Building Materials and Composites
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Lecture - 33
Thermal Insulation and Sound Insulation

So we will start lecture three of this module, which we initially targeted like damp proofing and insulators. So we have finished damp proofing in the previous two lectures. Now we move into insulation part. Insulation is of two type's namely thermal insulation and sound insulation. Damp proofing was mainly used for protecting the building from the enemy water.

The term insulation means protecting the inhabitants of the building from temperature. It basically protects the people from outside heat and cold. So you need to have a comfort condition within the building or the inside of the building. Similarly when you plan for a hospital or a school, you also have to have sound insulation.

To control the noise externally, you can always give signage like no horns, no over speeding etc., in front of school or hospital. But yes, if the locality is a bit noisy where the school or hospital is planned, it will finally give discomfort to the children or patients. So you need to know how to insulate a building. First we will take up thermal insulation.

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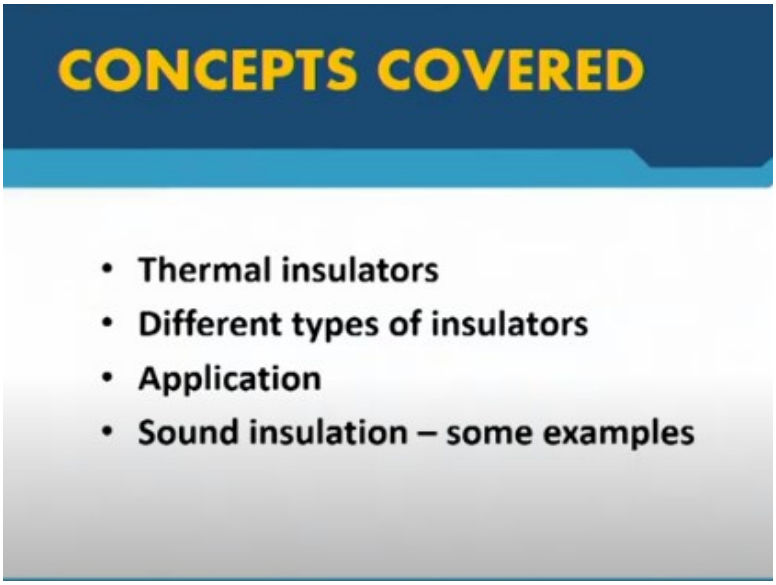

So we will try to cover thermal insulators along with their different types followed with their applications. We will also look at sound insulation which has been covered with some examples there. All thermal insulators are more or less sound insulators. In due course you will eventually come to a subject called 'acoustics' where you will be exposed to sound insulation in detail.

Similarly you will have energy efficient buildings maybe as an elective course in your course curriculum, where you will have further detailed study on thermal insulators. But as a basic course of building materials, we need to know the materials which are involved in these two particular purposes.

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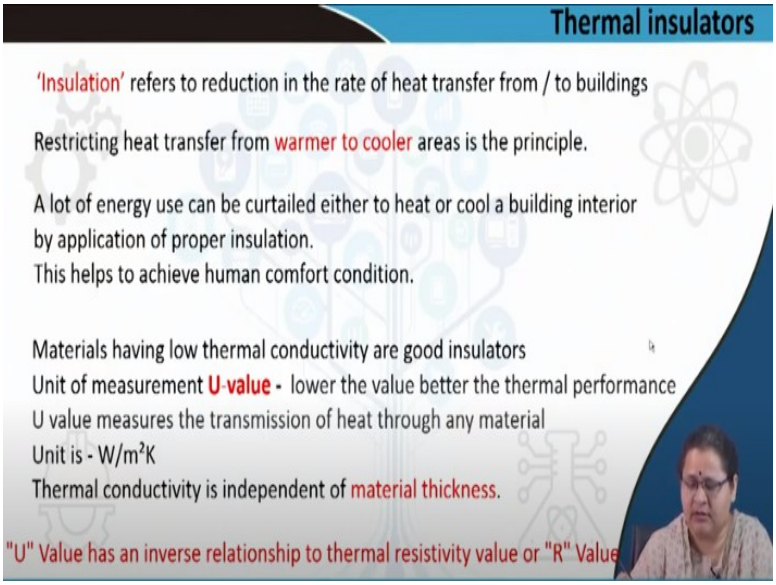

The thermal insulators are nothing but materials, which will reduce the rate of heat transfer from or to the building. The heat transfer always happens from the warmer side to the cooler side. If we want the inside to be cool, we have to restrict the heat coming from outside. If we want the inside to be warm, we have to restrict the heat to get out.

