Environmental Geotechnics
Prof. D. N. Singh
Department of Civil Engineering
Indian Institute of Technology, Bombay

Lecture - 19
Application of Industrial by products

Let us begin today's lecture ok.

(Refer Slide Time: 00:21)

Let me continue with the applications of industrial waste, the sub topics of today's lecture are Application of Industrial waste or the byproducts. As I said in the previous lecture that now a days we do not term industrial waste as such, is it not we say that these are the by-products and then we have to utilize them but the whole intention is to recover precious things out of the waste. So, no more the waste which is or which was being termed as waste is waste nowadays.

Here we have discussed in details application of fly ash, very common industrial by product which comes out of thermal plant. The silica flumes in the previous lecture I had asked you what is silica fumes. The rubber tires we were talking about in the last lecture, glass aggregates and dredged material and I will try to emphasize here that why characterization of these by-products is a must.

(Refer Slide Time: 01:43)

What are the issues involved in this whole study? The first is issue is that you have to identify the application, then what are the properties which are required for application, then comes environmental sustainability followed by some protocols which are developed in laboratory by testing the material.

Now, testing of the material and creating the guidelines is nothing, but the protocols and then modeling of a engineering behavior of this materials. Then constructability and field performance of the material and ultimately what is the long-term performance. And, the most important issue here is that whatever you are doing should be following the regulatory constraints. What is mean by regulatory constraints? That your activity should be within the permissible limits of the values which are not going to toxicate the environment and so on.

So, these are the steps which are important when we talk about the major issues or the you know the questions which are bothering everybody. What is the application for which you required a material or a by-product that is 1 and then what are the properties associated with it. Then whether it is sustainable or not environmentally, what type of test should be done and by conducting these tests, what type of protocols we are going to develop. And protocols are nothing, but the guidelines, code of conduct then modeling of engineering behavior of this materials, constructability and field performance. How do

they perform, their long term performance and ultimately we keep in mind that nowhere the regulatory constraints should be violated.

(Refer Slide Time: 03:47)

So, let us talk about the pozzolana, because the first and most important thing in civil engineering is a pozzolanic material is it not. So, it is nothing, but a volcanic ash from Pozzuoli in Italy, this is how the name came pozzolana. So, this is naturally occurring volcanic ash and the property is if you add water it hardens. So, hydration of the material and the counter part of this in our country is Surkhi; I think most of you can appreciate this word Surkhi is it not, is a ash of any material. You add little bit of lime, upgrade the properties and then it can be use for construction purpose.

I would like to draw interesting parallel layer, when we talk about natural volcano and manmade volcano. See this is the natural volcano. Any guess what would be in manmade volcano?

(Refer Time: 04:47).

Yes. So, a power plant alright. So, these are nothing, but they are working almost parallel to each other. So, here you find lava coming out of the system and then ultimately this lava precipitates, cools, gets crystalized and so on. Here whatever is going into the environment precipitates after sometime it will form a top layer of the soil, whatever

remains in boiler units is nothing, but your pulverized fuel ash which is normally we call as fly ash and by virtue of its chemical composition this material becomes a pozzolana.

(Refer Slide Time: 05:31)

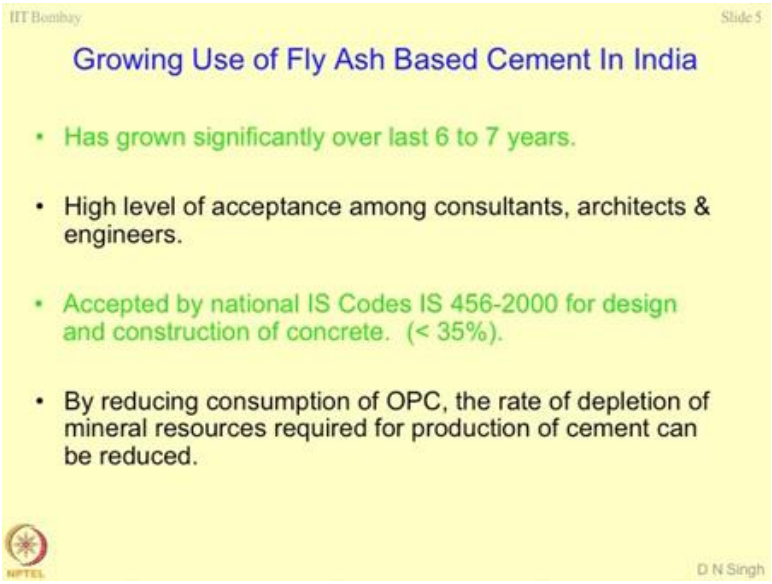
So, I am sure that most of you are aware that fly ash has been used as soil stabilization is it not, lot of laboratory studies have been done to show these properties of the ash where the land reactivity becomes very important, the amount of free lime which is present in the ash is very important; so, that it stabilizes the soil mass. Some in-situ studies have also being done on pavement bases and the sub-bases of the roads. I had shown in the introductory lecture that how this fly ash can be utilized for making pavements and roads.

