

**Geoenvironmental Engineering (Environmental Geotechnology):
Landfills, Slurry Ponds & Contaminated Sites
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**Lecture – 31
Slurry Disposal on Land**

Welcome back to this class. Today, we are going to start a totally new topic. For the last several lectures, we have been focusing on solid waste are coming out from the municipalities; industrial solid waste coming out from industrial areas, but all of this waste has been in the form of solid with some moisture. We are now going to start a new topic on slurry type of waste; slurry type of waste means that you have waste which is mixed to the lot of water and comes to the waste disposal site in a pipeline. All the waste which we have dealt with earlier comes to the waste disposal site; how does it come to the waste disposal site; in landfills, how does the waste reach the site?

Student: (Refer Time: 01:23) and even trucks.

In trucks, anything else?

Student: Trains.

In trains, anything else; in ships and barges, most of it comes in trucks, but do you remember, waste is transported even in trains in dedicated trucks and waste is transported even over water where the options are that the landfill is on the other side of a water body. In one of the US sites, the landfill is on island the waste has to go through water to reach the landfill. It is supposed to be the biggest landfill and when the twin towers fell down, where did all the waste go? What do you think happened with the waste or the twin towers; vanished? No, so, it went to a landfill, right and it was transported by various means to that landfill.

However, that waste could not have been transported in the form of a slurry; slurry disposal is for waste which is finer than sand; silt sized sand is silt; silty sand; which can be mixed with water and then can be pumped. Can you mix gravel with water and pump it? No, you can mix gravel with cement and pump it in the form of a paste; you have concrete pumps, coarse aggregate you can mix in a paste, but we are talking of lean

slurry; slurry which can be mixed with water; waste which can be mixed with water and comes in the form of a slurry.

So, this next half an hour or more; we are just going to get a flavor of this slurry deposited waste and see; what are aspects of disposal which are important for us. So, what kind of waste comes in the form of a slurry, much of it in India is the ash coming out of burning of coal and all of you have burnt wood or coal and you have felt the ash is it very coarse particles no it is something which will just fly and its fine particles.

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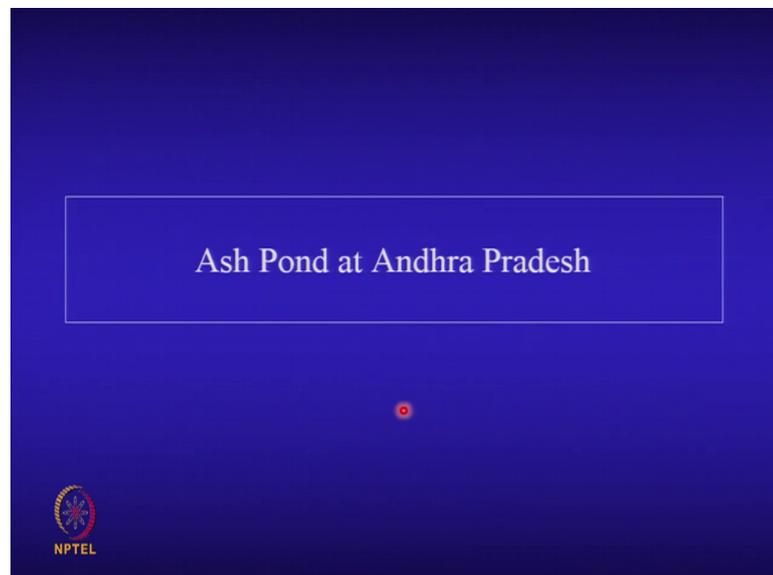
So, coal ash is one, the second major material is mine tailings, coal ash is coming out after burning of coal, mine tailings are coming out after crushing of rock or crushing of ore.

So, what happens is you want to take out iron or copper or lead or zinc; you dig deep down to get to the ore and do not think that huge blocks of iron come out or huge blocks of gold come out, likely here is your gold does not come out like that; it is embedded in small proportional in the rock, it should be able to extract it, you have to crush the rock and then process it by several steps to be able to take away the metal or take away the material which have value to you. In this process of crushing the finer; you crush it the better, it is because more is the material which is released, if I take a rock sample and crush it into 4 pieces, will the gold start coming out of it? No, but I crush it into as fine as talcum powder then it is possible that some of the metals would be released, you have to

still go through a lot of processing chemical and physical to get the extract, but your left with the parent rock in its crust form which is gone through chemical processing, right.

