Building Materials and Composites

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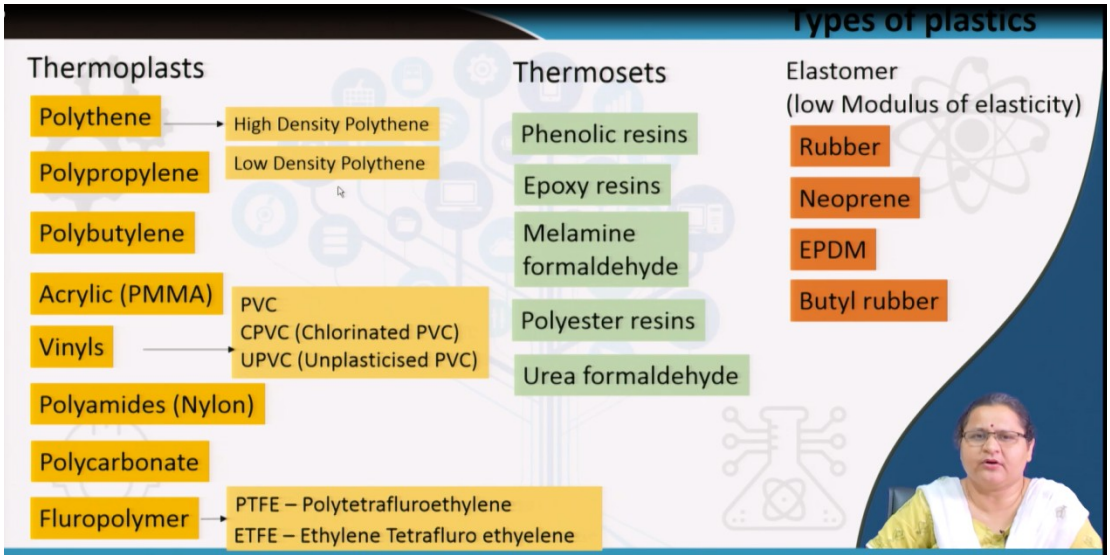
Lecture No. #40

Plastics (continued)

So we have understood plastics that they are of basically two types: thermoplasts and thermosets. And yes we had seen the special applications where it is creating an expression, which is the architects imagination, application and obviously it is also having some purpose or some function. And now, we will be entering into the different types of plastics, which we need to know, because we have seen a number of materials but which is what, we need to know or get aware as architects and also need to know what is the purpose, why it is being used. (refer time: 01:24)

Now, we will enter into the different types of plastics not the types based on thermosets and thermoplastic. But, farther down within the thermosets, within the thermoplasts, within the elastomers which is the rubber part, which we did not cover in the previous lecture, we will just mention those considering its application in building industry. So we will try to cover the polyvinyl chloride which is the third most used plastic material in this industry.

We have acrylics, we have fluoropolymers, the polycarbonates, polystyrene and polyethylenes. So we will try to find the particular or specific properties, what makes it usable for the particular purpose. (refer time: 02:42) So first let us try to see this slide. Here you see the same names the thermoplasts, the thermosets. And also there is another in orange what you see here which has low modulus of elasticity, which is nothing but the elastomers which is also derived from petroleum. We have rubber, neoprene, EPDM and butyl rubber. Coming to thermoplasts, these are more what we use.