What happens basically when you aim for stabilization, the whole objective is that swelling pressure and percentage swell of the soil should decrease if you add fly ash. So, this is the first property which you are looking for when stabilization is talked about. That means, swelling pressure of the soil should decrease, percentage swelling should decrease, its liquid limit, plastic limit, plasticity index should decrease in other words the system becomes more workable. So, when you plastic when you modify the plasticity of the material what will happen? It can be compacted very easily.

So, this is how stabilization can be achieved just by simply compacting the soil mass or by adding some chemicals, additives like fly ash, like mixtures like fly ash you can change the plasticity of the material and hence you can achieve better compaction. When

you are adding fly ash into clays, what you are doing? You are creating a matrix of the grains where finer gets modified or getting altered because of interaction with the coarse grains which are present in the fly ash; so, the compaction increases. CBR modification, I am sure when you are adding it to the in-situ soils and the whole intention is to increase the CBR of the native soil. So, that the pavements and sub-bases can be constructed over it. Fly ash-cement mix, this is also lot of people have tried fly ash with cement or with calcium added to the soil mass. So, this becomes fly ash cement lime mix or whatever.

(Refer Slide Time: 08:07)



This is a interesting scenario where fly ash application is becoming very much mandatory and you know its growing in Indian scenario. So, application has grown significantly over last 6 to 7 years; particularly in the field of cement industry part replacement of cement, people are trying to use this material. And, there is a high level of acceptance among consultants, architects and engineers.

Now, there is a norm as per IS code 456: 2000 for design and construction of concrete structures you can use fly ash up to 35%; less than 35 % up to 35 %. And, what is that you are achieving by using fly ash based or sometimes is also known as fly ash blended cement is it not. So, there is a difference between OPC and PPC. So, ordinary Portland cement if you had some fly ash into a it becomes a PPC. What is PPC?

(Refer Time: 09:15).

Yeah. So, basically you are adding pozzolana to this it become a PPC, you can control the rate of setting of the cement, you can control the ultimate strength which you are getting out of this.

(Refer Time: 09:28).

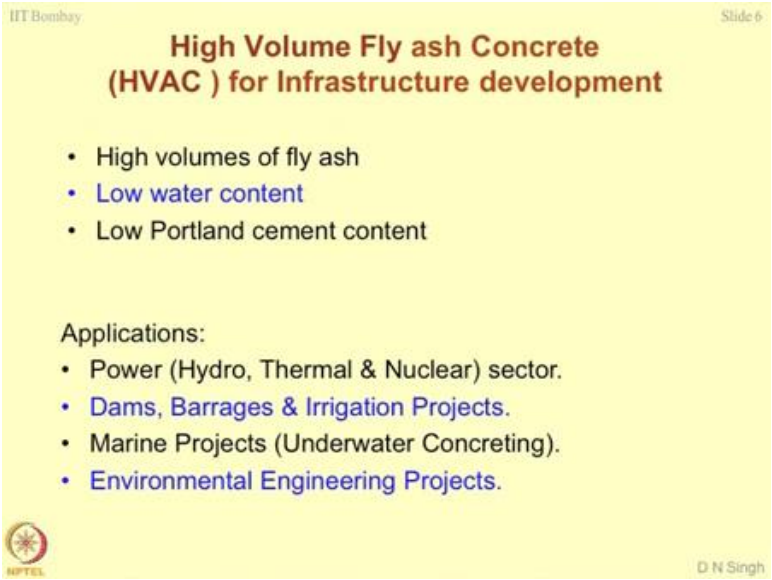
Sorry.

(Refer Time: 09:30).

