Building Materials and Construction
Prof. B. Bhattacharjee
Department of Civil Engineering.
Indian Institute of Technology, Delhi

Module - 12
Lecture - 2
Polymer in Construction: General Introduction

Let us now look into another material that is polymers and there usage in construction. In the first lecture of the module 12 which deals with polymers in constructions.we shall be concentrating over self on 2 basics of what is polymer and so on, and where the civil engineering are used in construction they used and then in the next 1 more lecture will look in to specific usage right.

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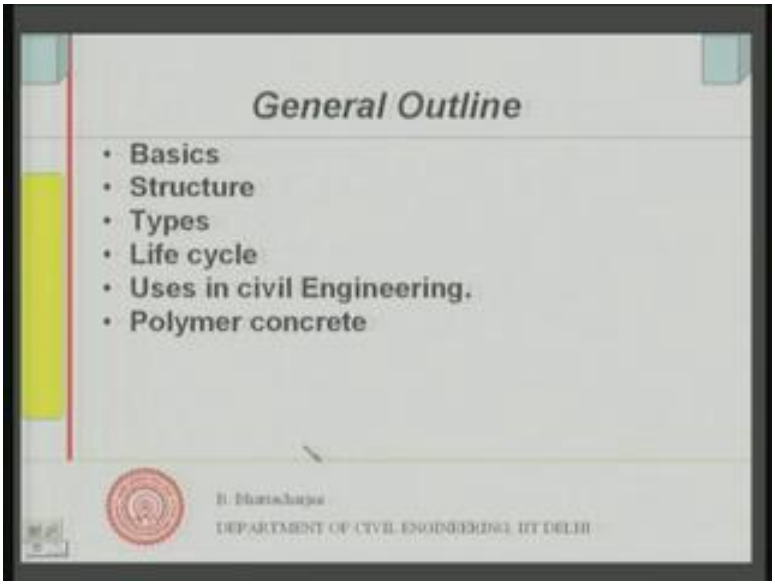

So that is what it is therefore, general outline of this lecture is we have will discuss some basic, looks into the structure ofpolymeric material then types, life cycle, uses in civil engineering. And just I will try to introduce about polymer concrete composite one of them is polymer concrete. The other one, of course will discuss in the next lecture. So let us say what is let us see the definition what is polymer, what you understand by polymer.

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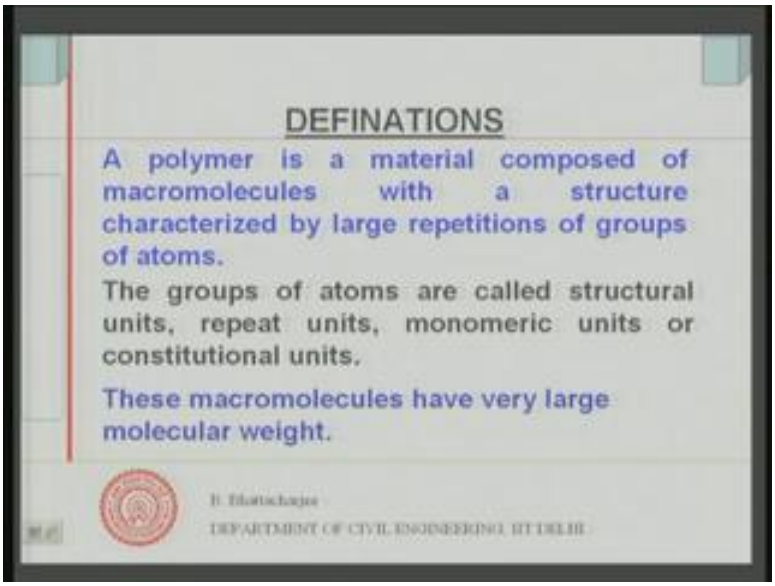

Now, you know very interesting carbon has got a peculiar property and silicon has it somewhat, you know carbon can browned with the carbon item and you can make long change as possible. And that gives raise to polymeric material in fact, in nature very large number of materials are polymer the human body the tree in a tree timber as you see the tree basically it is cellulous fiber in lignin.

Now, the cellulous nothing but alongs in polymer. So in nature the polymers the human bone is has got a polymeric structures in so on, so you know the large amount of material used by the nature or revolved in the nature are polymeric.Now, how do you define it? A polymer is a material composed of macromolecules with a structure characterized by a large repetition of groups of atoms.

So, you have groups of atoms which are repeated large number of time right, which are repeated large number of time in the structure of the material and form a macromolecules and that is what you call us.The groups of atom are called structural units, repeat units or monomeric units or constitutional units.

So, this all names are used in very many literature the groups of atoms are called structural units some time they called repeat units, monomeric units or constitutional units.I am sure some few must as most of you does standard it something basics school chemistry.

But this since you have starting this in usage in schedule engineering where repeating some of them right.These macro molecules have large molecular weight it can be understandable, because it is repetition of some smaller molecules. For example, polyethylene or polypropylene now you have propellant which is repeated very large number of times to get polypropylene. So you can repeat, the repetition the amount of repetition can vary.So, molecular weight depend up on how many times this is repeated right.So that is what it is, basically has the large molecular weight, so this material have large molecular weight right.

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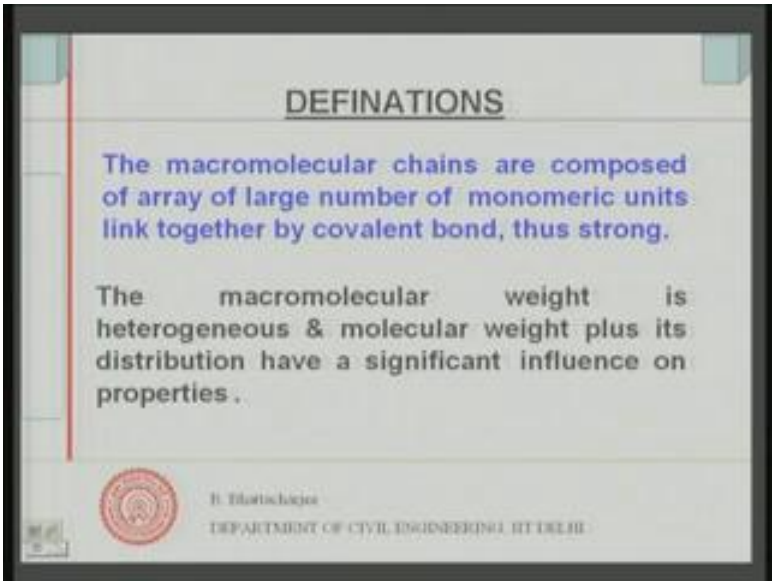

The macromolecular chains are composed of array of large number of monomeric units link together by covalent bond.Now, the covalent bond is between carbon and carbon and therefore, they quit strong you know this is strong and relative terms. Because you have seen, thinks like bender volt bond in case of cements, which have basically note as strong as a chemical bond; the physical bonds and cements bond actually aggregate system.

So, such physical bonds by an large and in case of metal use of metallic bonds which are even stronger and then we also talked about, in a electrovalent bond between chemicals I mean irons.But then we get nothing do it such material as such, because the strength does not come for such solves are similar things.

But now we are looking a different kind of bond that is covalent bond, that exist between the carbon items and therefore, it can be quite strong. The macromolecular weight is heterogeneous it may not be same throughout; the weight the macro molecular weight. Because, you have large number of molecules repeat in monomeric units or repeat units which have gone to form the macro molecule.

So, molecular weight would be relativity large that is what you have seen, but in the whole material the molecular weight may not be same. Some places you may have higher molecular weight, where as in some other places you may have lower molecular weight.

