Building Materials and Composites

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Lecture No. #39

Plastics

The last two lectures of this module or the finishing module rather will be on plastics. Yes plastics have come into the building industry for a long time. But it had limited applications until it is being explored more and more. We have discussed plastics when we were doing composites, glass fiber reinforced plastic, where we were talking of pultruded sections, etc., which has replaced aluminium or maybe wood.

In our day to day life, in our day to day buildings, we are finding replacement of many other materials by plastics. Now do we find plastics in a structural component? Maybe no. It does not replace reinforcement bars. It does not become a wall which will take load. (refer time: 01:50)

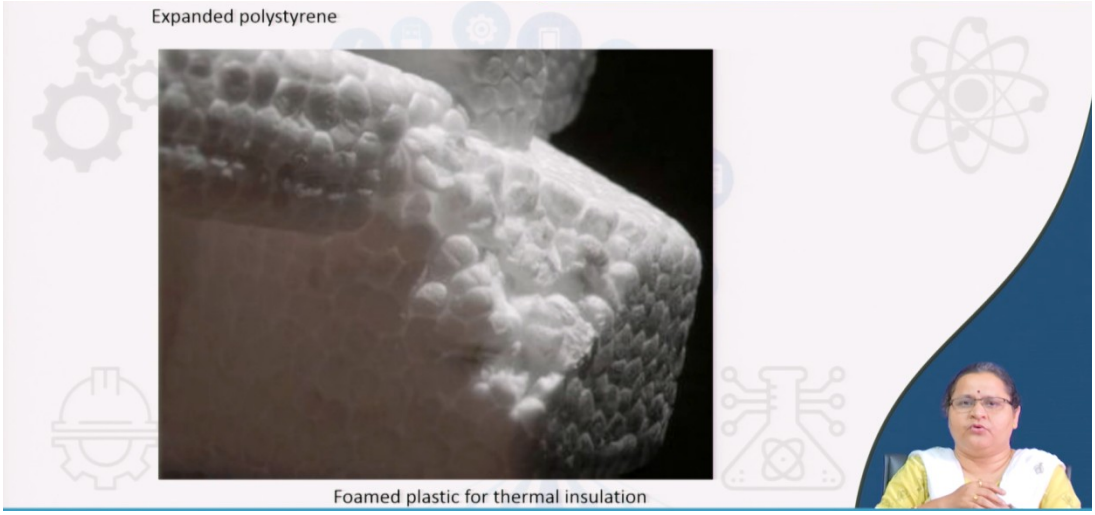
So let us try to discuss on what are plastics? What are the two major types of plastics? Characteristics of plastics and constituents of plastics in this particular lecture. (refer time: 02:10)

But prior to moving there, we will see this huge structure by Zaha Hadid, which is of glass fibre reinforced plastic and glass fibre reinforced concrete, a mix of it. It is Heydar Aliyev Cultural Centre in Baku. You all may have seen it or will study it in your courses. You will know architect Zaha Hadid. So this particular shape structure was possible because of the composite material of GFRP and GFRC. (refer time: 03:01)

Here you see another building which is an aquatic centre Beijing Aquatic Centre. Because it is Aquatic Centre, it is looking like water bubbles forming the facade. It is not taking any structural load, but the material is such that it is giving that feel that it is a bubble or bubbly kind of thing. So it is again an expression possible by the use of plastic. So it is the architect's imagination, how he has used it.

But the material has made it possible. So there are different types of plastics which can be used up to this level. (refer time: 04:10)

You have all seen this, which is expanded form of plastic, polystyrene. We call it regularly, we see it in packaging industry, thermocol. We find it in insulation. This is also plastic. So you are using plastic as an insulator. That means its thermal conductivity is very low. We have discussed this in thermal insulation, this material. But this is nothing but one kind of plastic. (refer time: 04:52)



And in our regular life if you see the Venetian blinds, if you will see the shower curtain, which is actually allowing the water to roll down just like self-cleaning glass. You see plastic flooring, vinyl floating. It is just pasting the flooring on top of the existing flooring giving it a new look. All the polypropylene sheet which is the seat of the chair or the back of the chair.