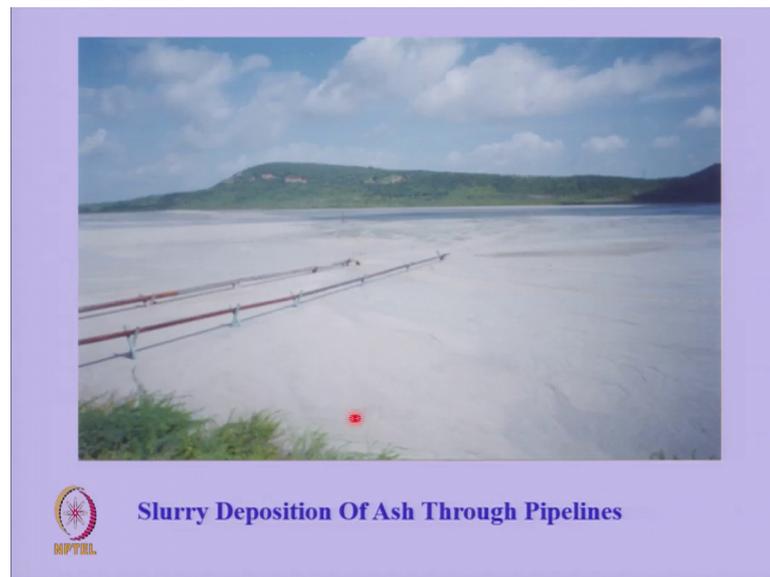
So, if you are doing gold extraction or if you are doing led extraction; you would have crust this and you would have sent it through various processes where additional chemicals would have be added in the end; what is left is this rock powder; with these chemicals at a high water content, you mixed it with water and it comes to you in the form of slurry. So, at the tail end of a mine, it is called mine tailings; mine tailings, slurry and there are other types of slurries with which you deal.

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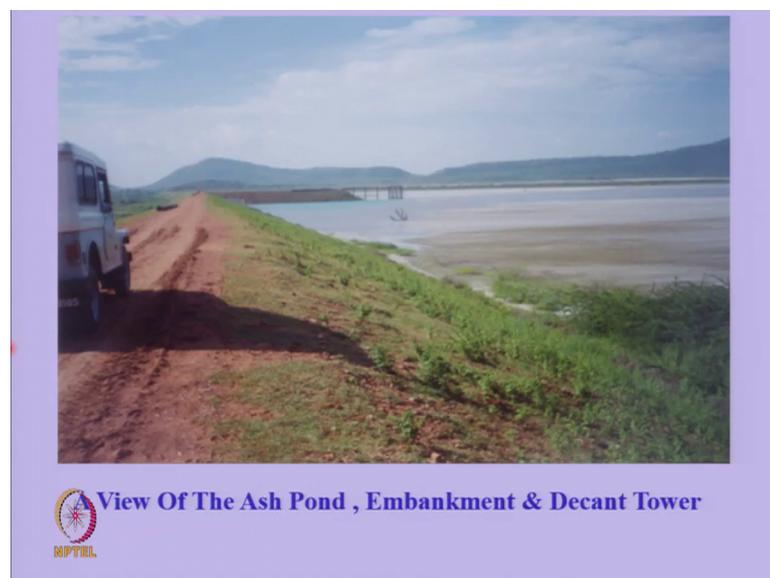
So, we going to look at some slurry waste disposal sites and how do they look like.

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So, this is a huge area in one of the adjacent to one of the thermal power stations; this is coal ash.

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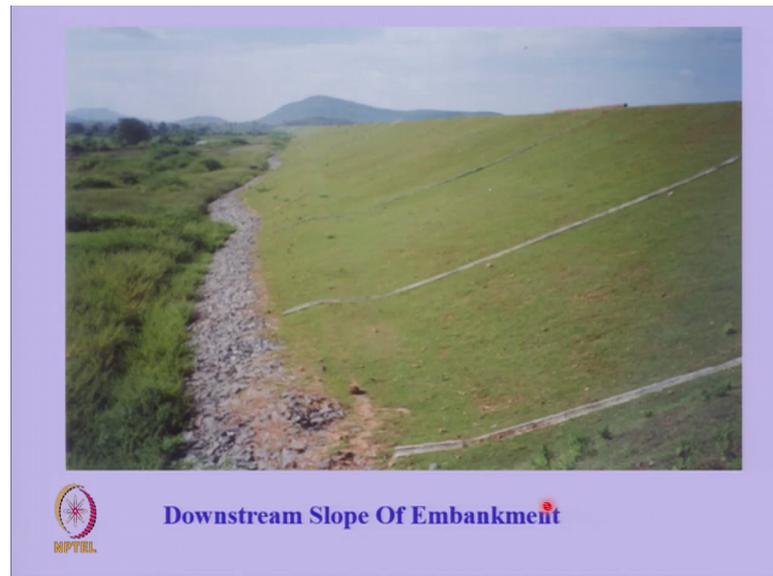


This is water; the ashes coming in these pipelines and be deposited here and just to get an idea may be this is 2 kilometers by 1 kilometer in size. So, on 3 sides are hills, on one side is an embankment, just like you create a water reservoir, you have created a pond in which the slurry will be deposited; the technique very simple; you deposit your slurry

coming out of a pipeline in a pond, within a few hours; the particles will settle down and clean water will be at the top, you take it back for transporting more material.

So, the water and slurry; the water used for making slurry; just a medium for transporting these particles and it is good because you can pump it, it is good.

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If you were to try and send this material on a truck, it would tend to fly out. So, you would have to containerized each truck this operation can go continuously because the slurry pipelines can work twenty 4 seven as long as the plant is working.