So, that is what it is heterogeneous not same it may not be same and it is heterogeneous and depend up on how many reputations you have what you called degree of polymerization.So, this is heterogeneous number 1 and molecular weight plus its distribution have a significant influence on properties.Because, we know the various physical properties depends on molecular weight.

A heavy molecules generate tends to be solid in normal temperature and lighter once tends to be fluid of some form very light once you may be in guess this form.So, molecular weight dictates lot of properties and the heterogeneities or its distribution also have significant influence in properties right.

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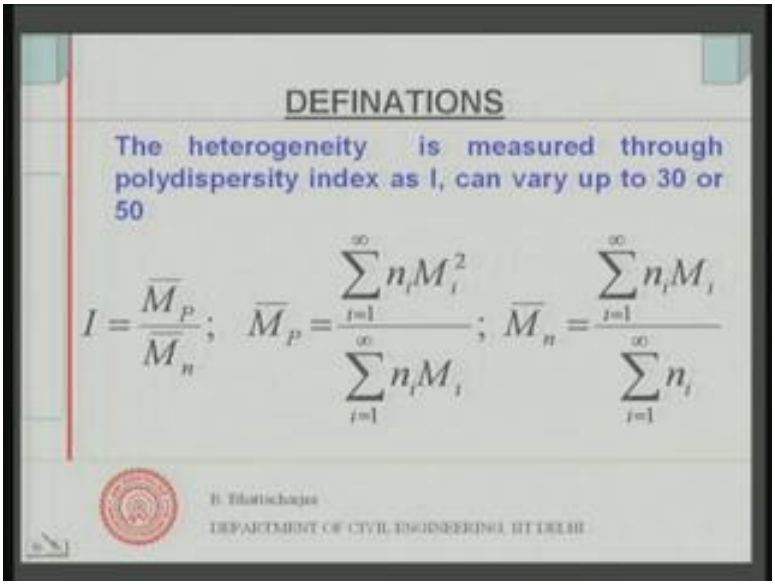

Continuing with this now this heterogeneity can be defined in terms of what is called polydispersity in index. And this can vary from 30 to 50 right 1 issue is degree of polymerization, so how many times does it repeat right polydispersity index measure the heterogeneity of the molecular weight and it can be you know as highest 30.

Let us see how does it look if it look at the how do define this polydispersity index are I is defined I you know this is are I we define by the sequencing by 2 different molecular weight.This Mn is nothing but average molecular weights, where n stands for number of I means sigma I sigma ni this stands for actually the degree of polymerization, that is total number of repetitions present.

So, out of which ni you know for let us say, n1 is the number of molecules having molecular weight M1; M1 is the number of molecules having molecular weight M1. So, n1 M1 plus n2 M2 etcetera, etcetera when you sum them up and divide by the total number of n1 plus n2 etcetera. But total number of reputations, what you get is an average molecular weight.

So, this is purely an average molecular weight and this you can see is, a molecular weight kind of weighted average.So, what we have done? We have multiplied this by Mi again, so niMi squared divided by ni Mi. So, what some this will give? This will give you, the molecular total weights of number like n1 is an number of repetitionwith M1 molecular weight.So, when you sum total up you get the total weights and this each multiplied by the molecular weight.

So, niMis quare now this tells us this is the weighted average sort of and this divided by Mp divided by Mn this poly dispersity index. So, this can be as highest 30 or 50 now, in case of resolve uniform if it is all uniform then this will would have been simply 1. Because, you know this multiplied by M with this actually will you would have got average Mp and Mn same.

If would have is all uniforms same value Mi like everywhere, the number of Mi you know this is simply aconstant same 1. So, you can take it outside the summation sign said here also and take it outside; the summation sign and you would be left simply M average or single M here and this would have been also same M and this ratio have been 1 if it all uniform.

But this therefore, as ameasure of how much dispersion is available or polydispersity index in case of polymers and this can vary as highest 30 or 50.

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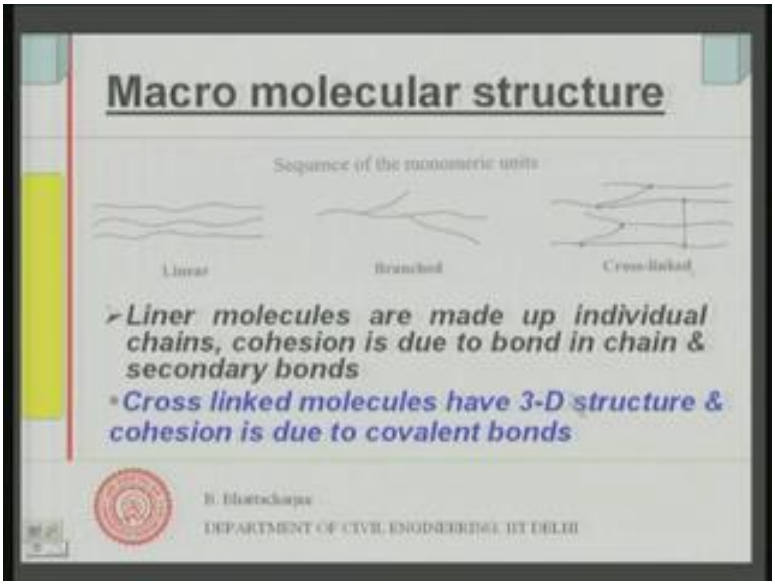

Let us see what is the macro molecular structure right? What is the structure of the macro molecule? We have seen the structure of course, other materials as such and this have what is called 3 varieties of you know monomeric units are connected.For example, in linear this will have call connected in linear manner in this 1, so this is called linear sequence of units they will be linear-linear structure.

So it can be burnets for example, thing coming out like this branch and this are third varieties called cross linked structure, where you have this change they might be in 3 dimension.For example, in 2 dimension this is in 1 dimension 1 level, this is another level.So you have completely cross link structure that means, you have got a 3 dimension structures.

So, linear molecules are made up of individual change and there cohesion is due to bond in the chain itself. So in the chain itself be cohesion, because if you try to pull them the covalent bond will be opposing such if you want to break it then you have to exact force to break that particular covalent bond plus. There are secondary bonds use a when there was sign between the chains.

So, the secondary bonds between physical bonds between them, but the main thing cohesion due to the bond in change itself and secondary bonds.So, the linear structures molecules all c atoms are arranged in linear manner; what about this branch same 1, but small branching. In cross linked molecules they have 3-D structure as I said, because this is 1 dimension these in plane, this in another plane and the cross link like this.

So, cross links molecules have 3-D structure and cohesion is due to covalent bond between these and between this everywhere, you have covalent bond and obviously, you understand that this would have a much higher cohesion existing right.Because, suppose in this 1 tries to remove this even the other plane; the molecules in the other planes will be opposing such, movement simply through this kind of cross linking, cross linking bond, so that is what it is right?

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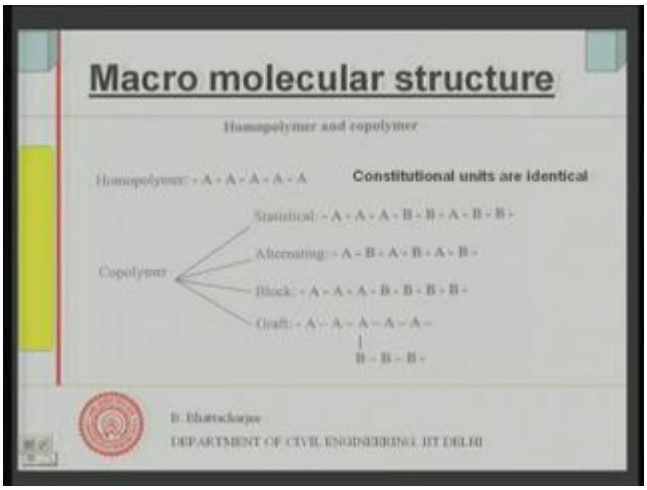

There can be another kind depending up on the this was depending up on the structure of the chain and the other kind could be depending up on, whether we have similar type of molecule or different type of the similar type of molecules.For example, this are called homo polymers which have got all 1 type of molecule repeated several type. And if you have more than 1 then you call it copolymer.