Yeah durability can be achieved better that is right. So, the whole idea is to reduce the consumption of OPC, why? The production of OPC itself is anti-environment, is it not? Emission of lot of carbon dioxide and other gases plus the natural resources you can conserve by adding the fly ash. So, the whole idea is when you go for blended cement that we want to save energy as far as construction is concerned, conservation of resources, minerals and less pollution of the environment and degradation of the environment.

So, by reducing consumption of OPC, the rate of depletion of mineral resources required for production of cement can be reduced. So, this is the beauty of going for fly ash-based cement design. There is another concept which is picking up these days is High Volume Fly Ash Concrete which is known as HVAC.

(Refer Slide Time: 10:25)



A good example of this type of construction for infrastructure development would be; any idea? Most famous application very recently which has been achieved Bandra-Worli Sea Link that is right. So, Bandra-Worli Sea Link is a good example of HVAC where high volume of ash has been used for increasing the durability of the concrete.

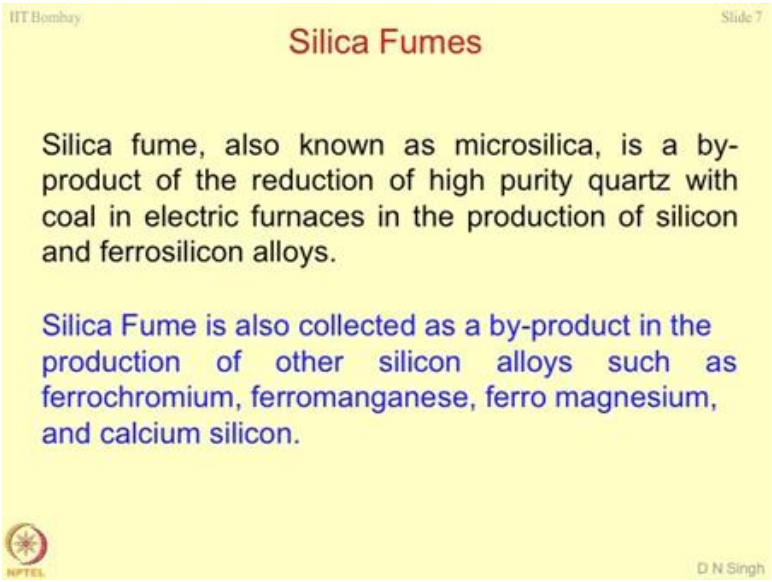
So, the essential attribute of this is that the volume of fly ash which is used in the system should be very high. And, you are doing the entire design based on the concept that minimal possible moisture content or the water content and also, we want to reduce the consumption of OPC. So, these are the three attributes for designing HVAC that is high volume fly ash concrete.

HVAC corresponds to high volume ash concrete and you will find most of the applications in power industry, power sector whether it is hydro power, thermal power or nuclear power design of domes of the reactor buildings and the shells of the reactor building where, HVAC is being preferred these days.

Another beauty is you can use up to 50% of the fly ash by compacting it in a specialized manner. So, this is where people have started talking about self compacting concrete also. Most of the dams, garages and irrigation projects are also using this type of concrete, most of the marine projects where underwater concreting is required, they deal with the HVAC type of a cement. And, sometimes the projects which are associated with environmental protection or environmental engineering projects, you do not want to contaminate the environment much. The reason is fly ash is not leachable in most of the cases alright.

So, this helps in creating a matrix where leachability becomes much small and of course, when you add fly ash the durability is increasing because, the pores which are present in the normal concrete get filled up and the porosity of the system decreases.

(Refer Slide Time: 12:53)



Then coming to the silica fumes this is also admixture which is normally added in construction of concrete. By definition silica fumes are known as micro silica also, the particle sizes will be very very small. They will be finer than you know 0.002µm. And, this is a by-product of reduction of high purity quartz with coal in electric furnaces during the production of silica and ferrosilicon alloys, most of the electronic industry is based on these alloys, is it not silicon and ferrosilicon alloys. So, the more and more electronic components are produced then more and more silica fumes are also been created.

So, silica fume is also collected as a by-product in the production of other silicon alloys such as ferrochromiums, ferromanganese and ferromagnesium and calcium silicon. So, these the spatiality items and when you produce these systems when silica produce silica fumes come out as a industrial waste. Are you aware of a something where there is a caution on using silica fumes in concrete? Anything related to silica should be highly corrosive and carcinogenic alright. So, if you are using too much of silica in concrete what happens? It becomes a anti-dose; so, rather than giving more strength, what it does? It starts having more corrosive affects in the concrete.