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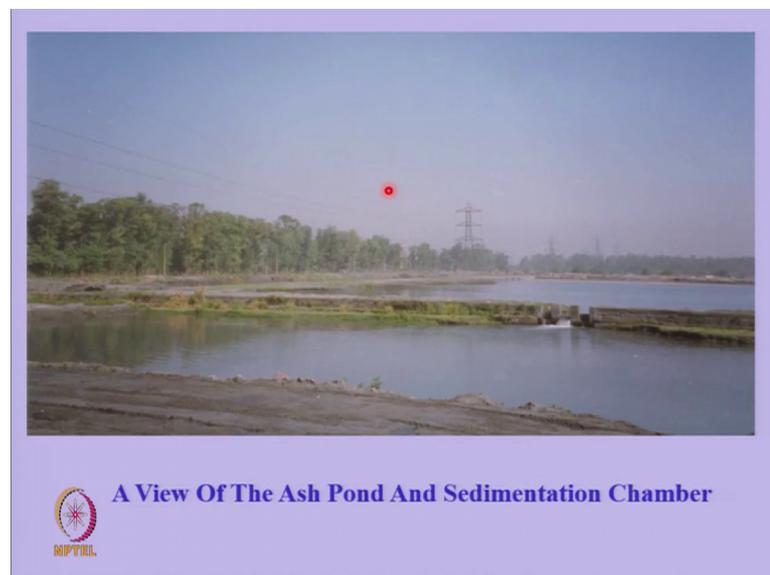


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So, we can see this embankment there is a water decanting structure because the water has to go back. This is the embankment that you can see. This is the decanting structure, this water falls down into this well and comes out on the downstream side.

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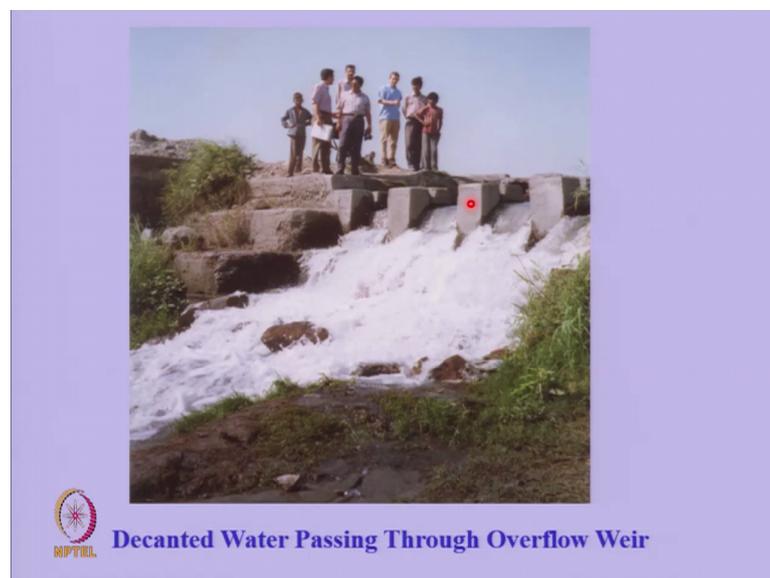
So, this is being taken back again in this pipelines for back in thermal station for recirculation. Let us look at another ash pond, this is an old small ash pond in Delhi; has of not 2 kilometers by 2 kilometer; much smaller size, but again lot of water being used that is the inflow slurry pipeline.

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You can see that grayish water coming in the; here it was not a close system. here the overflow water is allowed to overflow through the weir and it goes into Yamuna.

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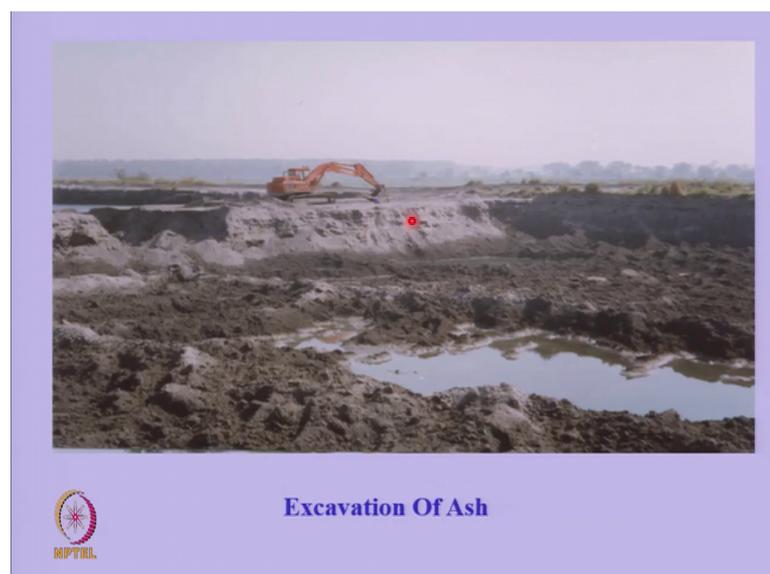
So, here settlement time is adequate then clear water will go through, but if your settlement time not adequate; what will happen milky water will go through.