For example, AAA and A this 1 type of monomer and B is another type of monomer and they are polymerized to give you copolymer.Now, this copolymer can be of 3four types for example, statistical in this case they are all random A AA B B A B B so they are linked in a random manner whereas, in this 1 it is alternating A B A B A B extra.Here it

is block form by AAA then B BB altogether and this is called graft A this is link to B BB.

So, the structures could be different and in this 1 we say constitutional units are identical.So, in case of homopolymer units identical, in case of copolymer we have different constitutional units and they can be again arranged in different manner statistical alternating block or graft.So, that is how macro molecular structure looks like right.

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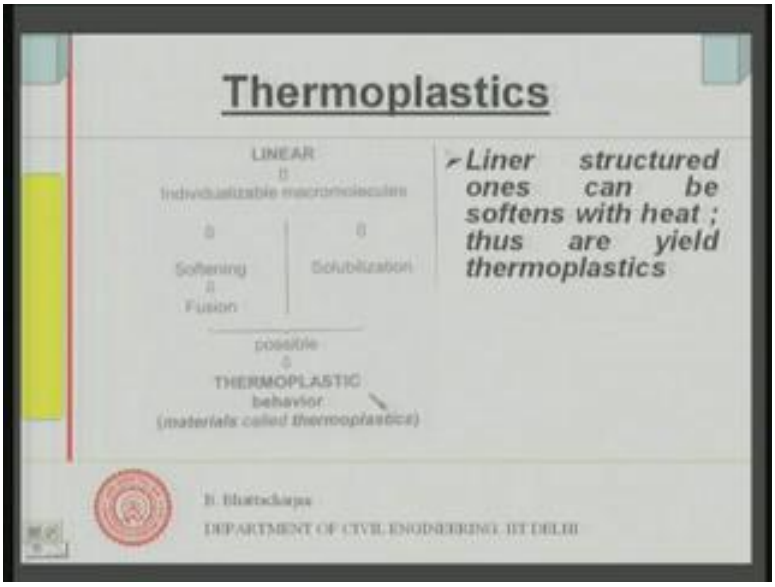

So let us, look into something different now you see now we said do you get linear polymer which means that, if you applies stresses on to them or less is the heat on to them some energy then this chain the chains can be separated easily and individual molecule can be separated. So, in this 1 linear structure when you have linear structure it is possible to individualizable macromolecules relatable easily.

Because, through supply of heat or similar sort of all went can easily individualizable macromolecule, because they are the bonds are only along the one direction there long change.So you go to break it and therefore, it is possible to individualize relatable easily.So, this can take place by you know heating and in that case what results in softening and then it fusions.

So, this is possible in this case soluble through solubility it is possible to separate them and this sort of behavior we call it actually linear structured 1s can be softens with heat and this are yield thermoplastics.So, this we call as thermoplastics; thermoplastics are once which can be individualize very easily through heat or even through solvent and it is possible to individualize them and you get what is called thermoplastic behavior that means, they will soften as you heat it up right.

So, this materials are called thermoplastics; they have thermoplastic see behavior that means, you heat it up the softens and possible to remade them back to the shape that you want and therefore, they are called thermoplastics. We have number of them use in construction as we see.

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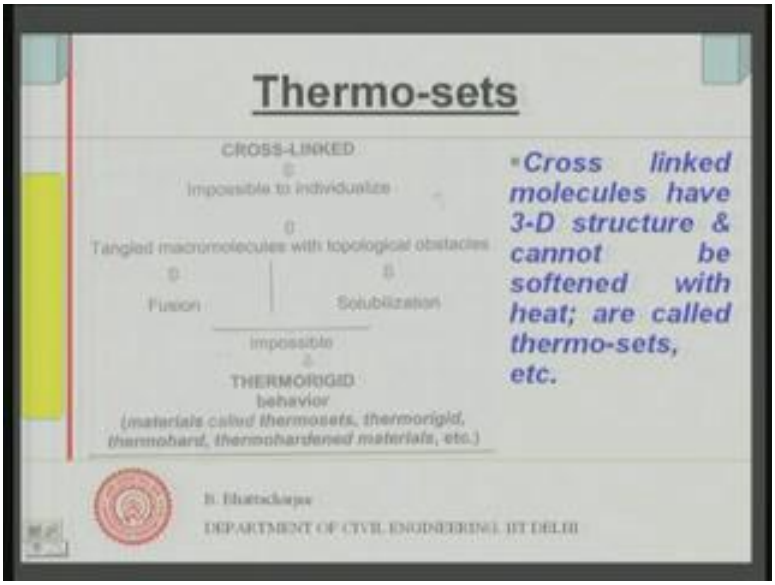

As suppose to this the cross link structure you know, if you see that in that case the sliding of the chains are not possible 1 over another and they are cross link.So very easily you cannot break, because there will be opposition from the cross link 1.So, there it is not easily you cannot separate or individualize the molecules so easily.

So, you cannot separate them easily therefore, it is not possible to individualize in this particular case and they remain tangled macro molecules with topological obstacles. So that means, in 3 dimensional obstacles and therefore, fusion is not possible solubilization are not impossible and this you call thermo grid behavior and this materials are called

thermosets, thermorigid, or thermohardened materials, extra. Because, it is not possible so possible to individualize them you by supplying head.

But remember, if I supply heat off course they can get decomposed at certain temperature or certain amount of heat is supplied.But you can break this molecule, they got completely decompose structure might be totally disturb.But is unlikely you able to soften them, so that is not possible we can obviously in presence of oxygen some of them can easily burnt from in carbon di oxide and things like that.

But it is not possible to soften them and remold themI mean, when it breaks the cross link breaks then it is decomposed; it is no longer again it not a reversible situation like the you know linear structure, so this are thermoplastics. Cross linked molecules have 3-D structure that we have seen you have 3-D structure and cannot be soften with heat and they are called thermo sets and thermorigid, thermo harden or thermohardened materials, extra. So, these are 21 of the ways of classifying the polymeric materials, but there is the 2 types of polymers are there.

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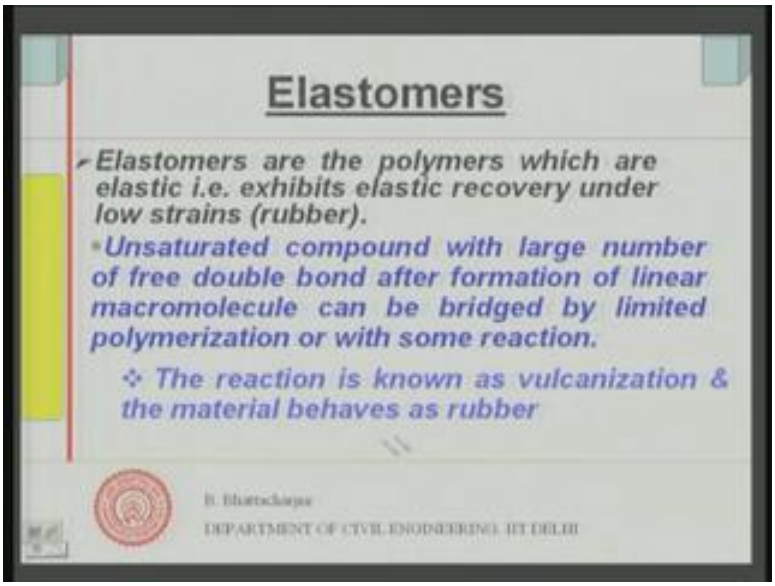

A third type of polymer is known as a elastomers and we have usage of all of them in civil engineering, you have thermoplastics and thermo sets will shall discuss detail them in detail some time later on. And elastomers you must a hard of them, because most of the bridge bearings; bearings in the bridge structure, bearing of the deck system over the period is usually elastomers.