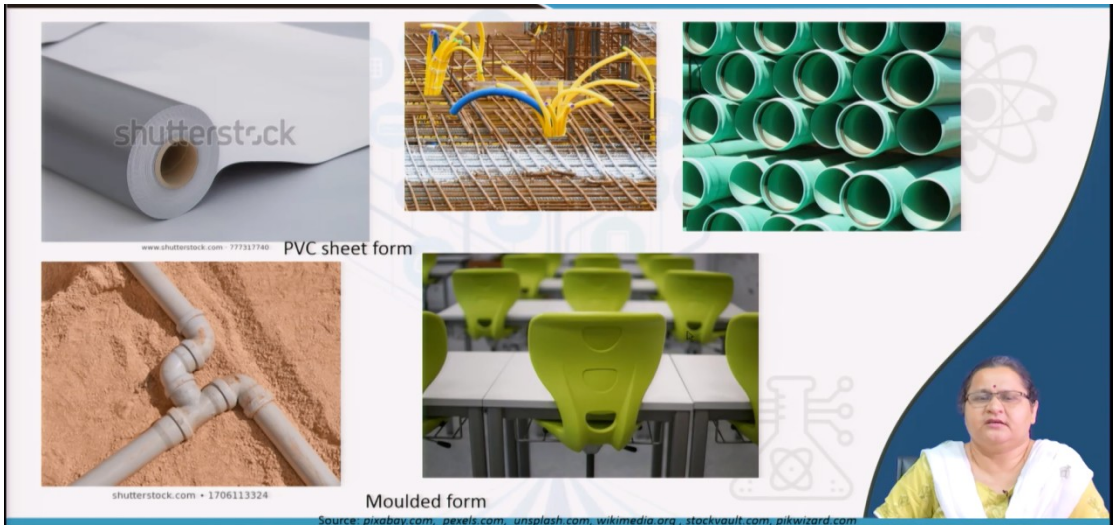


The polythenes, the polypropylenes, the polybutylenes, acrylic, vinyls, polyamides, polycarbonates, fluoropolymers. Now here in the polyethylene you see high density polythene and low density polythene. And we also have another intermediate, medium density polythene. Similarly, with the vinyls you see you have polyvinyl chloride, chlorinated polyvinyl chloride, and unplasticized polyvinyl chloride. Also on the fluoropolymer side you have polytetrafluoroethylene and ethylene tetrafluoroethylene. PTFE and ETFE.

So you will come across the terms PVC, PTFE, ETFE, LDPE, HDPE, acrylic which is actually PMMA but it is more known as acrylic, is more available name is more used name is acrylic. And other is polycarbonate sheet which has replaced GI sheets, any kind of corrugated metal sheets. Other is the thermosets. You see the resins; polyester resins, phenolic resins, epoxy resins.

And the formaldehydes; melamine formaldehyde, urea formaldehyde. Where do we see? These are all in adhesives. EPDM. Where did we hear this term? When we were doing damp proofing. So these are the if you remember this slide these are the major types of plastics used in our domain. (refer time: 06:25)

So you see sheet form, you see moulded form, you see moulded forms of chair. This is again repetition of the pictures. (refer time: 06:46)



So we will enter into the major component what has plastic replaced and who has replaced. Plastics have replaced glass in sheet form. The acrylic, it has replaced glass. Plastics have replaced galvanized iron sheet, again corrugated acrylic sheet or polycarbonate sheet, replaced metals in pipes for sanitation, water supply, etc. Reinforced plastic replaced metals when used in pultruded form in door, window frames.

Replaced wood in door, window shutters. Replaced wood in indoor applications like furniture. Replaced wood in electrical wiring application with plastic casings. Wood fibre materials plastics have replaced for acoustical boards. 10% of sand can be replaced with

plastics in a concrete mix. Polymer modified bitumen that is mod-bit we had discussed during bitumen, is application of plastics giving it different property.

So plastic which was not degrading can go into road constructions, in its own form modifying bitumen. So plastic is versatile. (refer time: 08:53)

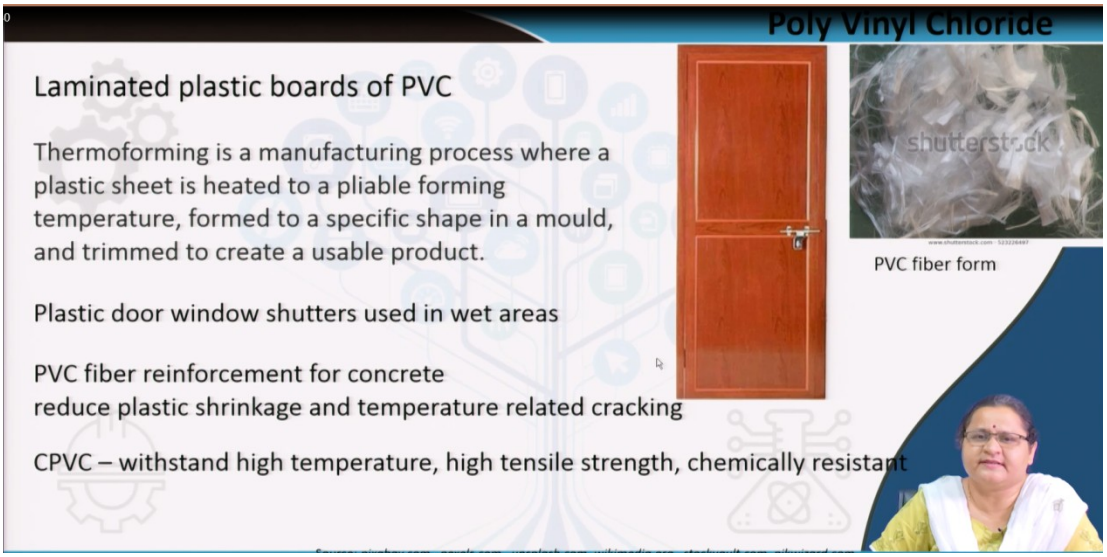
Now we first discussed polyvinyl chloride. You had seen a number of pictures and as I told you, the carbon chlorine bond of PVC is hydrophobic. So it resists oxidation, it is anti-corrosive and does not burn. It is non-flammable, unaffected by chemicals. Hence it becomes a carrier of chemicals. It becomes a carrier of corrosive items, the sewer lines. The sewer lines if it is metallic, it has acidic environment inside it.