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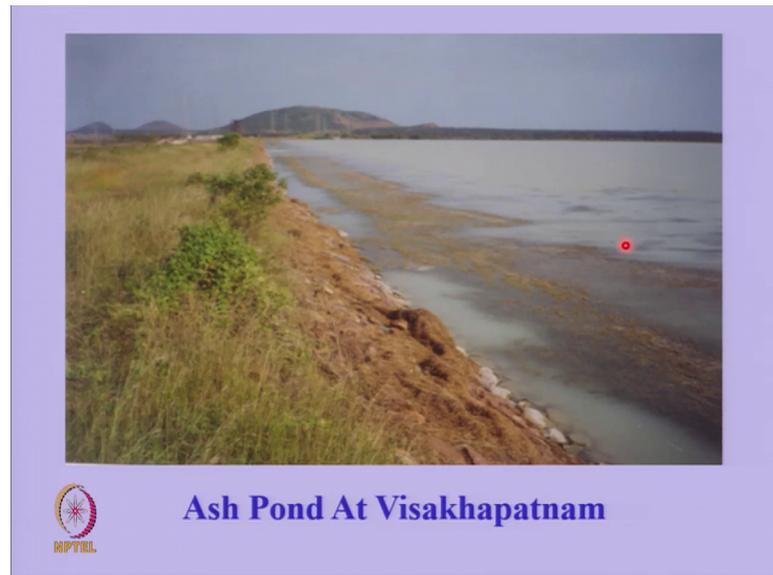


So, at the time when this pond was operational, this ashes; whitish grey, you could walk along the river Yamuna and you could see that in that portion, there was a milky water which was going in that is the way the layers of ash as they are deposited if you excavate; it you can see horizontal layers of fine and coarse ash; as it is hydrolytically settling first, the coarse particle will settle then the fine then the next load will come coarse and fine.

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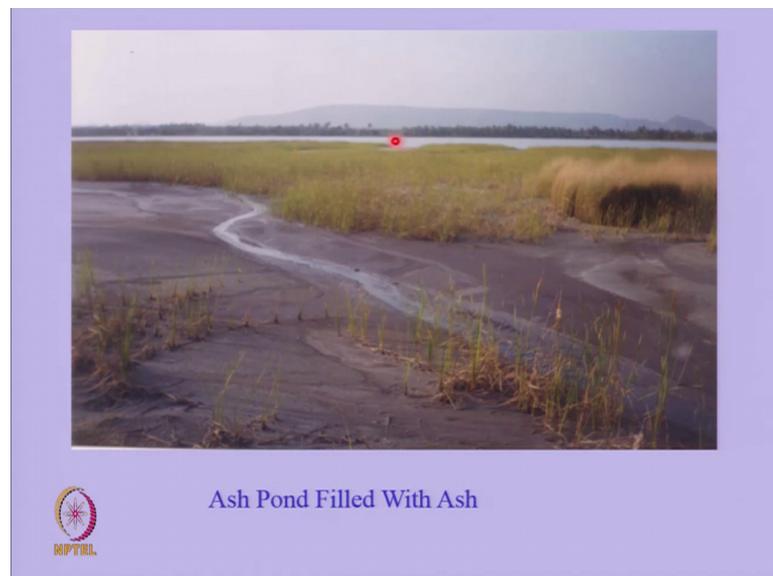


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So, you can see horizontal very thin-thin horizontal layering, this is an ash pond at Visakhapatnam, it is almost like a lake; a 2 kilometers by 1 kilometer lake.

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And on 1 end; this is full that is where the slurry is going and you can use the ash for purposes of infrastructure development.

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You will do this later; here it is been rolled like a soil using a the roller.

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Question that in your mind is; is this material safe, is it hazardous, is it having some heavy metals, can it cause problems that is something which we will address this adequate information. Now coming in from the US; that coal ash is causing contamination of the ground water by a very few; very rare elements like vanadium and boron very mild, but definitely elevated earlier most of the time this is been treated as not

being chemically harmful and whether that is true for Indian ash or not is something which is not yet been collaborate.

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So, now in America, all the ash ponds have to liners like landfills. In America, just 2016, the USCP has brought out the coal combustion residuals rules in which liners have become a big issue. Let us look at a another ash pond at Panipat, here are the slurry; lean slurry, I think 10 times the water to 1 time the solids.

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This ash pond that is your thermal power station; this is a huge amount of ash, it is you can see if it is dry, it is going to fly, it is called fly ash, it is duster machines. So, you have to keep it wet or you have to keep it submerged, if you do not want duster machines from these.

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So, in dry summer months, this can create a problem, here also they are trying to use the roller for compaction, yet another ash pond at Delhi. This the Badavpur ash pond.