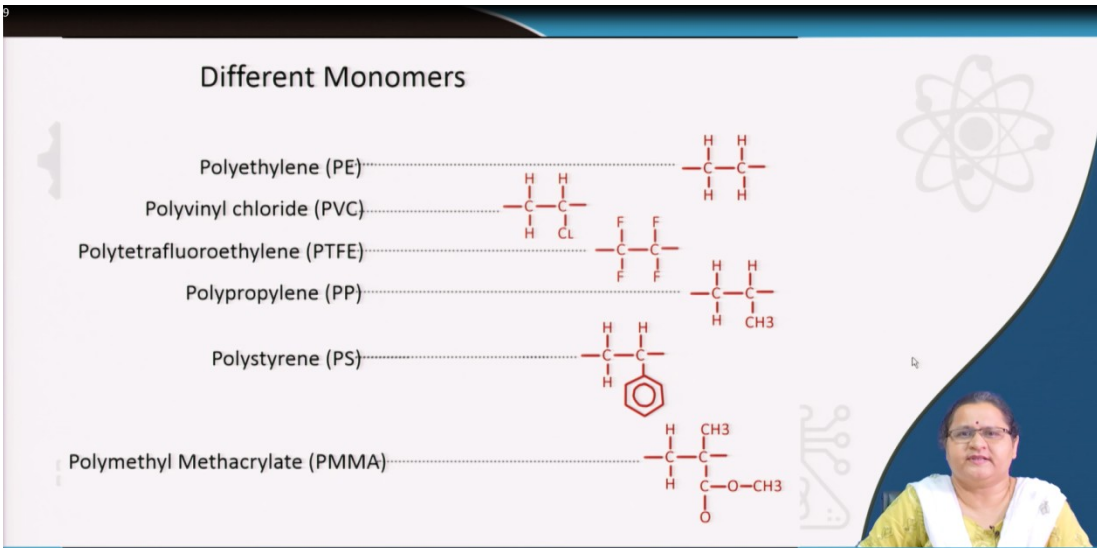
Or maybe some plastic polyurethane panel which can be used as a false ceiling or a wall cladding or a partition. We see all these things in most of our daily uses. We see these in offices. We see these in all domestic houses. So we need to know this material, which is a replacement of many of the materials. But yes, it may have some good points, some bad points and let us come to that. (refer time: 06:22)

So what are plastics? It is the generic name for polymers having high molecular weight. So what is polymer? Now polymers are monomers. Mono means single. Monomers chemically combining by the process of polymerization to form polymers. So what names I was telling in the last slide, those are actually the name of the polymers. What is the source?

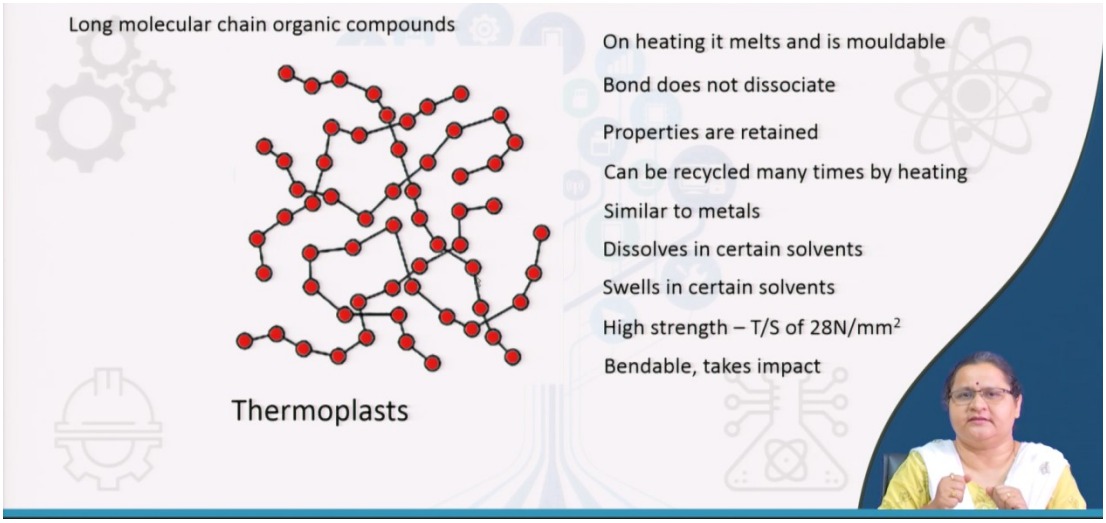
Usually crude oil or petroleum or it is cellulose derivatives. It is mostly synthetic made from wide range of organic polymers like polyethylene, polyvinyl chloride, nylons etc. And from the plant it is cellulose, latex. From animals it is formaldehyde, glue casein. From animal hides, etc. So plastic is the generic name for the polymers. Hence, there are various types of plastics.