So, typically 5-6% of silica fume is added in concrete and when you go for 5-6% silica the durability is maximum, because these are very fine particles which go and fit into the pores of the concrete which you have created and they seal them. So, durability increases

if you use silica fume, but not more than 5-6% otherwise corrosive action takes up. There is a very interesting concept which comes to my mind here I would like to share with you; densification of silica fumes is a very big problem.

So, if you can device a technique by which you can densify silica fumes you can become a good industrialist. The specific gravity of these fumes would be 0.6, 0.7. So, entire truckload of silica fumes will weigh approximately only few tons. So, transportation of silica fumes is a very big problem. So, that is where some people tried to work on densification of silica fumes.

So, normally silica fumes are transported in liquid forms. So, you put them in water. So, at least they achieve the density of water. So, this is a sort of a densification, but this is not a very good way of densifying silica fumes because, it starts reacting with water. So, its reactivity may get lost during this interaction. This is a very good example of how a product or a material gets or starts interaction with water and it loses its pozzolanicity of course, some studies are required in this direction.

(Refer Slide Time: 16:35)

Now, let us come to the need of recycling and reuse of tires, in the previous lecture we were talking about this. So, apart from being a threat to human health and the environment in what way because a piled-up stack of tires will always produce poisonous gases and then it pollutes the environment. It is very unsightly to see; you cannot depreciate this if rubber tires are lying you know next to your habitat or on the

roads or what where ever. So, they create land pollution also and rain water gets collected so, this becomes a place for mosquito breeding.

So, these are the issues which are involved with this, sometimes they may catch fire and hence you may have tire fires also, it becomes significantly important. So, this is where recycling and reuse of tires is becoming very important and geotechnical engineer should take definite interest in this task. So, either they are stockpiled or they are land filled, but then again because of volume it is very difficult to put them in a land filled as such. So, there has to be some genuine application of used rubber tires.

(Refer Slide Time: 17:57)

Some of the applications I have shown here for road embankments. So, you can stack them one over the other and then you can form embankment out of it; it is a good practice of creating embankments of the lagoons. So, you can put a layer of tires and cover it with the soil cover and this system can act as a embankment of sufficient strength. Sub-grade insulation for roads wherever you require insulation in the very hot and tropic countries this is where you can use as the sub-grade of the roads.

Even in the freeze and thaw type of a road also you can use this. Another interesting application is asphalt rubber pavement, where you can go for mastic asphalt or shredded rubber tire mixed with the asphalt and you can get the best possible end product in the form of the road. Most of the advanced countries they are following this of course, in

India also now this concept is coming. What are the requirements of the pavements which should be fulfilled by this material?

(Refer Slide Time: 19:05)

So, durability is very important issue that is flexible and rigid, is it not? How do you define flexible and rigid pavements?

(Refer Time: 19:26).

That means elastic modulus; so, based on the elastic modulus you can find out the system is going to be more durable and this is where deformation modulus also comes into the picture, thermal resistance of the surface, rutting resistance. So, it should give you a sort of a feel as if there is no rutting on the roads, because of the application of a material which is being used for designing pavements. Wearing because the number of passes you know every day over the surface so, wearing resistance should be very high. Shrinkage resistance should be very high and skid resistance should be very very high.

So, this is where rubber tire with steel mesh meets all the requirements. Simple normal tires which you are using in your automobiles they can be used. What test you will be doing to obtain these properties, when you are mixing this material? Sorry.

(Refer Time: 20:39).

Abrasion is valid for aggregates, see for rubber doing abrasion test is not a good idea; have you seen this, yeah.

(Refer Time: 20:53).

First of all bitumen or asphalt bonding with this material should be a very important test, if you are doing coating of this material on asphalt or you are mixing it with asphalt. So, the bond strength should be very good then second test it should define its durability. CBR again it is normally not done, you have seen these turfs like your hockey turf or football turf, tennis turfs or racing tracks. So, there the top layer happens to be a synthetic material.

So, this is where actually tires can be used for creating a very durable and no deformation, no rut formation pavements. Now, thermal resistance is a very big problem; most of time what happens in particularly north India where the temperatures go very high, during summers what is the major problem related to roads? It basically melts and skidding or most of the accidents are because of this process.