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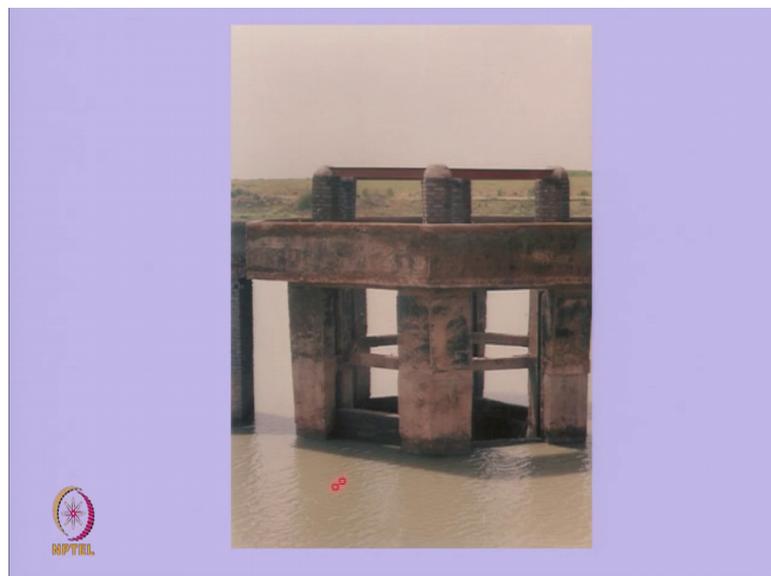
And the slurry in flow; they are growing greenery on it. So, that ash does not fly embankment. So, the ash is being deposit here.

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That is this water decanting structure. So, as you see; the water comes into this as a well.

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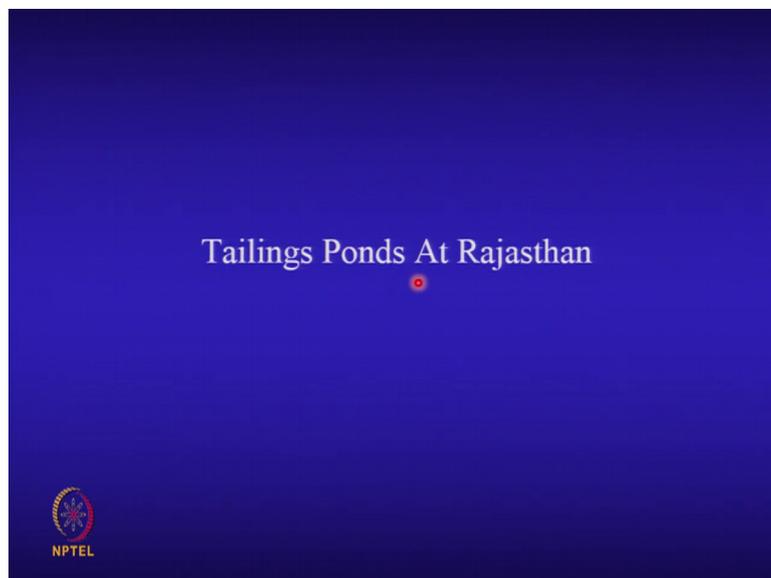
And the water is flowing in; is this clear water; not clear because very fine particles of ash take about 12 hours plus to settle. So, if the retention time is not 12 hours then if the water starts to overflow before that; then the fines will go out and the limits for discharge to rivers is got 50 ppm. So, we have commit the 50 ppm long.

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Once this is full, they are growing some; you know vegetation on it. So, that you get a green look and the fugitive dust emissions are minimal. That is the thermal power station. So, far we looked at coal ash.

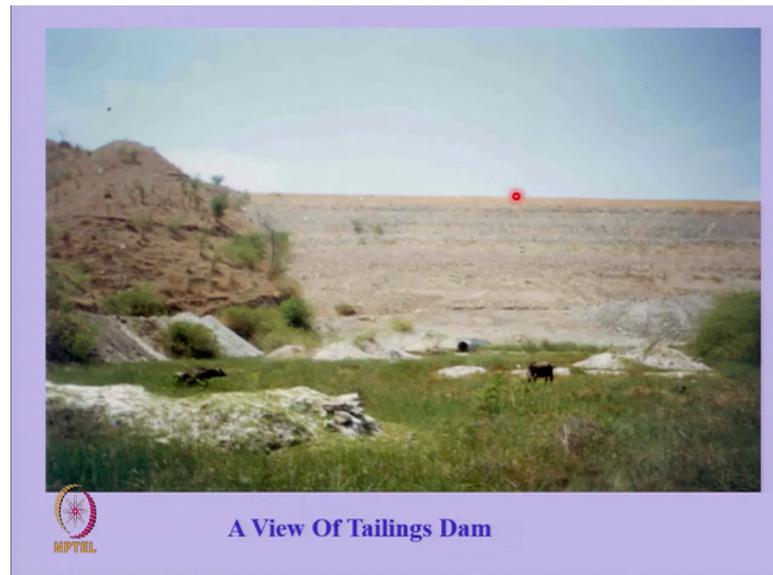
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So, we have about 80 to 100 thermal power stations; each producing millions of tons of ash. There is a lot of pressure on reutilizing ash and ash being silica tendency to use it in earth works or even better use the ash in cement because it has some pozzolanic properties and to make bricks anything which requires material; I mean when you make