In cold weathers we follow the principle of trapping heat. So a lot of energy use can be curtailed by appropriate use of material so as to have a proper comfort condition inside the building. Based on this condition we need to select our insulators. Gases are very bad thermal conductors and air is one such insulator that is freely available. But yes you can have argon. Where do we use it? Where can we use air as an insulator?

We just discussed in our previous lecture about cavity walls. We had learnt that in case of hollow block concrete, where we have air gaps or pockets inside the building material. You can have arrangement of bricks in such a way that you can create air pockets (rat trap bond). So we can cleverly use air infill within a building material and have insulation. Yes in our country context that is may serve the purpose.

But we also need to think of extreme temperatures like -40 ^{o}C or maybe 50 ^{o}C, and what kind of insulations we need to add up because air is not the only choice. Materials having low thermal conductivity will obviously be good insulators. You cannot have non-conductive materials. So we will have low thermal conductivity.

That means the U-value of the material will be low and the thermal performance will be better, as insulation will be better. So U-value measures the transmission of heat through any material and we will try to look into materials which have low U-value. That means, higher resistivity value or higher R value.

We also need to remember that material thickness is also important as it has a role in the variation in the rate of the thermal conductance or resistance. As you go higher or further in this domain, you will go into detail calculations of U-value of composite materials etc., which I am not covering here. Now we will move to the different types of insulators.

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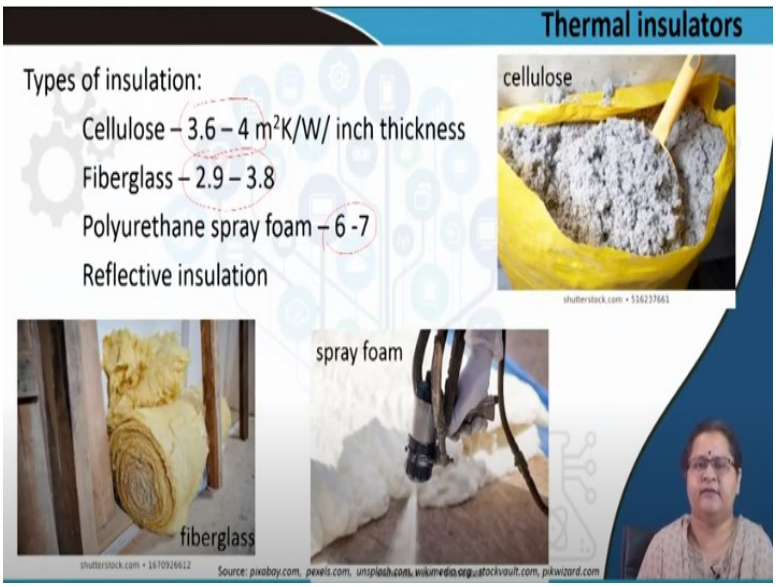

Now as I have told you, they are bad conductors or having higher resistivity. We also can have reflective surfaces as insulators. Materials like cellulose, fiberglass, and polyurethane spray foam have reflective insulation. So you see the numbers associated to the materials that is cellulose and fiberglass are quite similar. These are the respective R values.

Note that the units of R values have just reversed as $R_{value} = 1/U_{value}$

Whereas you see that in case of polyurethane foam is quite high between 6 to 7. Now what are these materials? Cellulose is one material which is obtained from some organic material. You can see it is a woolly material, grey in color. We will come into the details soon. You see this is fiberglass. It is available in rolled form.

We have discussed fiberglass in the module where we covered glass. We will come to that again. Polyurethane spray is a foamy material coming out from the nozzle, it is being applied for reflective insulation.

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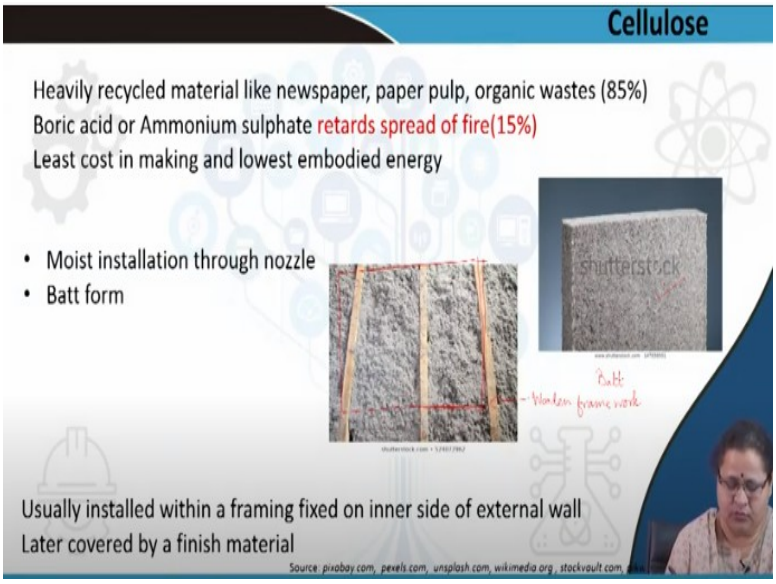