So, elastomers are nothing but, polymers which are elastic exhibit elastic recovery under low strains like rubber.So, this are elastomers; elastomers are polymers which are elastic and exhibit elastic recovery under low strains, so these are elastomers. If you have a unsaturated compound, unsaturated monomers right after the macro in the macro molecule has from if you have large number of unsaturated compound.

What does it mean? You got double bond you know, carbon can have double bonds and triple bonds. For example, in ethylene you have got double bond you have triple bonds that you must be remembering.So C2C triple bond and there is unsaturated that means, such bonds are can be broken up easily relativity more easily. Then, first bond that is a single bond itself, so such unsaturated they have got double bond or triple bond right.

Supposing you have got free double bond, large number of feeds unsaturated compound are 1 which will have double bond, triple bond. Supposing, you have macro molecule which is unsaturated and it has got large number if free double bond after formation ofthe linear macro molecule.Now, by some application of sum third reagent I can actually do some bridging for those linear change by breaking the double bonds or triple bondsor I can do this by further limited polymerization.

Since there are unsaturated there are double bonds, they can be easily broken and may be now some sort of cross linking becomes of partial comes linking may become possible.So, this is what one can do and this reaction is known as vulcanization and the material behaves like rubber that means, you may get songs small under low strain it behaves elastic it can recover very easily. So this is what is this materials that means, it is partially cross linked rather than completely being linear or completely cross link is somewhere in between. So, this material is somewhere in between and that we call as a elastomers.

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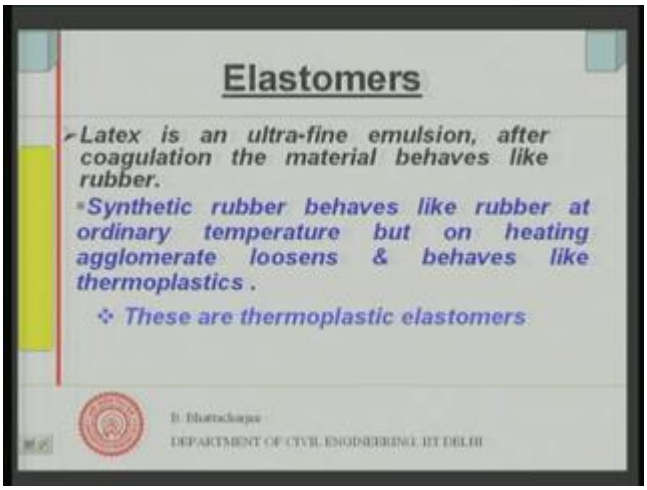

Just another terminology sometimes will come, because will come across not only in rigid bearing. Butyou must be hearing sometime we discuss about, polymer modified concrete is a concrete or very much use in repair word there also called latex modified concrete.Sp latex is nothing there are ultra-fine emulsion materials and after coagulation the materials behaves like rubber.

So, this latex is a nothing but, ultra-fine emulsion very fine powdery like things and they form have many emulsion and once coagulated behave like rubber. So, this behave like rubber, so this are elastomers synthetic rubber behaves like rubber at ordinary temperature but, on heating agglomerate loosens and behaves like thermoplastics.

Now, first of all we have natural rubbers and synthetic rubbers; natural rubber comes from pre and bean use for many many years before industrialization.Now, the synthetic rubbers butadiene and Aesopian durable at later when uses of rubber became very, very popular right.Now, this synthetic rubbers of the materials which are made into synthetic rubbers behave almost like rubber at ordinary temperature.

Because, they have the same sort of thing partially crossed in structure.But on heating, this agglomerate loosens and behaves like thermoplastics thus, because the kind of bond that exist in this structure is different. Then, the natural cross linking structure that exist between the you know different change, partial cross linking you know the bond that exist is different from the natural rubber.So, they behave like what is thermoplastic set high temperature rightso, this we call as thermoplastic elastomers.

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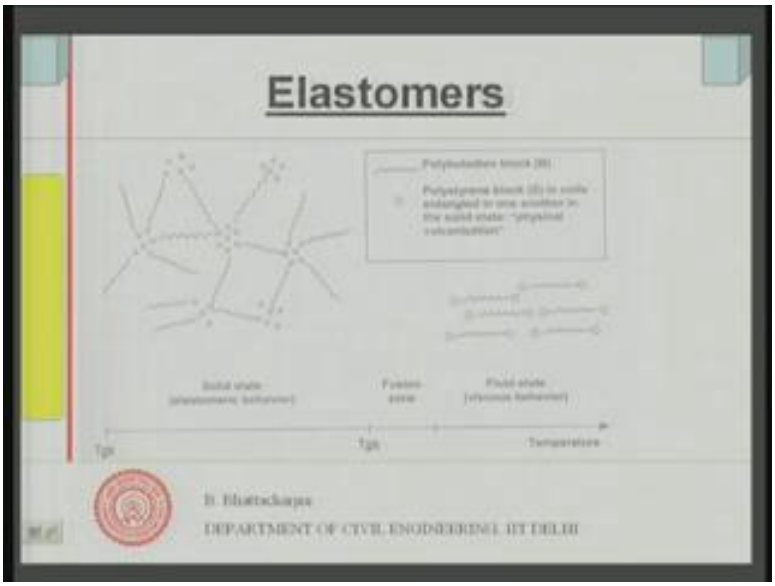

Now this diagram will make it clear somewhat, because synthetic rather is what is most commonly used today like this is the case with style, this is the styrene butadiene rubber this be are system actually.So, this place it is if you can see this is the change this changes of the partial processing linking's are there and does not solid state you get a electrometric behavior.

Then, as you increase the temperature there are some point they actually get this is a fusions own and then they become comes into the huge state, when they are all individual changes. Inthey are tingled with each other, at the solid state and therefore, they behave like rubber and then when you increase the high temperature this changes are separated out and resulting in formation of behaves like thermoplastics with we go to fluid state and that is what it is.

So therefore, there thermoplastic elastomers should call them thermoplastic elastomers.So what we have seen is, there are three classes of what you have seen is there are 3 classes of polymers that is thermoplastics, elastomers and thermosets and all are used in construction all are used in construction.

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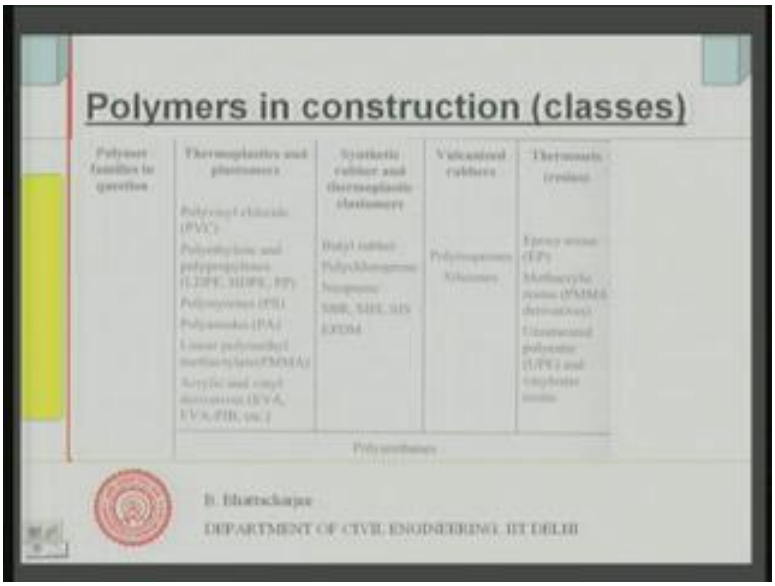

Let us see how they are used where there used right, so thermoplastics you know this are the polymer families in question that is thermoplastic, this is the elastomers and thermo sets. PVC is a thermoplastic so far we have define this clauses and now you are talking about them. PVC is a thermoplastic right thenpolyethylene or polypropylene, PVC pipes are very common are we have known about them PVC pipes used in waste water pipes in buildings and many other usage actually it is a very common.