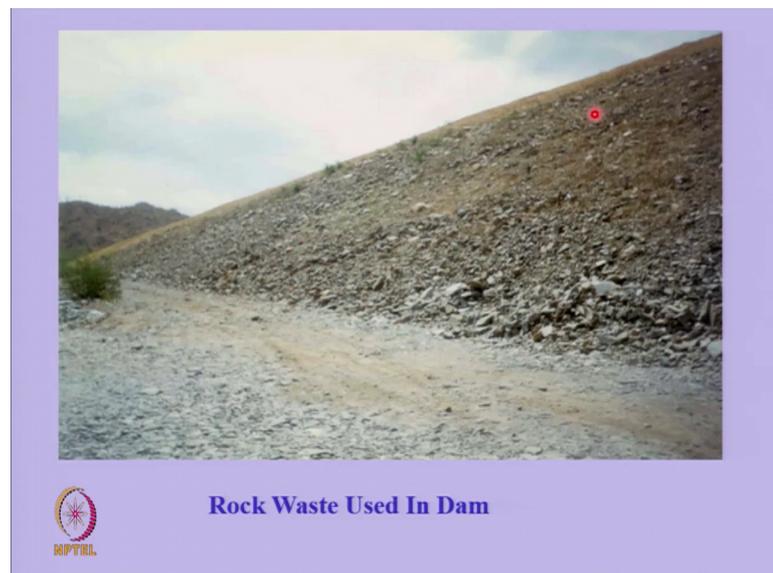
a building you need bricks you need concrete you need aggregate coarse, fine aggregate; all these materials have dug off from mother earth, but now if you have got a waste material in building blocks it at least the ash is held in earth works, ash is not held, it will undergo leaching in building blocks, you will have a burnt brick or you will have in the cement the ash will be confine.

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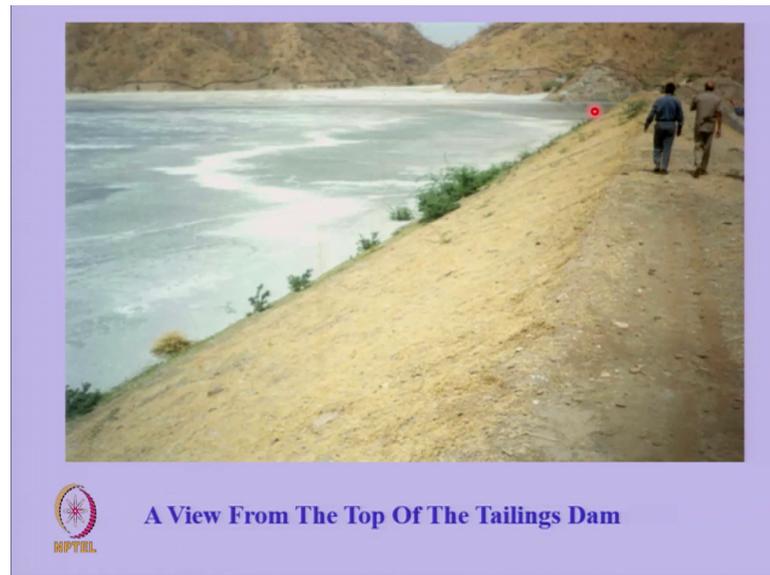


Let us look at tailings ponds; this is a dam behind which the tailings are been stored. This dam is made up of rock waste which is coming out from the mining operations.

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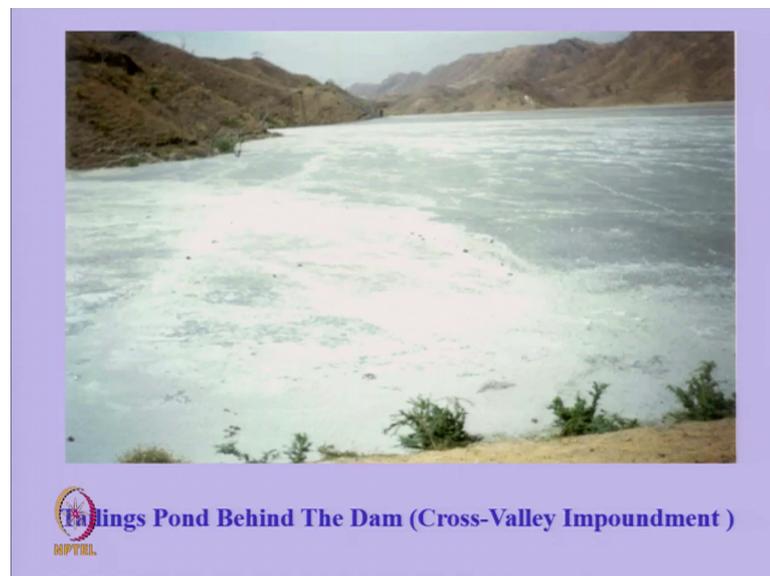


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And these are just like ash; you could see a whitish grey material; this is the whitish grey material of the tailings pond.

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And again here it is a cross valley impoundment. So, you can see hills on all sides, right and this was the embankment across the hill. So, it could have been a water reservoir or water dam and when it is full then you trying to grow vegetation on it to give it a green cover.

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This is yet another tailing pond, as you can see, this is these are the tailings this is the water which has accumulated.

