tougher, more ductile. So they provide lateral support. Since there is reinforcement, it will be supported at certain points with help of the matrix.

Now the matrix may be a continuous layer giving the support. It may be intermittent support. So actually the reinforcement may be covered on different sides with the matrix, with the binder. That is the matrix phase. So these lateral supports to the fibers may be either in the form of metals or in the form of ceramics, or in the form of polymers.

Next we have the reinforcing phase which is mainly the fibers or the particulate matters. In case of MDF boards, it was mainly wood particles, which are into the matrix. The fibers or particulate matter are strong, dense, light, but bound by the matrix to give them that continuity and make them to behave as one unit.

So based on the need, alternative materials can be obtained by changing the percentages of the matrix or the reinforcement. You can give special characteristics and what will happen finally, it becomes economical in the area where it is to be applied. Just giving the example of MDF boards, it is of three types; light density, medium density and high density.

So by applying different amounts of pressure, adding different amounts of particles in it, you get three different kinds of wood composite. So now you understand why I told initially that we have already learnt many of the composites.

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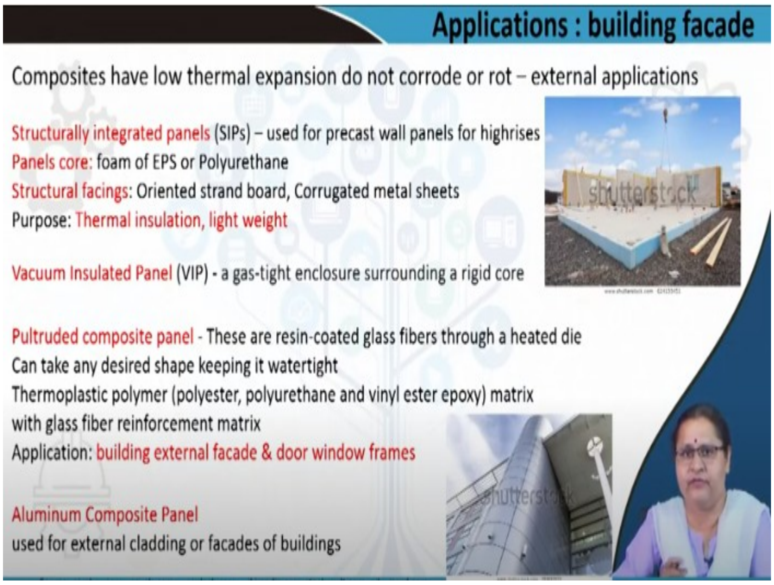


Now let us look at some of the applications of composites in building facades. So composites usually have low thermal expansion and they do not corrode or rot because their properties are improved already. So we can go for external applications using composites. We have seen in these types of applications in precast slabs also.

Structurally integrated panels or SIPs which are having foam or EPS or polyurethane sandwiched in between, with a coating of maybe metal sheet or maybe oriented strand board or any other material, which can withstand the external conditions, you get structural integrated panel. What is the advantage of it? These are getting thermal insulation at the same time they are light in weight. Where do we apply them?

We can apply it where the structural system is there and you are using this SIPs as filler walls. Being lighter in weight, it reduces the building load in overall terms. So you can choose this mainly for high-rise buildings or tall structures. Another type is vacuum insulated panel (VIP). Here a vacuum is created between the two members by evacuating out the gases.

Hence it gives insulation, it becomes airtight. No air can enter in it and being light in weight, it can act as a external facade. We have pultruded composite panel. This is manufactured using resin coated glass fibers through a heat dye. So glass wool can be passed through resin. So resin is the matrix and glass fiber is the reinforcement which can be given any desired shape.

You can use these in pipes, you can use these in walls, you can obviously make facades, you can make door swings, door window frames with glass fiber reinforcement within the resin. So the major important point is it can take any shape because the resin here is a thermoplast. Aluminum composite panels (ACPs) were discussed when we did non ferrous metals.

It has a very thin core of polyurethane foam held within the two layers which is supporting and are soft and light in weight,. You can bend it, give it any shape. The Epcot Center was made of ACP panels.

As shown in the picture, you can see a circular kind of façade that has been developed by using aluminum composite panel. So we have gone through many of these materials earlier.

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Sometimes the glass fibers are used as reinforcements within plastic, pipes, sheets, corrugated sheets as you can see the wood section in the image. Here the frame of the window section replaces wood, aluminum, and steel. So it has reduced the use of metals. It has brought in alternative material in use and provides better results.

These are not getting corroded like iron. These are quite rigid, hard and durable. Pipes for high-rise buildings are made with fiber reinforced plastic because of huge water pressure (say with a head of 200 meters). The pipe is facing that kind of water high pressure regularly. Due to this, Its linings may get corroded, the internal walls may get corroded. But if it is made of fiber reinforced plastic, there is no corrosion.