So if we come to cellulose, it has the least manufacturing cost and has least embodied energy in it. It is nothing but recycled newspaper, paper pulp, waste paper and organic waste. Since all these materials are flammable, we need to add boric acid or ammonium sulfate into it, which retards the spread of fire. So this only disadvantage of cellulose.

Cellulose being organic becomes easy targets to get attacked by termites etc. But with less embodied energy the production cost comes down. The applications are shown in the picture. In the first picture, you see it is a solid mass. This is called batt. Whereas in the next picture, it is the wooly thing that has come out through the nozzle that has solidified and taken this kind of shape.

And what you see in between are these wooden frameworks. So once this is pushed in, this framework remains out and you cover it or with you cover it with say plywood or some finished material. The insulator remains inside. You are pushing this kind of batts in the framework and you neatly cover it. One cannot understand that there is an insulation embedded in the wall. So this is fixed and covered, particularly the external wall and leaving the wall insulated.

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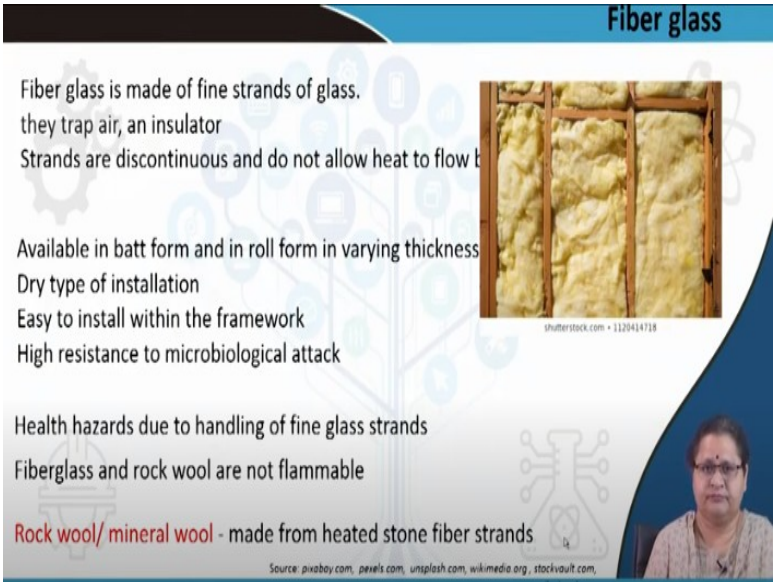

We come to fiberglass. Fiber glass is again nothing but fine strands of glass. When we studied glass we saw that glass fibers are used as reinforcement in GFRG. They are also used in glass fiber reinforced plastic. These are also used as insulators as it contains a lot of air inside it. So this air is trapped in and this trapped in air actually acts as the insulator.

So no heat transfer happens and these fine strands of glass are again discontinuous and hence heat cannot flow through these by conduction. You can either get them in rolled form or in batt forms. And in the similar way as you put in cellulose, you can

put in these fiberglass batts or fiberglass rolls. So this is a dry type of construction which was not for the cellulose when it was available in batt form.

It is very easy to install, but remember they are fine glass trends, hence they are very unhealthy. If you inhale them, they are having hazardous effect on human body. However, they are having high resistance against any kind of microbiological attacks. So keeping aside the health hazard if you can handle these with proper gloves, with proper masks, you can get the maximum out of fiberglass.

Similar to fiberglass, we have rock wool. We have mineral wool. We have slag wool. They are all having similar kind of R values between 3.5 to 4. These are obtained by heating stone; you get rock wool, you also can get mineral wool in similar way. You get slag from iron ore from different mineral industries. You can actually heat them at 3000 ^{o}C.

They are passed in air under pressure through it and you can get rock wool, mineral wool, slag wool, etc. So as I told you, similar to fiberglass, their R values are very close and amongst these few you find that cellulose is the cheapest. Cellulose is the most easily available and have less embodied energy. But application wise fiberglass is the easiest.