And it gradually gets corroded away by the soil it carries which is not possible if it is PVC. So PVC is replacing metals particularly in these building service lines. Now PVC is very hard and rigid when it is considered alone or when it is considered as the binder, but it is the phytalates which acts as the plasticizer and keeps it soft, keeps PVC very soft like rubber.

And helps it in getting in sheet form which can be further rolled into pipe form, can be molded into any profile. Now PVC, because it is not affected by chemicals, it finds maximum application in hospitals, chemical and pathological laboratories, computer laboratories. It is hydrophobic. It takes out the dust and the water from it. It does not allow it to stick. It does not allow organisms to stick to it.

Even general flooring can be of PVC. Potable water can be carried through PVC pipes, because metal pipes can actually on long term makes the water polluted. Sewer lines as I told you, it is not scouring the lines. Rainwater pipes, electrical cables and conduits we find maximum application of polyvinyl chloride. (refer time: 12:20)

We see here the laminated form of PVC. It is a sheet form. So this laminated board has been obtained by thermoforming. That is on heat application this particular form could have been made possible. This is a ply of plastic of a given thickness which has been finally made or given this shape. We find its application in doors, windows, shutters. And you can replace wooden doors and windows particularly washrooms, kitchen door with these kind of plastic doors.



So the wood does not get rotten, particularly the lower part and plastics are a good answer to it. Here you see PVC as fibrous form. It can be used as reinforcement in concrete which reduces shrinkage and also temperature related cracking. So if you add PVC fibre into concrete, where there are expected large changes of temperature, then PVC fibre is a good answer. Coming to chlorinated polyvinyl chloride.

This is chemically resistant and can withstand high temperature. High temperature means you can have water lines which will be carrying water at different temperatures. That means hot water lines say in hotels, in hospitals, when there is a central heating system, from the roof or some intermediate position, the water is being carried to different rooms, we prefer a CPVC pipeline.

It is chemically resistant and it can carry chemicals also. Unplasticized polyvinyl chloride. So here the plasticizers are not there, it is hard and rigid but they are strong enough. You do not require the flexibility, you have to push it down, boring pipe, electrical routes, major lines they have to be hard and rigid. We use unplasticized polyvinyl chloride over there. (refer time: 16:05)

Next we come to acrylics. The chemical name is of the polymer it is polymethyl methacrylate. It is Perspex sheet, we commonly call it, Plexiglass we commonly call it which resembles glass. It can be transparent; it can be translucent with some coloured tints, exactly similar to glass, but having half the weight of glass, same thickness: 10 times stronger than glass.

Much less affected by ultraviolet radiation and has promises a life of 10 years. Initially, it is as brilliant as glass that is as clear as glass when it is not having any other pigment. But the major drawback is it is difficult to cut. High-rise buildings if a glass pane falls or if you provide a tempered glass maybe it becomes much costly. In place you can use an acrylic sheet, replacing glass. Public buildings.

corrugated sheet as roofing material you can use acrylic sheets. (refer time: 17:49)

Now we come to the fluoropolymers. These are fluorocarbon which gains property in strength, toughness, self-lubrication from the aggregate effect of carbon fluorine bond or carbon fluorine hydrogen bond whatever the case may be. The first one is carbon fluorine bond in case of polytetrafluoroethylene. It is carbon, fluorine and hydrogen bond for ETFE or ethylene tetrafluoroethylene.

And these can have a high tensile strength over a wide temperature range. And that is why you have seen application of this ETFE sheet or the PTFE sheet applied on outer facade of buildings which does not allow heat to come in. Which is scratch-proof and chemically resistant. And it can be very fine membrane. You see thickness can be as low as 0.05 to 0.02 millimeter.