Elevator cables are also made of fiber reinforced plastic. So you can find out different applications within this building industry which have been gradually replaced by these composites. Here is another picture of glass and aramid fibers together. So there are two fibers instead of one. So this forms the matrix and it is in both the directions.

So when you put this within a matrix, then it becomes a very hard and durable material, with very low conductivity and they neither corrode nor get affected by any kind of environmental hazards. Even at times they are fire resistant. Therefore using composites in place of the traditional or known building materials give lot of advantages.

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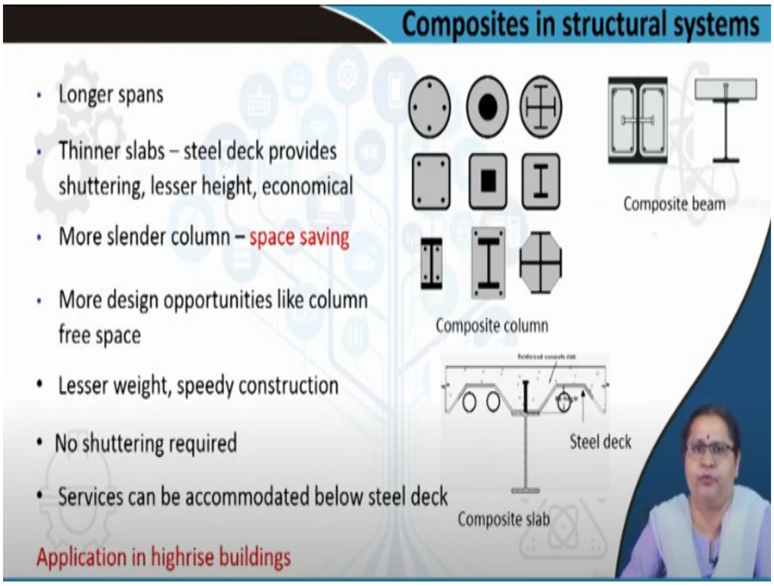


We come to another important aspect of using composites that is in the structural system. How can we get benefit from composites in structural system? Here you see some pictures where black shape denotes the iron part or the metal part and the grey color is the concrete. It is not like regular reinforcements. There is a single I section, two I sections together.

Another is entirely a solid square bar. Here you see it is an entirely solid core made up of iron. Here you see within the I section, there are again further reinforcement bars and it is filled with concrete. These are examples of composite columns. Some are composite beams where the I section is the major beam that is running horizontally.

There are reinforcements within the beam and there is a connector between the two. So the entire beam is not a simple concrete beam or steel beam, rather it is having reinforced beams as well as an I steel section beam. The slab is on the top which is projected on both directions, but here the I section is behaving as a composite member.

In another picture below, you see it is a slab which is cast within a member that is the steel deck. So the steel deck is nothing but a corrugated steel plate. The column is repeated here. So this I section beam has been placed accordingly and the deck is resting on this I section beam.

You can walk on such a floor as it has been filled with concrete. So the entire inside is concrete as you see marked here. So you get a flat surface on top of which you can walk. But what is gained? You are not using reinforcement at intervals. Rather you have used an entire profile which is reduced the slab depth very drastically.

The loss of depth of the entire thick slab helps to increase the building height. Other than this you have embedded these service lines as shown in red or maybe black circles, through which the wires, the conduits, the water supply, the air conditioning lines, all can pass through embedding them below the decked slab.

So if you can save height in each floor, you can finally gain a floor. When can that happen? When there are multiple floors that is when it is high-rise. Let us come to the major points. We can get larger spans using such kind of beam column system. So that means you will get uninterrupted space.

We need uninterrupted space for auditorium, office, multipurpose spaces and sports arena. We can use steel decks for longer spans as we need thinner slabs throughout. The deck itself provides a shuttering to the concrete which is being added on top of it to give it a smooth floor. Obviously, you get benefit on height and hence it becomes economical. In case of the columns, they become much slender.

That means you can avoid heavy columns. That means columns having dimensions say 1000 mm x 1000 mm reduces to say 500 mm x 500 mm. This drastic reduction gives generates the space. You get more design opportunities, because you are getting much of uninterrupted space. So you can play with space.

The self weight of the building becomes lesser because, you are reducing the slab thickness, decreased column cross sections; you are using maybe some composite panels for the walls. So finally, it is reducing the weight. You do not have to wait for 28 days of curing etc., because it is already cast on a shuttering. So further construction work can be carried on. So you get speedier construction.