So, elevated temperature, the stability of the asphalt becomes a very big issue. So, if you want to increase the thermal resistance mixing shredded rubber tires in asphalt seems to be a very good idea. And, that is why you say that discrete resistance gets decreased, similarly shrinkage gets decreased. The wearing coarse definitely wearing will be very less because of material which is mostly elastic in nature.

So, this type of cross sections can be you know used at places where close to the signals where traffics come and apply breaks. So, most of time you will find in city that close to the signals the roads are always in very poor shape otherwise the entire stress is good. So, in Bombay city what they have done, they have used lot of paver clocks close to the signals. Why it is so? Because, interlock is very good and they give added resistance to the breaking phenomena. So, most of the time vehicles will come very close to the signal and then we apply break and that is the place where most of the wearing process goes on to the surface.

So, if you want to stop this process this type of technology is very good, but the biggest difficult is that amalgamation of asphalt with shredded rubber tire requires lot of understanding of the material and a controlled process. So, it has to be at a certain

temperature and the bonding between the two is should be very good, it should not peel off.

(Refer Time: 23:51).

It should be with paving surface; so, you can change the thickness of that crust and you can maintain a pavement of a required quality. So, it gives you a basically cushion effect, more impinging effect on the surface. The best example is your tracks use for racing or automobile testing. So, these types of technology should be developed in house and there should be some research associated with this. Now, have you heard of falling weight deflectometer? In your transporting engineering courses you must have been taught about falling a deflectometer, if you apply commonsense what does this mean falling weight deflectometer?

(Refer Time: 24:42).

Deflection of?

Pavement.

Pavement that is right. So, particularly this test is done for airstrips. Why?

(Refer Time: 24:55).

Yes right. So, the whole jumbo jet lands on the airstrips you know. So, the air strip should be so strong it should not deform otherwise what is going to happen? So, this is where lot of research is required impact resistance of the pavements and the turfs which we are creating. Most of the time military people do this type of test, are you aware of or no? Whenever you design airstrip the quality of the airstrip is checked by doing this test, the deflection should be minimal when you drop a weight from a certain height is just like your SPT test.

So, this is a very good subject on which people can do lot of work. The design of the makes, design of the makes which is more durable, deformations are less, thermal resistance; lot of science is required here, lot of engineering is required here, lot of understanding is required here. I have used a word here and nobody ask me that what is meant by shrinkage resistance. So, let me ask you guys now where do you find shrinkage

resistance or shrinkage occurring on pavements? Is something known as shrinkage cracking of the rigid pavements sorry.

(Refer Time: 26:20).

Concrete pavements yes; why it happens and how to stop it? Ok you are right; so, what is the best way of stopping shrinkage cracks?

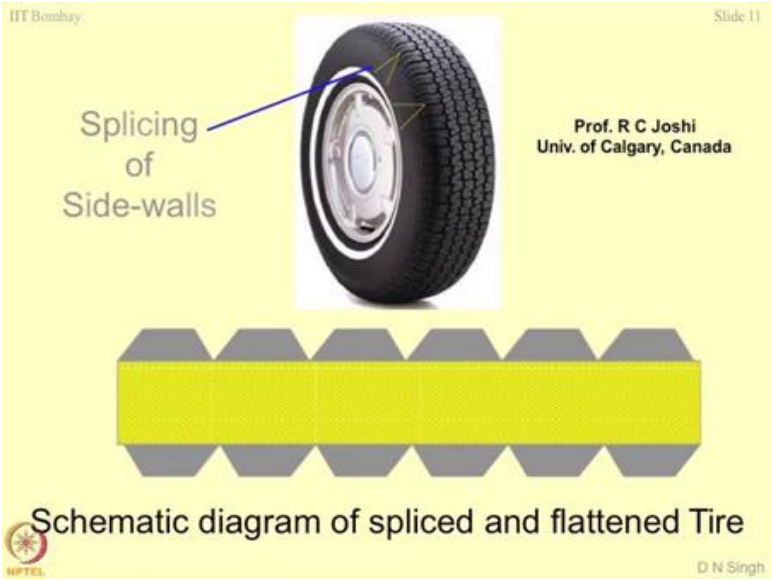
Double bars.

Double bars that is right. So, there comes the concept of double bars. So, if you use double bars then shrinkage cranks can be stopped. So, it is basically because of thermal incompatibility of the material when it comes in contact with ambience. So, temperatures are very high and then in between there is a concrete pavement and below that again there is a ground surface. So, there is a big temperature difference.