And it can withstand a large change or difference in temperature with low coefficient of friction. Low coefficient of friction why do I mention? Anything comes on top of a PTFE sheet will roll down, will fall off. Hydrophobic is case when we talk only of water, but anything which hits it will not sit on it, but will roll down. It has very low surface energy. That means, it does not attract anything on its body. We will see its application more. (refer time: 20:32)

This is PTFE sheet of Burj Al Arab, which is on this entire facade, which is facing the sea which is protecting the glass from the ultraviolet radiation. Behind it the heat is not going. So it is also acting as a thermal insulator. So there is an air gap. So this membrane the circular way it is put it is actually acting as a hydrophobic membrane. It is taking off sand. It is taking off any water coming on to.

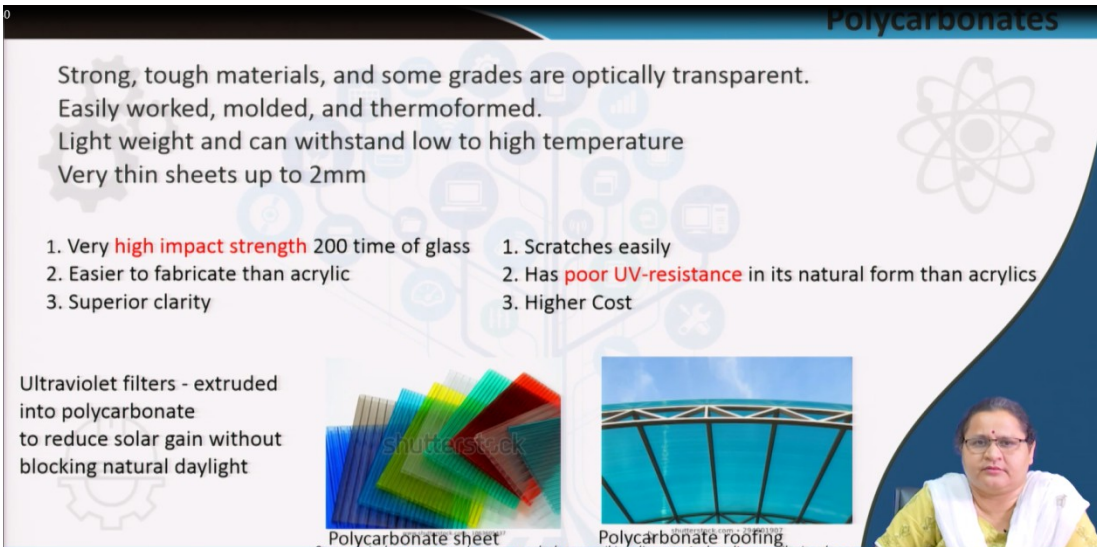
It is protecting the entire glass fabric. It is giving a cooling effect to the entire building. You see application of ETFE sheet in Eden Park. It is a bio park where these structures, these circular structures are made of very thin ETFE sheet. They are scratchproof. No one can cut it. They are they are air filled. Same is also adapted in Allianz Arena Football Stadium.

We have in India an example of PTFE sheet application with glass fibre fabric, which is in the Jawaharlal Nehru Stadium, New Delhi. So these air filled panels are giving it a thermal insulation. There is practically no wall. But it is a framed structure which is coated with this PTFE, with this ETFE pneumatic panels. The same was in the Beijing Aquatic Center. Those were PVC sheets with air insulation.

So these are fluropolymers. These are the advantages. Now you may have heard of non-stick pans, non-stick utensils. The top coating which makes it non-stick is actually this PTFE and it is scratchproof. It is so thin even then it is scratchproof unless and until you are doing scratching it purposefully with knife or some sharp object. So that is why you are asked that this fluorine gets exposed.

So you are not supposed to tamper it, otherwise it is a scratchproof layer. It is impervious and hydrophobic too. So nothing sticks on top of it. (refer time: 24:25)

Coming to the polycarbonates, you see a number of sheets here in different colors. But these are all capable of withstanding the ultraviolet rays of the sun. They are tough materials, optically transparent. You can work it, you can give different shapes, you can mould it out. And it can withstand differences of temperature. Very thin sheets up to 2 millimeters.