Polyethylene or polypropylene low density polyethylene, high density polyethylene, polypropylene varieties of uses are them of there in fact, there use the fibers.Fibers can be used to reinforced concrete or plaster to avoid cracks some example: polystyrenes, polyamides, linear

Some of those example will come across when you talk about, specific usage like and so on so forth, when you look into the specific uses some of this will come across. Synthetic rubber and thermo plastic elastomers ducal rubber this is very much use, this is use is sylene bitter labor solutions then poly clorpine, nephew rubbers with bearings, stain in butted rubber system, butadiene, styrene, styrene isoprene's styrene, extra.

So, there are several this rubbers there used as in told you also in polymer modified concrete system rubber latex are used. There used cylindes, some other use in cylindes some of the modules in off course, bridge bearing is off course of you know this kind of

elastomers materials.Then, polyisoprene's, silicones they used vulcanized rubbers they use for certain usage. In fact, silicon are used for water proofing purposes.

As usual see sometime and thermo sets resins like a pox resins they used in repair works very much, methyl derivatives, and unsaturated polyester and vitalized resins. So, you see their specific uses later on their used for various sound and then use for very much and very much commonly used for repair works and the polyethylene off course rather which belongs to everything. So, usage of these materials in civil engineering we just saw looked in to it.

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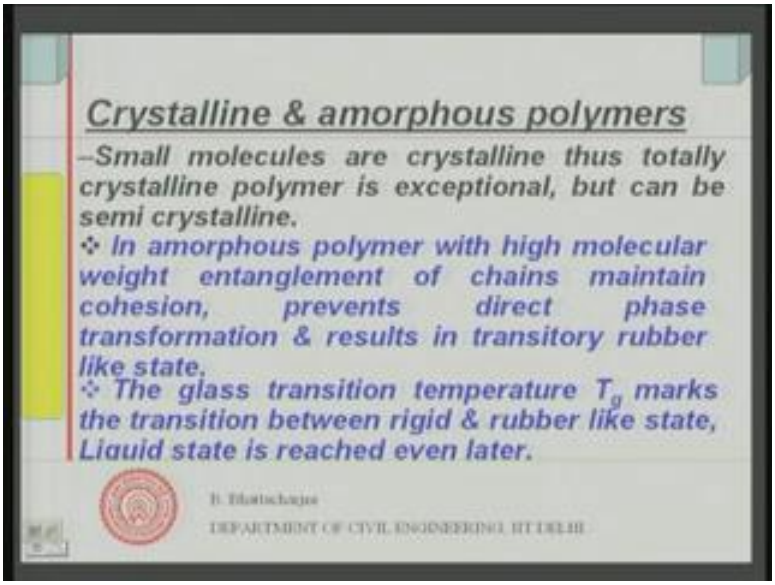

So, this is the clauses and where there used now, rest just look at something else from the basics.You see small molecules are usually a small molecules can form crystal crystalline. The small molecules large molecules usually are not crystalline thus you do not see crystalline totally crystalline polymer, which should be an exception.

But polymers can be semi crystalline, but more importantly amorphous polymer with high molecular weight they are more common and you have they can have with high molecular weight if there are number of change they can be at engulfment of change. So, which maintains the cohesion and prevents direct phase transformation and results in transitory rubber like state.

Now, what happens? When you have number of changes right and there entangle.So, when we are heating them heating them out when your heating first of all the chain themselves is the entangle then we secondary force, secondary bond through this entanglement.So, if you are trying to separate out the changes completely this will not be possible; some of them might be separated, some others may not be.

So, they do not have melting point what happens is, they have does know you know prevents direct phase transformation solids to liquids state away it is not there.This something intermediate happens and there is a transitory rubber like state exist.

So, inthis case of polymer among as polymer this behavior is change generally in linear change and the temperature at which actually source softening starts, we call it glass transition temperature.So glass transition temperature, it marks the transition between rigid and rubber like state.So, it is an rigid solid state to the rubber like state and then liquid state is reached much later.

So this is important, because after glass transition temperature its utility as structural material re you know its utility totally changes is performance would completely change, once it has each that glass transition temperature.

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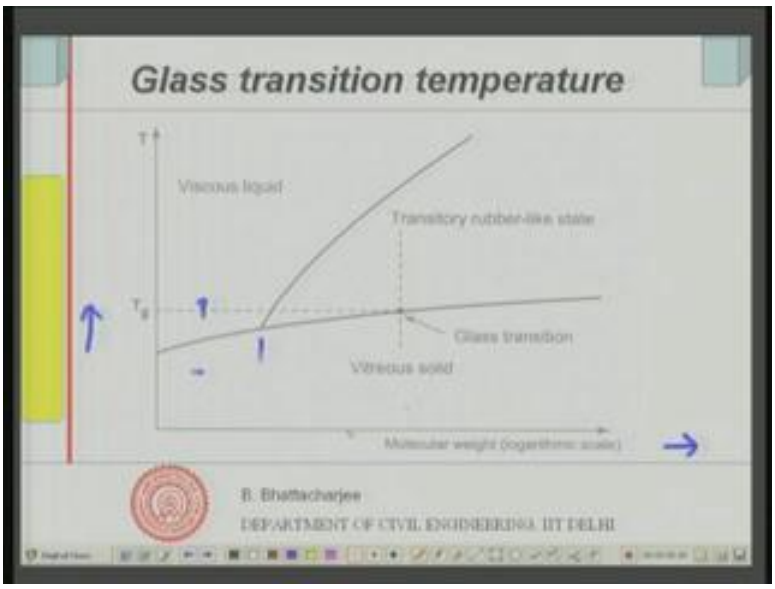

This diagram will make it clear, see in this diagram what we are showing is on this exercise I would molecular weight, on this exercises got temperature. So, is my

molecular weight is less is all crystalline sort of and possibly form solid state right; this is solid state to discuss liquid states state jump is there.But when I increase the molecular weight this no straight jump, rather there is a transitory rubber like state.

So, if I look at this point from discuss solid to you know in between point where just starts becoming rather state this temperature I call it glass transition temperature.So, in higher molecular weight this is what you see and higher the molecular weight this gap tends to increase.Now, this further on further term raising the temperature here it will become discuss liquid.

So this is called glass transition temperature however, the utility a solid finisher here; because not it is become something like soften rubber like state.So, this is glass transition temperature; another aspects of behavior of the polymeric material. So, well very important now looked into this fundamentals of the polymeric material.Now let us, look into some of their utilities; towards use in buildings of in constructions.

Now, most important aspect of the behavior of the behavior against fire, because we know this materials are all actually carbonizes material.So, they can constitute what is called fire load which you have mentioned earlier, you know fire load the load constitute actually fire load many of them, not all. And their temperature sustain is also know very high.

Because, you to depend on that long chain molecules m of s molecules should depend up on the transition temperature, which may not be very high. For some of those cross link structure they are decomposition temperature also is not very high not of the order of hundred I mean 1000 to 1200 degree centigrade the 100 or 150 to 200 I mean 150 and 200 similar of those order.