(Refer Time: 26:58).

So, this may cause also wrapping stresses or sometime call them warping stresses. So, shrinkage resistance becomes very important in case of designing the system when you are using crumb rubber tires alright.

(Refer Slide Time: 27:23)



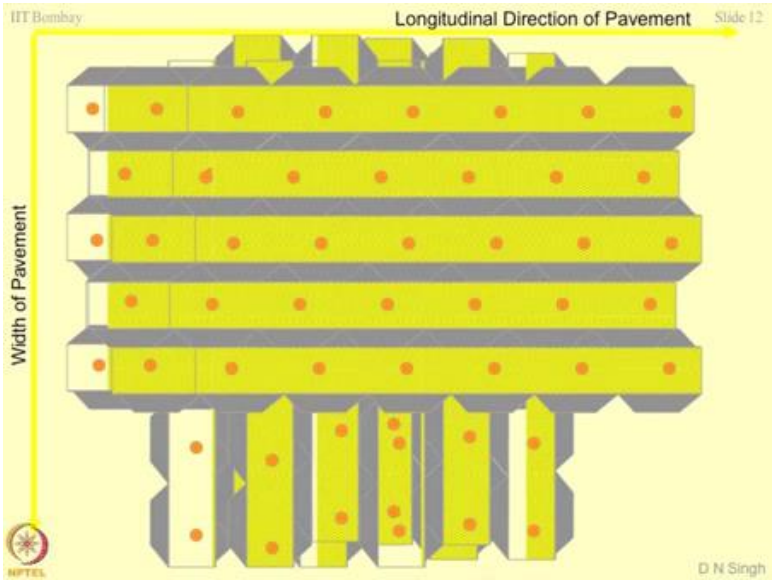
So, this is a typical tire, this part of the slides I have taken from Professor R. C. Joshi's presentation; I got impressed with what he presented. He visited us 5-7 years back I think

from University of Calgary, Canada. Yes, he found the industry based on this technology, but I do not think it was done. So, you take a tire and then slice it from the side walls. So, this is how the marks are, you can cut the rubber tire like this ok.

So, this is how it becomes and then straighten it. So, one rubber tire after slicing it and straightening it, it becomes a sheet clear approximately 1 meter.

Now, you think of using the sheets with the help of some you know rivets or bolts to create a cushion out of it. So, how this will be done? This will show you on y-axis is a width of the pavement, the amount of width which you required and on the x-axis is longitudinal direction of pavement.

(Refer Slide Time: 28:33)



So, here comes your first layer of the tires alright, sliced and straighten tires. So, you just layer it like this and what do you have to do? You have to bolt them to the formation. So, the first layer ready, on this you go for the secondary bolting clear followed by again riveting and so on. So, ultimately this leads to a formation of a thick pad which can be used as a cushion or a pavement on the top of the rigid bases. So, this technique people have used, they have created some tracks out of it.

This will be low cost first of all, quiet durable and the third thing is you are using the tires which are lying in plenty and there is no other application of these tires. So, this is the way you can keep on increasing the height of the cross section or the entire pavement

which you are designing. Whenever you get time try to adopt this technology and do some study on this so, so on alright.

(Refer Slide Time: 30:05)

So, let us talk about now beneficial use of glass aggregates. So, glass aggregates are nothing, but you collect most of the glass either in the form of the bottle or the packing material, crush it and the heap of the crush glass will look like this; it is nothing, but shining sand particles.

So, once you have converted glass into this type of a structure you can utilize it the way you want. So, these are the applications, the first is construction aggregates. There is a big scarcity of construction aggregates in every city now and the problem is from where to get the best possible aggregate. So, as I said in the previous lecture the beauty of this material is that this is a crushed glass and glass is nothing, but a form of silica. And, we do not want reactive silica all the time in our construction particularly when you are filling it, using it as a backfill on beaches and so on ok. So, if you go through the applications of crushed glass aggregates, in the first one which is gaining lot of attention of people is construction aggregates.

For all these applications nowadays, we require people who are you know dealers, vendors and entrepreneurs. So, you can adopt this type of business if you are interested, the first one is fill aggregates to require aggregates of filling somewhere in the backfills particularly. You should appreciate the point that soil is becoming very very scarce

everywhere and the amount of glass which is being generated in the present-day society by everybody is tremendous. So, you just have to have a crushing unit people do collect the glass, crush it, collect it and supply it.