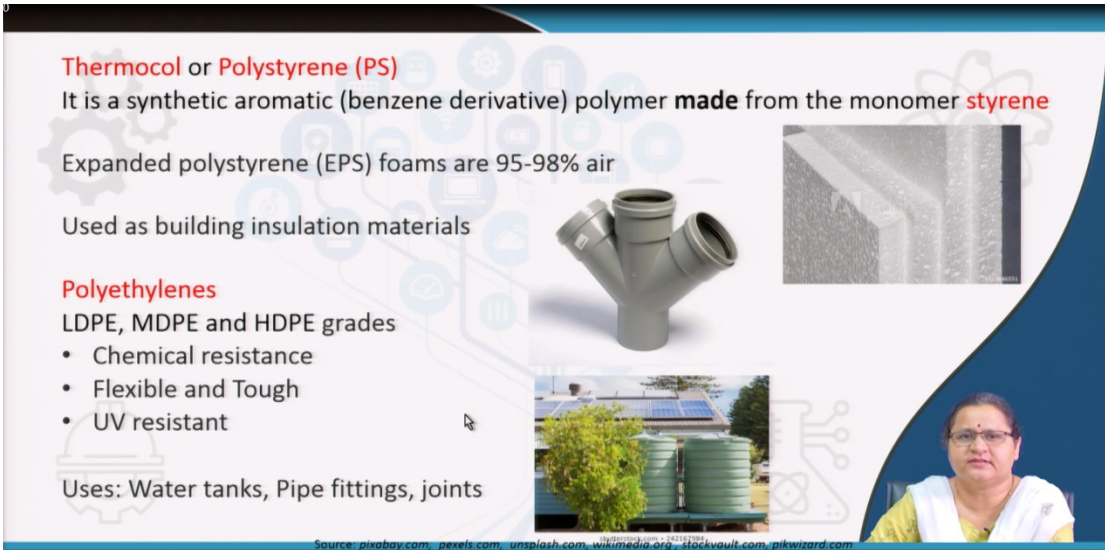
You can see this is a polycarbonate roofing, very thin membrane on the steel support. Now although they are very thin, they have high impact strength of maybe 200 times that of glass. Acrylic is difficult to work with whereas, polycarbonates it is easy to work with polycarbonates. You can get it clear, you can get it having some colour sorry it has poor resistance to ultraviolet radiation whereas acrylics have better resistance to ultraviolet radiation.

It is higher in cost as compared to acrylics. Now you can improve the ultraviolet radiation resistance of this particular polycarbonate sheet by adding some filler materials into it and that is the additives that can actually make it more durable to outdoor uses. And hence polycarbonate sheet similar to acrylics have large application in outdoor environment.

Say cycle sheds, say outdoor or temporary shoppings, temporary even bus stops bus shelters. These are all having either polycarbonate or acrylic sheets as their topping. So it has replaced maybe corrugated metal sheets or maybe metal sheets or maybe even concrete. And it is giving a much easier solution, lighter solution to the function where there is no habitation.

It is keeping cycles, it is covering a portion, it is giving temporary shading to the spectators of a stadium, and you can use polycarbonate sheets. It is not a habitable space, but it needs a covering. These are examples of outdoor application of plastics. (refer time: 27:45)

Now coming to thermocol, that is polystyrene we had discussed it is used as an insulation material. It is expanded polystyrene foam EPS and it is containing around 95 to 98% air and when it is having chlorofluorocarbon then we get a higher thermal insulation and the filled in air is chlorofluorocarbons, CFC and it is having a higher thermal insulation value.