So therefore, the fire sustain is not very you know it’s they are not very they are susceptible to fire in that sense.But important point is that, although you know even fire dependent coatings are also polymeric in nature.So, most of the polymers they are suitable tofire but, fire deterrent coatings are also polymeric in nature you must found what is called Teflon. Now, Teflon coating is used in you know frying pans, nonstick pans, they are the temperature can you understand very high temperature.

So again that is nothing but, poly tetra flow ethylene PTFE, so that is again is a polymer therefore,you know having send that polymers are acceptable to fire not necessarily. Because, that is a very, very versatile material while some of them cannot sustain more than may be 200 to250 degree centigrade.But many others can sustain much higher temperature as well.

Butcommonly used polymeric material is 1 issue is, you do not at the movement we are not interested in their flame redundant properties or they are fire load. Because, but 1 must keep in mind the 1 important issue will related to fire is that, the smoke; fertility incase of fire is mostly because of the smoke.

So, quite often is the snide a gases or there 1 may you know coming in contact with such gases produce during fire.Let us say, fire loop then it can result in temporary loss of memory, temporary in nation of the brain and 1 may just remain there may not able to escape from fire.So smokes are more dangerous in case of fire, because fertility are more because of smoke from suffocation or temporary inaction. Because, the break in is not being active material.

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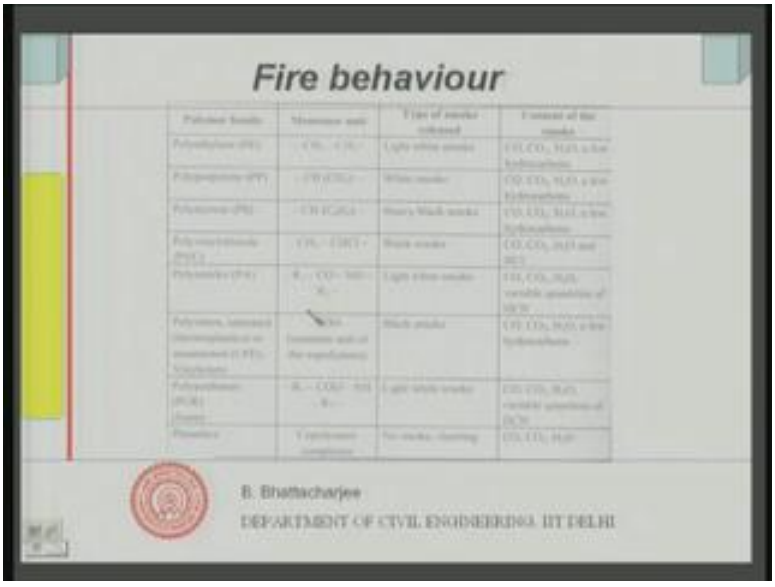

So the smoke behavior that is what we are looking in this case. Now, depending up on type of material for example, if it is polyethylene this is p is molecular unit is given and what you get is a light white smoke and produce the carbon monoxide, carbon dioxide and water and few hydro carbons.

Now, look at this I will come to the in between once poly urethane for example, fume; which is used as insulation in building materials quite often can be used as insulation material poly urethane. In many others structures uses in insulation fume, this 1 has got this group NH group and light white smoke but, you can have HCN production.

So, this is important issue related to fire desires there susbtability besides the one you using susceptibility to high temperature. Because, stability again high temperature just also important may be sharing properties those are also important related to fire.

Then, polyester saturated or unsaturated polyesters or enlisters you know this is the group, black smoke mostly carbon dioxide, carbon monoxide and water and few hydro carbon.Now, come to polyamides you know which has got again this nitrogen a might group and it can produce again hydrogen snide.So, the quality of the smoke is important, so while 1 is using them 1 must be knowing about this.

Similarly, PVC can generate hydro chloric acid and others mostly generates poly style in, polypropylene, extra.Most of them generates all phenolic, most of them generates actually carbon monoxide, carbon dioxide and water. And color of the smokes are most of them are white but, this is black smoke from polyester then this is black smokes for polyethylene chloride and heavy black smoke compound poly style.

So, this 1 must be ever of this besides there temperature sustain and in case of fire. With specific materials we never coming in coming across in our discussion in subsequent discussion will discuss about, their susceptible due to heat and things like that as when require.

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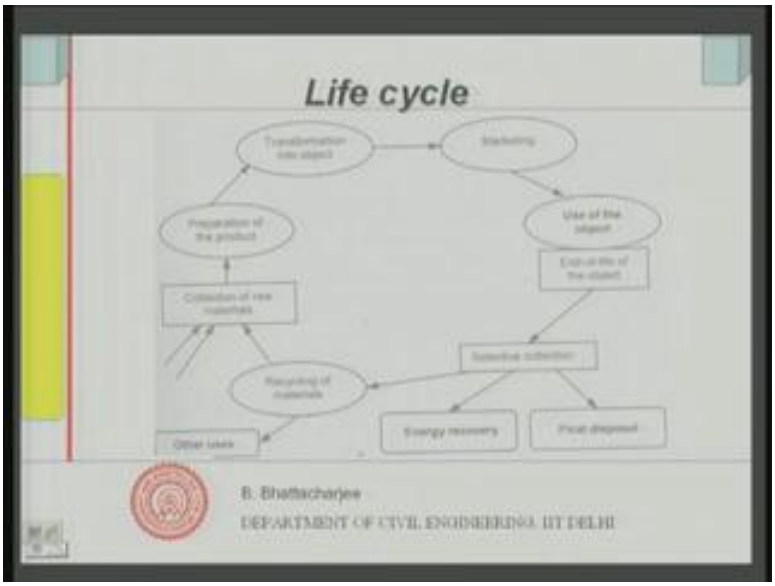

Another important issue is, the life cycle now, life cycle of polymeric material you see this are materials quite bit can be sustainable. If you are using if sustainable means, you know if you are able to recycle them properly. So, life cycle of this materials is important also important are there ageing you know degradation with time degradation with time I am not discussing in details.

But I just thought that I talk about the life cycle somewhat for example, a collection of the raw material you start from here; collection of the raw material then you prepare the product transformation into object right. For example, this preparation of the product means let us say in rubber systemand you have used in concrete. So, you have got polymer modified concrete hereor may be the product this may not be mark this may be use straight before that may be the system itself is marketed.

So, then use of this object inlet us say concrete making then end of the life of object. Now this life comes when it is degraded fully, because you have seen also in case in the context of concrete that they you know tend to degrade or react.Now, in case of polymeric material degradation may be initiated by simply radiation, ultra violet radiation or the solar radiation also by heat temperature raise or humidity or several other factors.

So, as the degree with time the degreed with time will come when it will not be functionally capable of doing its function; doing its purpose right when its functional

utility will be lost as define by the usage.So, that time it is actually attend it is you know its end of this life so once it is rigid end of its life. So, once it has rigid end of its life then selective collection is to be done right part of it will be finally, disposed right.

So, some from some energy can be required produce them with expense of energy from some of them we can recover the energy, and then part of it can be recycled or put into some other usage recycled and put in to other usage. And then a part of it can go to as a raw material or producing the new material its producing a new material is a type. So, that is the life cycle and this life cycle of the polymeric materials are important from sustainability like, life cycle of other materials are important for sustainability right.