Now these are mostly impervious in nature, if it is not organic derived organically derived that is the cellulose plastics. It is non-biodegradable. So that is again a negative point. It does not get degraded easily. It is malleable and can be moulded like metals. It can be given any desired shape and can be used as a building material wherever possible, because you can achieve any kind of moulded shapes like metals. It has a low specific gravity. It is more than 1 and varies up to 1.4. (refer time: 08:52)

After knowing these basic points, we see these are the monomers where you see polyethylene, which is carbon hydrogen bonding. Polyvinyl chloride, which is carbon, chlorine and hydrogen bonding. Polytetrafluoroethylene that is carbon fluorine bonding. Polypropylene where you see it is again carbon hydrogen bonding. Polystyrene and polymethyl methacrylate. (refer time: 09:34)



Now coming to the two types of plastics. As I have told you, these are organic materials, these are long molecular chains. They are having high molecular weight. So on heating these molecular chains remain as it is. It only gets reshaped, but does not break, does not dissociate. Hence, the properties remain as it is even if it is heated. So even if it is heated you nothing is breaking, none of the bonding is breaking.

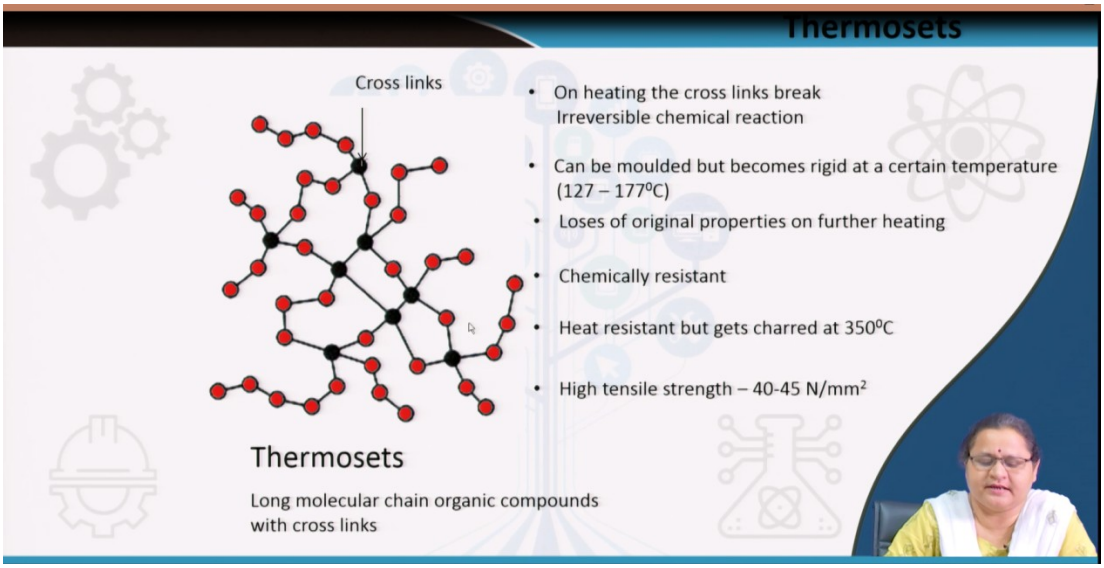