So, very low-cost industry, but I think profits will be maximum, try this out. The another one is filter media, there is a problem in getting good filter medium or the material, good aggregates are not available, good sand is not available in most of the part of the city by the way in Bombay city. Of course, this glass cannot be used as a replacement for sand or which you are using from river because of less reactivity. But you can alter the properties of this glass by giving it some treatment, pulverize it and after pulverizing this glass will become more amorphous not crystalline.

So, a crystalline phase is less reactive while in amorphous phase which is more powdered is more reactive. A simple example of this philosophy would be given a chance would you like to add sugar crystal in your cup of tea or sugar powder in your cup of tea.

(Refer Time: 33:12).

So, why? Because, powder is always more reactive; the reason is finer the grain more the surface area and more the surface area more reactivity. So, what you are doing is if you crush this glass to a grade where the entire glass becomes powder chances are at this glass may have more glassy phase. So, this is the term which is normally used by people who are involved with you know research in construction materials.

And, I will talk about this phase slightly later and we discuss how to characterize materials. And, particularly if you do XRF analysis then it becomes very easy to identify what is the glassy phase of the material which is going to be reactive. So, in filter media people can use it quite easily, some speciality uses particularly in pharmaceutical companies where these types of materials can be used. Glasphalt, have you heard of this name glasphalt? You are always hearing asphalt; now asphalt itself is because of what is the source of asphalt? It is a natural material or it is a?

Petroleum.

It is a petroleum product that is right. So, this is also quite scarce. So, rather than using asphalt people can go for mixture of glass and asphalt so, this becomes glasphalt. So, it again does this what we have discussed in the previous and we are talking about shredded tires and their application in asphalt and in tarmac, lot of value-added products can be made out of it fused glass. Now, this is what I have been discussing when we talk about fused glass basically you are altering the properties of the crystalline glass by giving it some physico-chemical, mineralogical treatment or just by crushing it simply. It becomes very active at elevated temperature.

So, you can melt the entire glass and then you can create a sort of fused glass which is going to be more reactive. Art glasses, different type of glasses which are required for artwork, terrazzo composites. What is terrazzo; have you heard of terracotta? So, terracotta is nothing, but a product from clay. So, soil is also very scarce, remember these things all-natural recourses are very very scarce these days; nobody is going to allow you touch them.

So, this is where you can use this type of composite for decoration purpose and so on foam blocks, paver blocks, brick blocks where you use them as a filler material rather than using sand and other aggregates. Another interesting subject on which some people are working is hydroponics. What is hydroponics? This is growing plants without soil, have you seen in some models where they use lot of tables, jells for creating plants? Yes so, this is one example. What is the reason? I have given you some logic just 5 minutes back.

Silica is a very very active material. So, wherever you have silica it allows growth of microbes and those microbes, on these microbes actually plants will survive. So, it is a good example of high, how these plants can be grown without using soil. Different type of bottle cleaning programs where you can use this material as, abrasive value will be very high of this material. So, you can make slurry and you can use it for washing purposes, not for dishwashing because of the abrasive effect your dishes will get spoiled. The way people are looking at it is a industrial mineral basically.

So, mineral which is created by human activities it has abrasive properties, shot blast media and in as a filler in most of the materials, scrubbers particularly. There are some specialized applications as fill aggregates in road bases, trenches, filter media, on site

water system, drinking water filtration earlier they used to use sand for drinking water supply and filtration. Beach sand is a good example most of the cities want good clean sand is it not. So, these glass particles will be very shining during day time, it gives a very good feeling as if you have walking on a very neat and clean beach.

Drainage aggregates because of their size and because of their stability and durability they do not get disintegrated so easily. Some type of media and of course, decorative and landscape purpose and so on. I have talked about glasphalt and tarmac these are nothing, but bitumen paving matrix where you can use the system. In your opinion bitumen is a natural material or is a manmade material?

So, how seems to be divided, you should think over it sometimes because you are using so much of bitumen is it not; more and more industrialization, more population growth everywhere you required top capping of the roads pavements. It is basically a natural product and that is why it is becoming very scarce. Yes, it is a natural product.

(Refer Time: 39:13).

That is one of the ways of extracting bitumen, but most of the bitumen comes out of the natural formations. I think geologist can tell you better.

(Refer Time: 39:27).

Coal beds it is a form of coal this is also becoming very scarce. So, everything actually what we are doing and suddenly right now is under threat form environmental scarcity.