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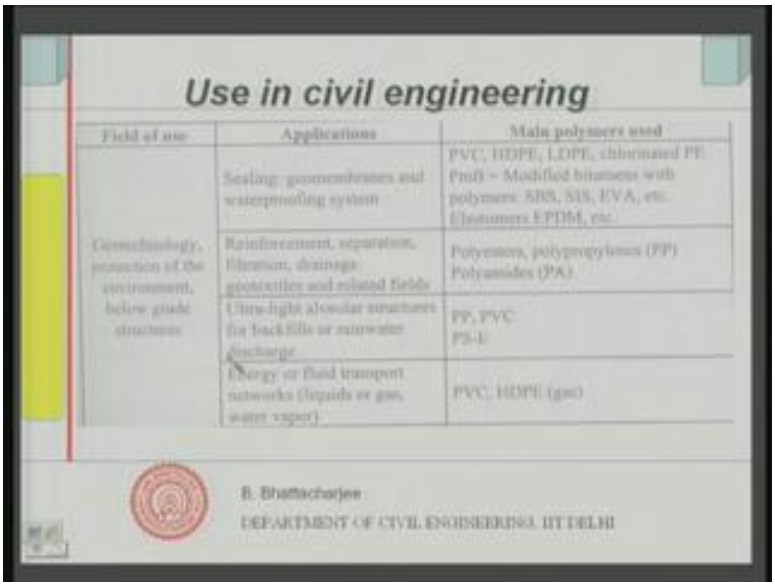

Let us see what are the usage in civil engineering right; uses of this polymers in civil engineering let us see.Now, first main field where good lot of it is being used its Geotechnology or Geo technical engineering. In other words, environmental below grate structure below ground or below ground or you know in Geotechnical engineering.

Geo membranes or water proofing system this is very common Geotextiles is special class of materials being used and there use sealing Geomembrane and water proofing system and what we use their PVC Polyvinyl chloride, high density polyester, low density polyester, chlorinate polyester, modified b 2 men's with polymers they are used in also road styrene, butadiene styrene, isoprene's styrene, rubber system, EVA, etcetera etcetera elastomers various kind ofelastomer.

So, in technical engineering 1 is the j membrane extra in water proof in system all this varieties of polymers are used. In Geo technical engineeringfurther for reinforcing the auth separation of refreshing granites, Geo textiles and related field there is the other big field where it is being used. We use polyesters, polypropylene and polypropylene and polyamides.

A, then also in altrolyte structures backfields and rain water discharge use polypropylene, PVC etcetera. Now, in case of transport of fluid, pipes we use PVC high density polyester for gases, so this is the uses in Geo-technical engineering.Today it is this Geotechnical engineering, today it is reinforcing or construction oflemmings bends and construction.

Let us say, various kind of embing of varieties are formed say fly-over approach or approach to fly-over or you know, so where you do not have space.You are actually reinforced are to support this itself instead of itself instead of huge of retaining all of say machinery or concreteRCC was most commonly used.

Butnow, the reinforce has reduced this only u just have a lining; solid RCC lining is there at the end but, reinforced art construction is used very much in approach of fly-overs and many other places there are n number of places.So, a huge use of polymeric material in Geo-technology is there.

So however, this will not be the part of our discussion, because this forms part of you know as there can be special course on this and so will not discuss this will not part of the building material construction, but this is a very large and important subject and important use of polymeric material.

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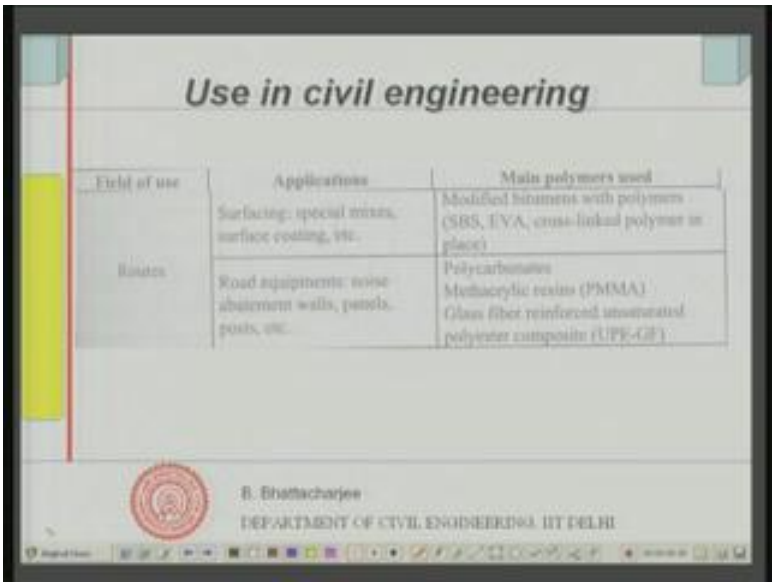

The second important usage of polymeric material is in roads for purpose of surfacing, because bitumen you know bitumen again is involved in is in it organic polymeric material.So, special mixtures surface coating extra for roads and modified bitumen with polymers extra.So, this is polymer in a modifier or modifier for bitumen system this is very common and this is where it is using roads.

Then, noise abasement walts panels posts and produce road equipment use polycarbonates and then glass fiber in reinforcement unsaturated polyester composite; send roads they get lot of views. So again this 1 will not be discussing much, because it will be form in possibly part of any payment course. The earlier on form part of an Geo technical course, what you are looking as building materials and constructions that to keep out all the large use in civil engineering.

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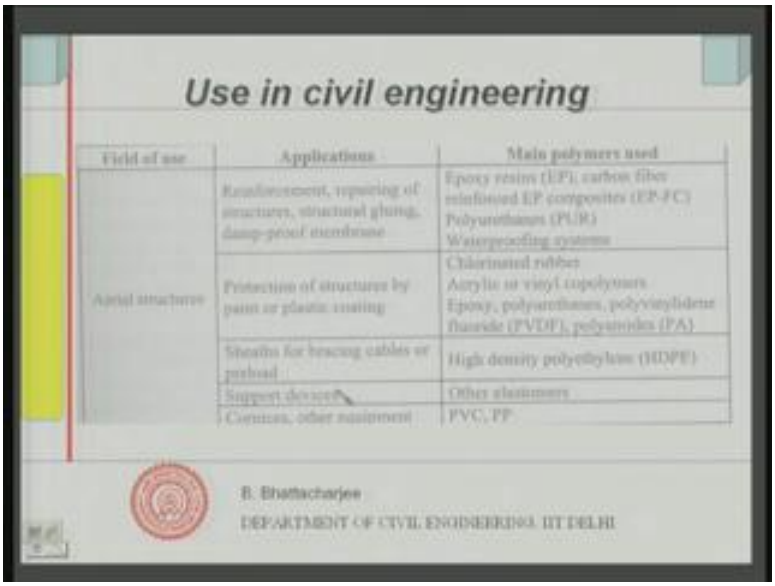

So, where will concentrate ourselves course is uses in structures above ground and it has got huge use theiras well.For example, in some sort of reinforcement; fiber reinforcement course computational reinforcement I have mention this reinforcing RCC it the polymer composites as not been a successful material.

But fiber reinforcement polyester, polypropylene fibers, for take a restriction purposes are important signage cracker restriction this is very much in use.Then repairing structures, great amount of repair is being done polymeric material that is for many advantages position in terms of high strength or required strength, low curing time and better durability.

So, will discuss some of them in details then gluing, they have been structures structural gluing water proofing of varieties of kind particular dam proof membrane.So, they there uses very much here and the type of material that used is epoxy resins I mention to you sometime earlier. Carbon fiber reinforced epoxy system, epoxy composites this are special use.

So, you can have complete structural system, roofing system made of polymer composites not very popular in Indian situations, because they are not very cheap.But thin structures can be made of polymer composites; polyurethane water proofing systems.So, the water proofing system, repair and complete structural system there as the large use some of them will look into.

Production structure by paint and plastic coating both for steel, mainly for steel and similar sort of metric once.But can also be use in case of concrete in very, very aggressive and environment, because epoxy coating is other similar other coatings you know or very much in use in very highly aggressive environment.

So, I can give you an example in way let just see what are the materials there used chlorinated rubber, epoxy, polyurethanes, poly vinyl chloride and poly vinyl dine, chloride and poly vinyls. Now, I just want to give you an example where used coating where you say urea retain structures; the structures concrete structures for storage of urea.Now, you know urea apex concrete, so fertilizer it is uses fertilizer in data's compute.