So the properties are getting retained. Hence, even by heating to a certain temperature, you can mould it, reshape it and again reuse it. So this is the beauty of thermoplastics. That means, you can use it n number of times. Hence, it is recyclable. Similar to metals maybe. Metals as I have told it is hundred percent recyclable. Thermoplasts are also recyclable. Now remember thermoplasts are not hundred percent used.

It will be added with some other material because the polymer is the binder, but it will be binding other things also. We will come to that little later. Now other thing is on the tensile

strength, it can take up to 28 Newton per millimetre square. It is bendable, it can take impact. (refer time: 11:50)

So after knowing thermoplasts, the other important type of polymer is the thermoset. What happens here you see the cross links, the black spots are the cross links which actually dissociate when it is heated. But yes, it does not dissociate at very low temperature, which thermoplasts do. This dissociate at a little higher temperature and they become rigid. So these are having higher tensile strength, but they are brittle in nature.

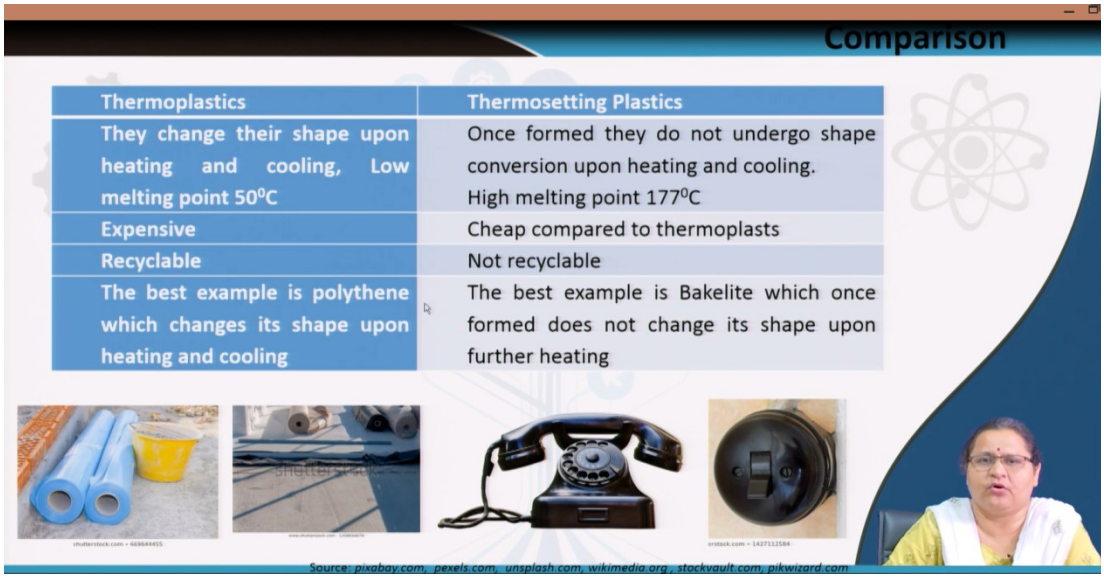


And they get charred at around 350 degrees centigrade temperature. They are chemically resistant. (refer time: 13:02)

Coming to the basic differences between the two, they change shape. They can be worked out at around 50 degree centigrade. Thermosets need a little higher temperature but it is only once formed, around 170 degrees centigrade. Thermoplasts are expensive whereas, thermosets are cheaper. Thermoplastics are recyclable, thermosets are not. And we can see that thermoplasts are much flexible and not so rigid, not so brittle.