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This is the embankment that is the slurry pipeline which is coming here. It is been dropped at the side of the hill, it falls down into the reservoir and this is gradual filling up of the reservoir with the tailings material. This is the second pond; tailings pond. Similarly this is the third site, again in Rajasthan. It is like a lake; wonderful lake, this also a tailings pond, this is the embankment must be about 10 meters high, you can see

the pipeline that is the slurry pipeline; slurry coming in, this is the deposited slurry that is the lake. So, the water is ponding; there they are holding excess water and this is all most full. Now this embankment is full still slurries is coming in eventually, they will have to raise the height of the embankment to fill in more material because the plant is continuing 24 7.

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This is the highest tailings pond of the country, now no longer operational though a 100 meter dam; these are iron tailings in the form of a slurry.

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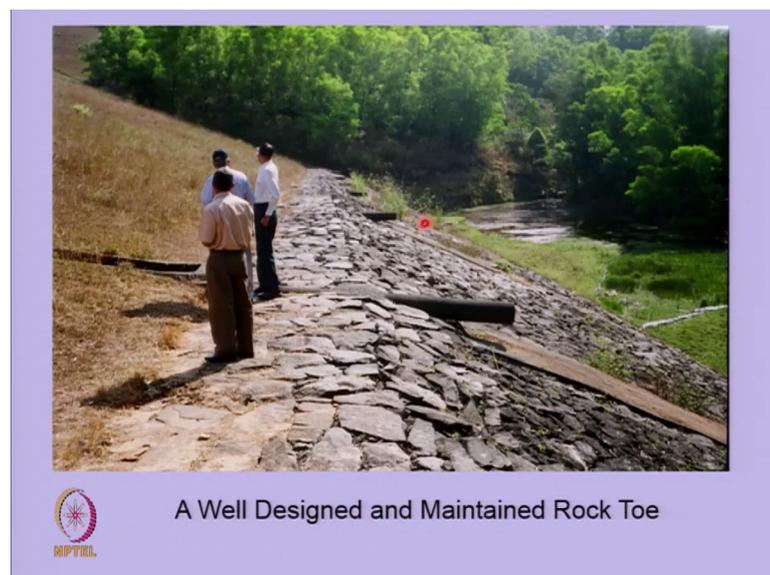


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This is a huge dam built like; again see some hills here. So, wherever you can have a hilly area around, you can just make an embankment on one side, but if you have got plain ground, then what you have to make the embankment on all the 4 sides to be able to make the pond. So, that it can settle down and sort of allow the solids to settle down and allow decanting of superannuated water.

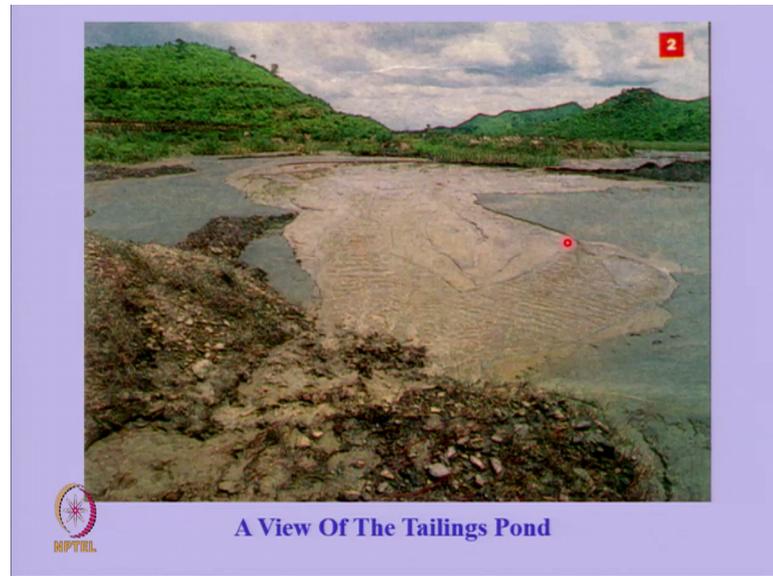
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And just we will discuss this later; this is the rock toe of this dam. So, the dam is about 80 to 100 meters high, the rock toe is 10 meters high, the rock toe is 10 meters high;

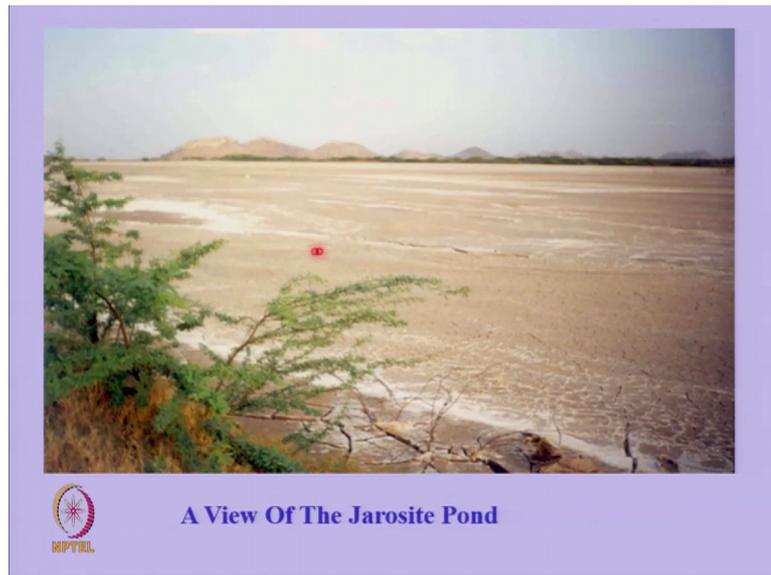
important thing for you to remember is these slurries are full of water. So, you have to design this dam as if they are water reservoir and you will have sea page through this and the water will come out on the downstream proportion.