So, in such a structures it is customary to coat the surface that will come in contact with urea by epoxy coating very small thickness micron coatings of epoxies are used.So paintings are used in concrete structures, depending up on the situations and steel production is definitely used many times used pains and extra.

Then, bracings are sheaths for cables you know for pre stress cables sheathing, cable sheathing, high density polyethylene cable sheathings are used right or production against environment of cables there can be sheathing can be used this are the value thing.Bearings I mention to you supporting devices bridge bearings there all elastomers. And thenchronics and other equipment many other places use PVC and polypropylene etcetera, etcetera.

So, that is the huge use of this polymeric material in civil engineering. Some of the usage will like to see in subsequent discussion in this part of this lecture and then next lecture obviously will go to the usage all together. Although this can form this can actually 1 can have large discussion on this subject.

Because, the so much of usage today of polymeric material can such; may not be as much as possibly cement, concrete and steel.But could it take place definitely to the next place should be there.So but, since how about discussion is limited to try to make use of another hour that we have in this module to discuss about their usage. Butlet me, introduce 1 material 1 use right away.

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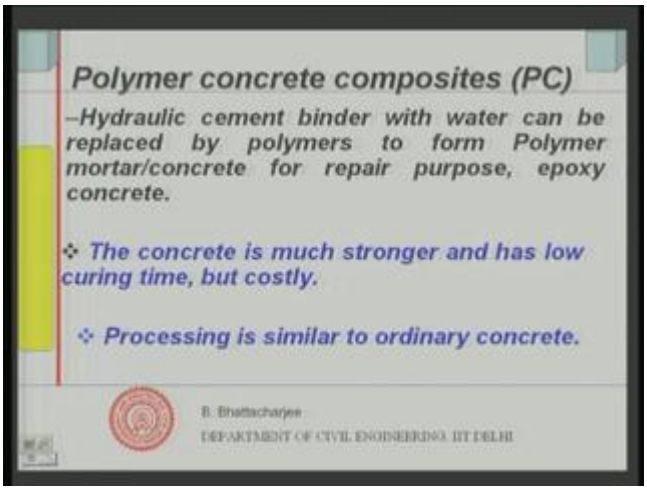

Polymer concrete composites mainly use for repair works right and you know 1 of them just take up today and next class, next lecture will discuss the other 1.Now we knew that, hydraulic cement binder has got an inherent problem of its capillary reprioritizes.So, in early days in a people were thinking how to improve this and increase the strength and 1 thought was replace it hydraulic cement completely, by possibly inherent concrete by polymer concrete you know polymeric material.

So, polymer concrete composites there are 3 varieties I have just taken a point today polymer concrete that is called polymer concrete; PC stands for polymer concrete.

So, in this 1 what you do is we actually replace the hydraulic cement binder completely which what you know and hydraulic cement binder with water which goes our binding material.We completely replace by polymers in harden concrete in polymer mortar you know polymer mortar or polymer concrete and mainly use for repair purpose. For example: epoxy motor, epoxy concrete.

Whatyou have done? You have got the same aggregate system, they will remain plus instead of water we have actually a monomer and some sort of catalyst extra, monomer or resin and catalyst extra and then this will polymerize and then bond aggregate. So, you will have instead of hydraulic cement binder now, will have aggregates; aggregate system bonded with bonded polymeric material, which is form bonded with the polymer.So, this is the polymer concrete you know polymer concrete is nothing have this right.

So this concrete is much stronger and has a very low curing time, but is a costly. So, it been used in extensible repair work in some for other but, 1 must remember this is costly. So, you cannot really use it all places that you like, but this has been one roots in fact it strength can be twice or thrice it is very easy to get about 7080 MPa concrete with polymer concrete.

But nay way 70 80 MPa concrete is also possible from the root of cement binder concrete as well, but it has got a very low curing time. So, you can cure it very fast and use in repair works mainly polymer mortars are use today, in various repair works particularly reinforced reworked structure extra.

So therefore, they have their utility in repair works, because the costly you cannot use them a large quantity even though the strength is 70 you can get 70 MPa strength or 80 MPS strength very easily for other use or even 400 MPS strength from other cheaper goods. So, they not used as a bulk concrete but, definitely use for repair works and quite popular that purposes; easy to use and quick to harden.

And give you the right kind of property, that you desired processing or make mixing is similar only thing is, 1 has to be careful about the if you putting it in the mold 1 has to be careful about the molding you have to be a molding agent.If you have making precast unit, that is not use in repair just an application some from other.So, processing is mixing extra you have to mix the aggregate, the monomer and the catalyst together and that gives you the polymer concrete.

So, you might use a filler material infact usually it is the manufacturer say, manufacturer would suggestive what is the proportion of the glue which is basically a kind of a resin hardener which will be a catalyst. And how much of the aggregate of what form it should use, what should the micro filler that you should use generally that is a variable the proportion or variable form the many times from the manufacturer.

But it can easily be also determine, but then mix them similarly, as you mix in ordinary concrete or ordinary mortar and quite often can be used for repair purpose.So that is 1 thing we have looked into today; the other types of polymer cement polymer concrete composites we look in the next class.

That's the 2 1 more other class is a polymer cement concrete and that is more often in use in repair work then polymer concrete. So, you can have a imprecision system of the epoxy and several other varieties of polymeric monomer imprecation into concrete or monomer imprecation system in concrete, we look in to those usage in the next lecture.

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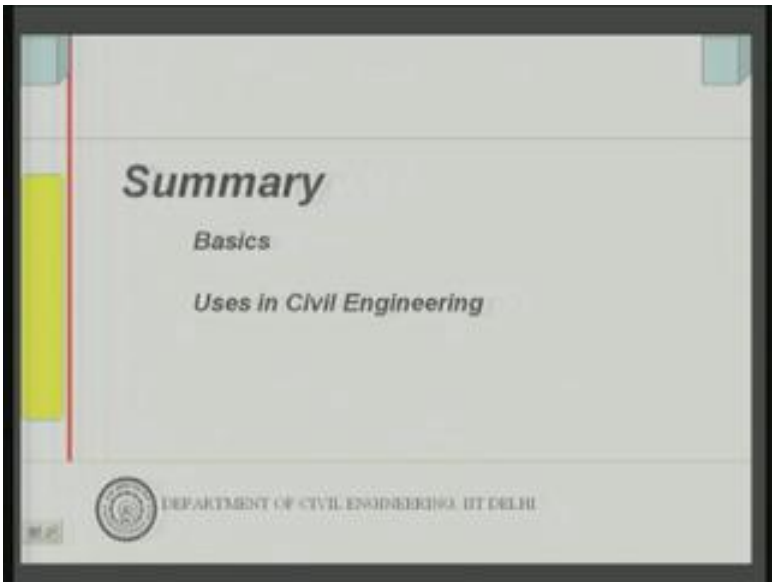

So, to conclude summarize this lecture what we have looked into today? You have looked into the basics of what is polymers.Some definition related to them something some characterize which have some fundamentals which are useful for our discussion. Then, you tryto find out some properties which would be useful as for as our usage in buildings is concern, and then you try to see where in civil engineering there been used.

Just I try introduce you the polymer concrete, in civil engineering usage you have seen the large chunk of uses goes in Geo text style, geo technical engineering and also in road making the load construction other than buildings and other structures.So, road and the Geo technical engineering applications will keep out of our discussion in the next lecture where, would discuss some of the usage as much as possible with in the time frame. Then, Geo technical and road usage will keep it up. So, I think that would ensues brings up to the conclusion of this discussion thank you we continue with this module in the next lecture.

Thank you