And they can change shape upon heating and cooling which is not possible for thermosets. Thermosets the very popular example is Bakelite. As you can see the early day switches. The early day telephones. They were all made of Bakelite. Even our handles of utensils, pressure cooker, they are also made of Bakelite. Whereas you see the other two pictures on this side where it is polyethylene, which is used as a damp proofing membrane for roofing.

If you see the pictures little clearly you can see the application of a very flexible membrane like material, thermoplasts. Thermosets if you have a membrane like material, it will break on minimum pressure. (refer time: 14:54)



Now coming to the characteristics. Plastics are sufficiently strong for taking general loading condition. But long term loading leads to deformation. If you keep something for a long period of time over a plastic chair the chair may get deformed. So it gains tensile strength by putting fibrous reinforcement into it. As we have talked of glass fibre reinforced plastic.

Then only you can achieve a higher tensile strength of say 70 Newton per millimetre square. So they can even fail without any warning. So that is why none of these plastic materials are recommended as a structural material. They are very good as a filler material, supporting material, fine. Taking general loads, a seat, a chair, a simple table it is okay.

But beyond that, it is general plastics cannot play that play the role of a structural material. Being organic, most plastics are susceptible to fire, temperature and heat. And as you know the temperatures at which thermoplasts melt 50 degree it can get deshaped. So a minimum fire can actually destroy it.

Polyvinyl chlorides, phenol formaldehydes, urea formaldehydes are exceptions, which can withstand fire because of their molecular structure, because of their carbon fluorine bond carbon chlorine bond. That makes it hydrophobic too. Then plastics being impervious are waterproof, but mostly affected by ultraviolet radiation. Hence, it is preferred that it has indoor applications more.

Because keeping it exposed to ultraviolet radiation makes it brittle and it may fail further without any warning. So life of the plastic becomes shortened. Yes, you can recycle it if it is a thermoplast. But indoor applications are preferred. Now plastics are resistant to acids, alkalis, chemicals and even corrosion proof. And as I had already discussed, plastics have low thermal expansion and thermal conductivity.

It resembles wood and foamed plastic and expanded plastic are used as thermal insulators. We have covered that while we discussed thermal insulation. (refer time: 18:29)

Now coming to the workability. Whenever we discussed materials we had also talked of workability, concrete workability, wood workability, joinery, glass workability. How to join, how to use it? When we have done brick, you are adding or joining by the mortar. So you have to use plastics in its usable way in a building. So you need to do certain operations on to it.

Metals. Similar to metals plastics can be riveted, welded, clamped. Plastics can be sawed, drilled, screwed like wood. So you see the versatility of the material. Sometimes I am comparing it with wood, sometimes with metals, sometimes with glass. You can fabricate it, you can blow it. Like glass, you can calendar it you can make sheets. You can cast it giving it particular shape. You can mould it, you can laminate it.

And the other advantage is, it is light in weight, low maintenance cost or maybe no maintenance cost. You do not need to put a paint coating on it. Because it is not disturbed by any of the weathering agents, even corrosion, even chemical action. So those are the very advantageous points of using plastic. Now plastics are inert but hazardous when it bonds. As I told you 50 degree centigrade, it will start getting deshaped.

It can produce toxic fumes, like you know polystyrene which contained CFC, chlorofluorocarbon that will be liberated in air, which is toxic. How to measure that? Just to introduce to these two terms, this is a scale basically from 0 to 100, low to high flame spread index. That means propensity to burn rapidly and spread fire. How much rapidly it is burning. So it is a comparative scale.

Smoke development index or SDI. This also measures in a scale of 0 to 100 and it measures the concentration of smoke it creates on being burnt. So these two terms actually help in measuring the quality of plastic, hazard of any material which is going to get burnt. (refer time: 22:32)

Now as I told you, the resinous part or the binder part is actually the plastic or the polymer part. Like in paints you learnt that base is actually giving the body to it. You are adding something which is not altering the quality of the material, but it is acting as a filler material giving it some body or mass to the main material. So plastic items have a resin component and then we have the fillers, plasticizers, pigments, lubricating agents and the catalysts.