(Refer Slide Time: 39:45)

Well just to give you an idea about the dredged material, because dredging is becoming a very important activity in geotechnical engineering these days. This is a typical dredger which I have shown here which is used normally for mega projects. And, this is and product you can do the complete beach nourishment or creation of the beach by using this process. You know what is this process known as? What is going on here can you guess?

Sand has been sprayed over, sprayed over to form an island.

That is right, somewhere you will see here that a lot of sand has being dumped already. Do you know where this project was done in the country, in our country? Paradeep, Paradeep is the place where this type of beach was created, you know Paradeep Port Trust with the help of EIL and Boskalis of Netherlands they have done this project. It is a beautiful project, now this technique is known as rainbow technique.

So, what dredger does? It is in the sea, it sucks dredge material or the geo material from the bottom and then pumps it out on the shore, they are simple technique. But, unfortunately this has become only a practice, not much of research has been done in this area. Because, you talk to any of these companies they will simply say that we have been doing this for last so many years without studying you know the material property how it should be, there are lot of science and technology behind this. So, this is how the

geotechnics of dredging is evolving as a very new subject in environmental geo technology.

Now, what is your opinion? Once you are creating this type of a system alright in nature what is going to happen? So, then you should ask me a question that why dredging is done? So, sometimes dredging is a capital dredging and sometimes it is melt in the dredging. So, when you are maintaining your channels and then you have to suck out the material throw it out, but when you are doing capital dredging the whole intention is to create something. So, my question was that once you have created these types of islands what is happening to the ecology?

Earthquake.

The answer is not really earthquakes, the answer is the entire ecosystem is getting affected how, we have created a land out of a water body. So, all hydro geological properties are going to get changed clear. And, how about the aquatic life?

(Refer Time: 42:33).

Aquatic life gets affected. So, they are all environmentalist these days you know they do not allow you to go ahead with this projects because, of the simple reason. And of course, if your sediments have contaminated which you are lifting from the sea shore and then you are dumping close to the habitat so, the implications are tremendous. So, you cannot just take out something and dump it very close to where you stay alright.

So, this is how the issues are becoming very very important in geotechnical engineering and I hope you will agree that these type of studies required too much intricate correct, unless you understand what you are lifting from the ocean bed, you can visit these websites to see of course, they will not give you much details. But at least some information you may get, there could be a situation where rocks are very close or there could be a situation where only clay is present.

So, when you are doing dredging in the rocky medium the biggest problem is how to cut the rocks, how to lift them and how to make slurry and throw it out. So, this is where a new concept comes in your geotechnical engineering which is known as biological properties of geo materials. Truly speaking people associated with engine oil and oil

industries they used to talk about this earlier chemical engineer, mechanical engineers. But nowadays the need is that we should also understand how to form a slurry of geomaterials which can be pumped on to the shore.

So, depending upon the dredger capacity this point to this point could be few kilometers even because, the chances that you may get the good material very close to the shoreline are very remote. So, you cannot stop your activity just by saying that, I cannot dispose it off on the, it could be few kilometers down and then you may have to lift this material and dispose it off. So, the issue is design of pumps, design of slurry, what type of sediments you are lifting from the ocean bed, how far they will go they all are under the earth spatial of geotechnical engineering these days. So, this is known as rainbow technique of creating beaches, I hope you have got better idea now.

(Refer Slide Time: 44:53)

So, what are the beneficial uses of the dredge material? The first is beach nourishment whenever soil or the sand depletes on the beach you would take out the material and nourish the beach. So, that the beach has look more beautiful, healthy; shore protection otherwise erosion may take place. So, if you want to stop this process you may have to lift the material from the seabed and dump it on the seashore. Soil creation enhancement, the marine sediments are supposed to have more microorganisms or biological organisms under is it not. So, you put them on this on shore, enhancement of the soil properties can take place.

Land reclamation this we have been talking a lot, habitat restoration sometimes dredging is done to create more habitat for aquatic life aquaculture, coastal Andhra Pradesh; I think this is the good example of how they do in a aquaculture. Is this correct? So, for habitat restoration sometimes dredging is done, use of construction materials particularly country which are surrounded by sea only. So, from where they will bring construction materials. So, this becomes a good source otherwise also you must have noticed from the rivers and the sea normally sand is dredged out. In Bombay, it is a big business and even a small town you can dredge out sand for construction purpose.