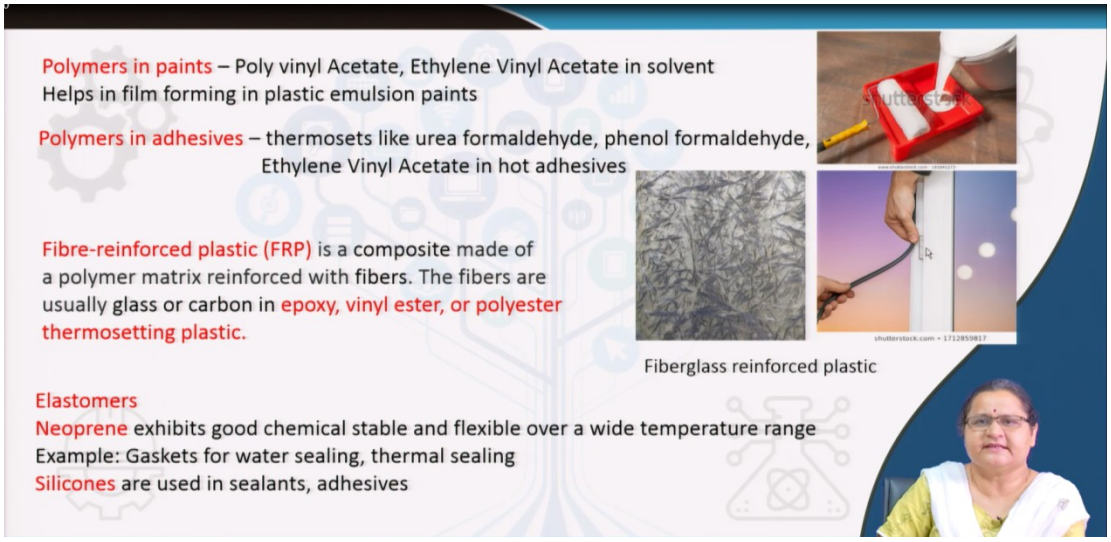


We have polyethylenes in different forms as if you can go back to the chart and you will find LDPE, HDPE is written over there, high density polyethylene, low density polyethylene and we also have a medium density polyethylene. So these are having various uses for flexible joints, water tanks, pipe fittings. These are ultra violet resistant and has outdoor applications as well as indoor applications. (refer time: 29:21)

Other than the poly thermoplasts we have use of polymers in paints, the polyvinyl acetates, the ethylene vinyl acetate helps in plastic emulsion paints, polymers in adhesives. Those are all thermosets. Urea formaldehyde, phenol formaldehyde, ethylene vinyl acetate, which is used for hot adhesive. So we find thermosets over there. We find thermosets in the FRPs that is the fibre reinforced plastics.

So where glass fibre is being reinforced the plastic which is used is a thermoset. We have epoxy vinyl ester or polyester as the thermosetting plastic in case of FRPs, we have elastomers which was the last item in the list. We have neoprene, we have silicones. Here you see the person putting a rubber gasket on the window. It is a tape like neoprene gasket which is rubber, which is an elastomer.

These are chemically stable and flexible over a wide range of temperature and used for water sealing, thermal sealing. So when it is a case of insulation of say double glazed wall, double glazed window you have to have neoprene gasket all around. You can use silicone gaskets, silicone as adhesives, when you are using precast concrete slabs. So the sealants are actually silicon based.



So these are various applications of plastics in our building domain. We may not remember them as plastics, because plastic is the generic name, but we may remember it as silicone, we may remember it as neoprene gasket, we can remember it as PVC or acrylic sheet or polycarbonate sheet or HDPE tank. And we will see we are using plastics for every now and then in building industry considering the casings of electrical lines.

So dry lines, wet lines, it is having so many properties that replaces many of the materials, which we commonly use for building. (refer time: 32:42)

Now coming to the end of the course, I would like to summarize telling that we do not have an end to this particular course maybe. This is a very basic course which is a building block of being an architect. You get training, when you are in very school level, very primary level you are taught ABC. Building materials is actually the ABC of architecture.

If you know this subject very well, if you explore every day, what is new, what are the challenges in this material, you will always come out with a very complete new good building. You have to remember all the aspects which a building experiences, because a building is facing the environment. It is facing the inclined weather. It is facing freeze and thaw if it is in a very cold country.

So context climate, affordability of the client, what is the type of building, what is the expected life of building, what is the purpose of the building, who are the users, who will maintain it all you have to keep in mind when you are choosing or recommending a material. Material should be reliable. It should be available and the skill should be available.

That is why our country could not move to the faster construction methods of precast items. Though they have limitations, but we at times require fast construction. So we have to understand what the purpose of the building is and we have to find whether these materials are code specified before recommending it. Ease of working also is another point to be considered, particularly like joining two items, the masonry works.

Research is on. We are advancing in this area, in this subject and its application. So maybe other materials will come. Many traditional materials are to be thought of which can be improvised and made available, so that we can reach, we can maintain the environment friendliness. We also have to look into the embodied energy or the amount of energy spent in making a building material.

When on one hand, we are looking into the basic materials, we are also looking into the nano-applications where a very small amount can do a change or bring a change. So we have to tread forward. This was the stepping stone, or maybe a very basic course for architects and hope you enjoyed it. All the best for your assignments.

All the best for your examinations, which will be held and hopefully you could do the assignments which were always communicated to you after every module. Thank you.