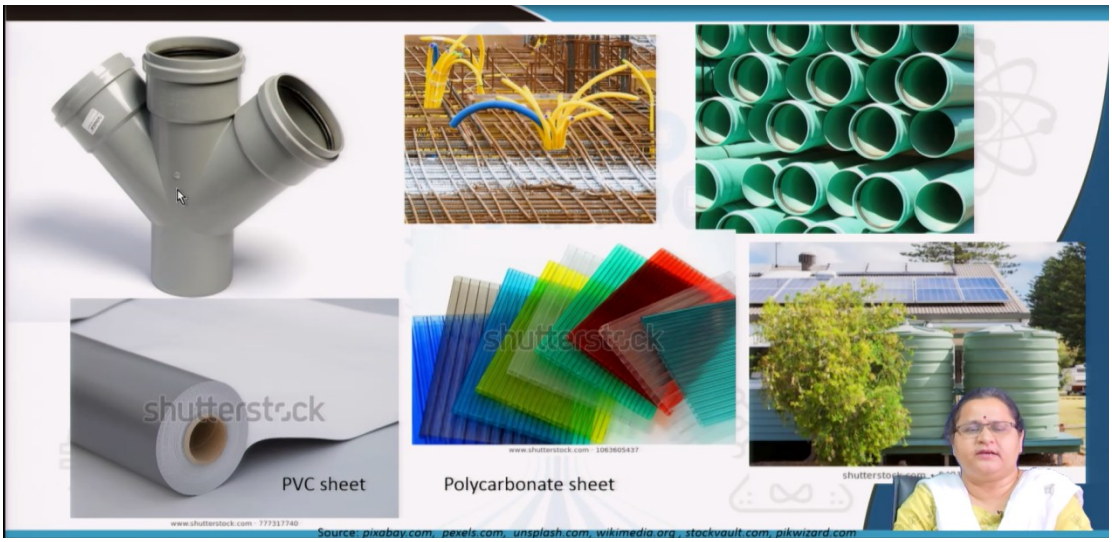
Resin which is the binder part is hard. Plasticizers modify the plasticity for gaining different strength, flexibility and hardness and they are separate polymer chain which push the resin chain and delay the crystallization process. That makes it flexible or pliable. And those are namely the adipates and the phylates phytalates.

Fillers or additives are the inert materials which may be fibrous form, which may be powdered form, which may be laminated form and they can actually impart other properties which the resin or the binder does not have. It can make it fire retardant. It can make it ultraviolet ray protected. Pigments similar to paints are the colouring agents and they can also act as a filler.

And you see it is similar to that of paints. Zinc oxide, barytes. Yes in the fillers, you can have chalk. You can use sawdust as filler material. You can use carbon dust. Now the lubricating agents are the paraffins, graphites and the wax, which help in demoulding. That means, it makes it slippery, lubricant so that it comes out very easily from the mould.

And the catalysts, it may be optional, which helps in polymerization like esters used for urea formaldehyde. So catalysts may be used, may not be used, but these are the constituents forming the plastics. (refer time: 26:30)

Here you see some pictures, where you see the molded joint, pipes, service lines. Here you see the sheet form. Here you see the tanks, which will be standing on rooftops for long years. So they are to be ultraviolet protected, they are not to be brittle in nature. So that particular type of plastic will come here. Here you see lots of pipes. It may be water pipes. It may be fitting into all these joints.



These joints has to be rigid, has to be strong. What you see in this picture is the electrical conduits placed on slab before pouring of concrete. So you see reinforcements and you see a number of pipes coming out. So these will be the carriers of the electrical roots. Here you see another sheet form that is polycarbonate sheet.

So all these are different types of applications other than what special applications I had shown you in the specific buildings. So those are very special application, very innovative. And yes, you would be fortunate to work with such kind of, making such kind of expressions. But otherwise, you as an architect will be handling all these materials or recommending all these types of materials in your day to day life.Thank you.