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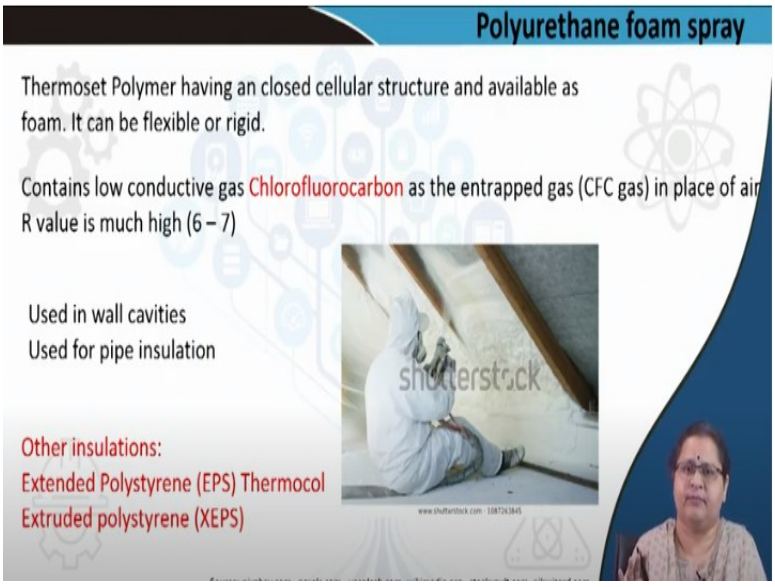

Now we come to polyurethane foam spray. As I told you, it has a high R value of 6 to 7. The reason is because of the low conductive gas, chlorofluorocarbon entrapped

within it. This is a thermo setting polymer having a closed cellular structure and available in foam form. It may be flexible, it may be rigid, but because of a different gas being entrapped, it is having a different R value much higher than that of the conventional insulating materials.

So we need to know where we are going to apply it. If it is a very cold country, you have to go for such kind of foam spray, because it will finally help in reducing the energy consumption. Other than these we have extended polystyrene which is commonly known as Thermocol. We have extruded polystyrene, which are also used as insulating materials.

We can actually put them into the external wall by putting a framework and embedding them and then neatly finishing it with a coating. It may be a plywood piece, it may be a metal sheet, you can actually cover it and make your house insulated.

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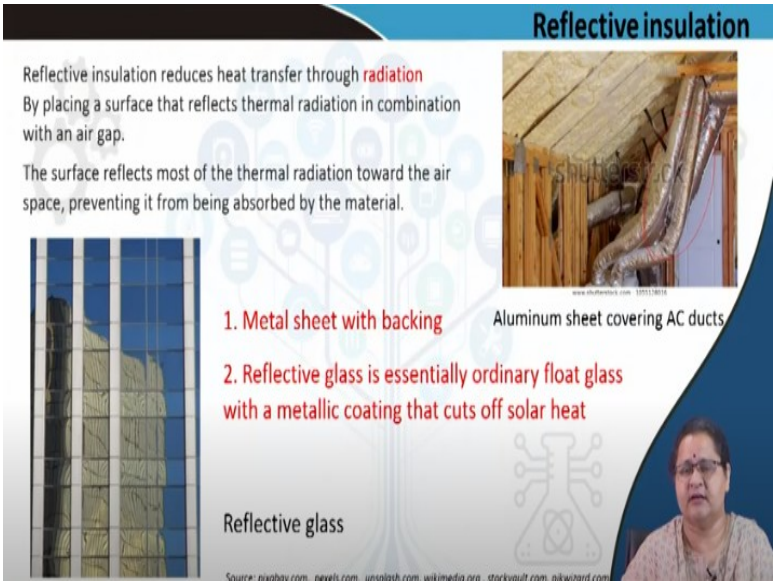

We now move to the reflective insulation. As I told you, you are reflecting the heat and the radiation from the surface. You can see in the picture, one is a metal sheet with a backing. These are all reflecting surfaces. The glass is also having a metallic coating on top of it on to which the solar energy when it is falling, and the radiation is reflected out.

So the surface reflects most of the thermal radiation, thus preventing the heat to enter into the building. So this is the basic principle of reflective insulation. Where do we put this reflective insulation or this metal sheet? All these are all put in pipes. These pipes may be the air conditioning ducts, where the cold air needs to move from one place to another.

Also we do not want the outer heat to make the inner cold air warm. So that is why these pipes are coated with this metal sheet which also has a backing and these are usually aluminum foils.