Services can be accommodated below the steel deck and mostly we find applications of these in high-rise buildings. So I hope you could get through that the application of composites in structural systems which you will see more in high-rise building and tall building applications.

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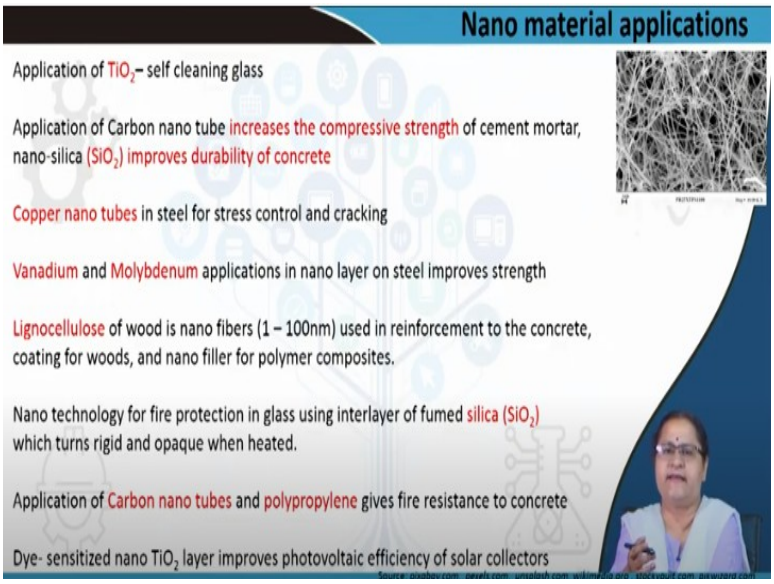

But, another group of composites are there which are applied as a coating, when we did glass. We had self-cleaning glass, which had a coating of titanium oxide which helped it to clean or clear the glass time to time by the application of water or application of sunlight. That was a nano application.

Nano materials can also go into composites. Carbon fibers can go into concrete to improve its characteristics. Silicon dioxide in nano silica improves durability of concrete. Copper nano tubes in steel helps to control the cracking. I am not going into details. Vanadium molybdenum improves the strength of steel. They are only applied a very thin layer.

We had learned lignin and cellulose. So lignocellulose of wood is nano fiber which is of the order of 1 to 100 nm (nanometers) and is used to reinforce concrete. So you can understand that at nano level, that is 1,000,000,000 (one billionth) of a meter, these materials can improve properties. We had seen wired glass. Wire was embedded within glass to give it special characteristics. That is also a composite.

The application of carbon nano tubes and polypropylene gives fire resistance to concrete. So there are so many benefits of building up composites and yes, we are having a shift in building materials. Yes it cannot be done in one day. It will take a longer time. But we need to open up towards these materials also. A lot of research is being done. You can get use titanium oxide nano coating to get efficient solar collection.

Because titanium oxide is not allowing the dust to fall on it. So obviously your solar collectors are remaining cleaner and hence the efficiency is going high for the photovoltaic cells. So there can be very intelligent applications of these nano materials also in composites.

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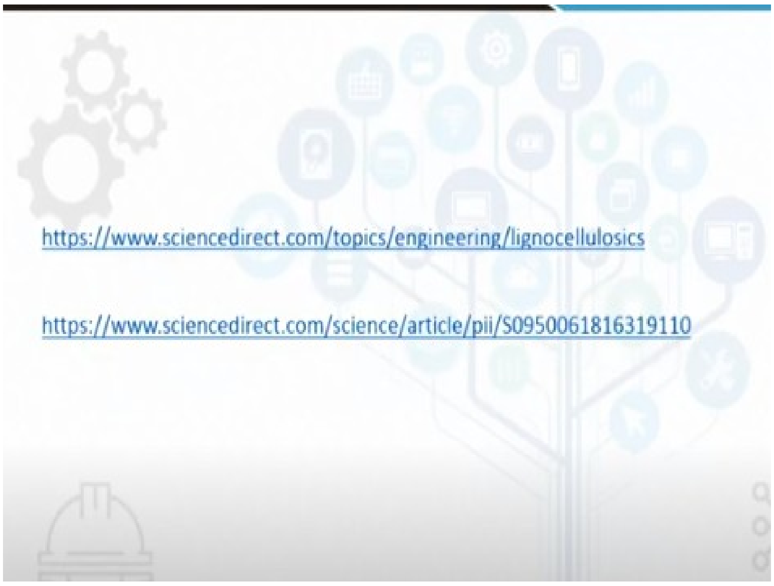


So with this, I would like to end this module. Here are two other references from which I had taken these materials, other than the books which I had referred earlier in my initial lectures. Thank you.