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Now we come to sound insulation. These are some pictures of rock wool, the fiberglass, cork sheet and the straw boards. These are also thermal insulators. In these materials the air is entrapped, which does not allow sound of specific frequencies to get or create any disturbance.

So particular application of this sound insulating materials are specific for specific frequencies. They may be of different thicknesses for absorbing different frequencies sound. So it is not only the material, but also the material thickness as in case of thermal insulation. It was differently affecting the thickness and changing the U value or the R value. Here also the frequency of sound that will be absorbed will also be dependent on the thickness of the material.

The cork sheet and the straw board are also organic materials. They have air pockets inside it. The sound of specific frequency actually gets trapped in these particular materials. They are spaced between the inner sides of the wall.

These are applied wherever you need that acoustical absorption, sound of specific frequency absorption with or without an air gap with the main wall. And they may be suspended from ceiling or they may be fixed to the ceiling. They may be fixed to the wall also. So in all the cases they will be absorbing sound. But that will be of different frequencies.

Here the important point is that different thicknesses of porous absorbers absorb different frequencies of sound and again different distances between the inner side of the wall and the material also helps in different frequency adsorption.

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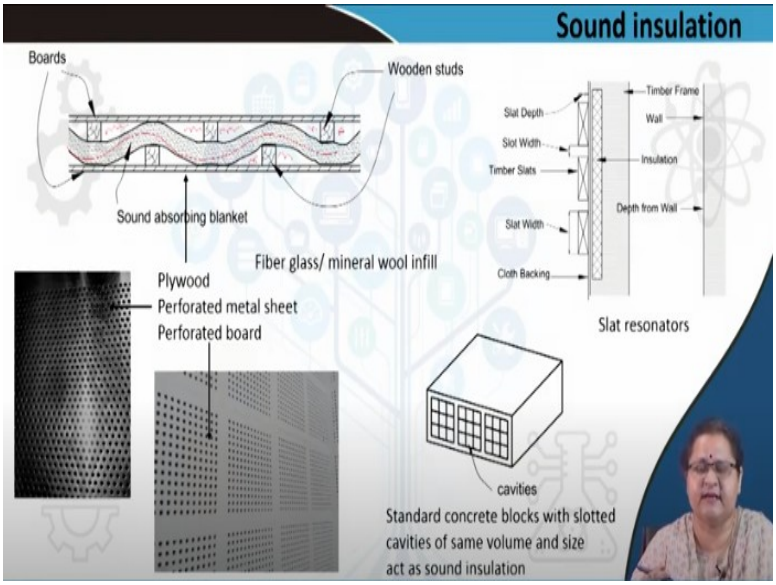

You can see some pictures of the fiberglass that are embedded. Here are the air gaps. These are the air pockets. And it has been kept in place by these wooden studs. So this was a void entirely of air into which this mineral wool or fiber glass has been pushed in. On top of it you can see a coating has been applied. Now this coating can be plywood.

It can also be perforated board as you see in the other picture or it can be perforated metal sheet as you see here. So the inside is the same insulator that is either the fiberglass or the mineral wool or the cork sheet. But on top is a layered. On the other

side it may be the wall or again a board or a lining or the finishing layer. It may be a separating wall between two classrooms also so that sound from one side does not move to the other side.

And the covering is also very important. It may be a plywood, which is a solid panel. It may be a perforated metal panel. It may be a perforated board. In all the cases they are allowing different frequencies of sound to get absorbed by the mineral wool which is placed inside. We see some different kind of sound insulator which is slat resonators. You see these are wooden pieces fixed on a wall which is fixed on a surface. They are separated from the main wall by some air gap.

And these studs, these supports, the slats are allowing some sound to get trapped into the gaps in between the slats. These are called slat resonators. You can have similar kind of thing developed by concrete. This can be a precast item of concrete which will have such kind of pores voids which will trap in specific frequency sound. So these will act as sound absorbers or sound insulators.

When we know which particular frequency we need to trap or insulate or absorb we will choose a type of particular insulator or particular material to do the task. These fined tuned details, detailed calculations, are a part another subject which is architectural acoustics. You can actually find out which material will fit into when it is a musical performance, when it is lecture performance, when it is a particular conference going on.

So depending upon the type of performance, the frequencies will be generated and that type of frequency will be required to be insulated or trapped in. With this, we finish the insulation part of this particular in this particular module. So we are looking forward for some more materials like composites, gypsum, etc., as a continuation of this particular module. Thank you.