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This is a photograph of I am not visited this, but in one of the magazines; several years ago, this was reported, this is the tailings pond for a uranium tailings in Bihar, it was having; it was effecting the local population, it is not only mine tailing which may come out in the form of a slurry, here is a process called mineral extraction which releases a slurry known has jarosite.

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And have a look at this. This is a Jarosite pond, no water, you can just see some yellowish material is a hazardous waste by the way the waste is coming in the form of a slurry.

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So, here also you can see this some accumulation of water there which is being decanted. So, this is also hazardous waste being disposed in the form of a slurry, it has a liner and it will have a power, but when you look at this whole area you will see that this green

outside and the vegetation is getting effected by the constituents of the slurry water and it is drying it out.

Slurry ponds appear to be very simple to make, but you have lots of distress in them, occasionally you will find; it will breach because they were not well maintained.

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So, I will just give you some shots that is in ash pond which has breached. This embankment has broken and material has flown out, you can see this breach ashes behind this, it has full flown out for few 100 meters because once a slurry starts to come out, it flows like water, it did not stop at 10 meters of 20 meters, it is not a thick paste.

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And just to give you an idea; how far this slurry has come can you see that and embankment failures and then you can see this is spread over here these slurry water and this embankment has failed some more shots; this was when I talk to about embankment you can see that this embankment is also under going distress can you see the erosion gullies.

This is stage one of the embankment, this horizontal line you can see this is the crust of the first embankment and this is now the second embankment, but the problem is the joint between the 2 embankments is not been designed properly. So, what is happening this is becoming a seepage plane horizontal permeability at the crust of the old embankment is high and water flows out and is eroding this embankment and this required remedial measures. So, that this should once this gives away the whole mine tailing will come out, I have the better shot about this erosion gullies and here is the what on which we are standing and here you can see I have you should stand on the top of the second raising and this is the original crust you can see its wet.

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So, and it leads to seepage of water and some distress already beginning to show up at that site, this is another location where there was distress to the embankment and nearby canal due to an ash pond being nearby. So, what I am trying to say is that when you deal with slurry ponds once the slurry dries, it is just powder. So, does not look very challenging, after all you are just storing powder behind a embankment does not no, but you if you do not read it like a water reservoir and specially when the heights of these embankments are not going 20-25; these are incrementally raised, you will make a small embankment, fill it up, then make the next height, if you do not design them like water reservoirs, water is very difficult to handle remember that.

So, you always fail, no, no, [FL] we will keep it away from the embankment towards the center, does not work these, tend to get breached and they have problems related to that the same material which we are talking off which is coming in the form of slurry, you can also come out in the form of dry powder. So, out of the 80 to 100 odd thermal power stations, we have one station in which it is being handled in the dry form and that is at Dadri and here we are making a mound of the ash.

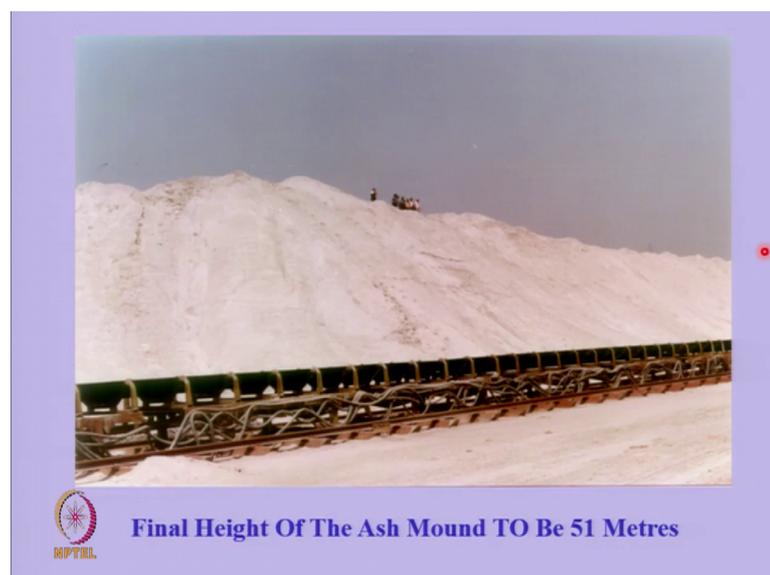
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So, this is the ash, it is coming on a conveyor belt, it comes on this belt, there is ;a this conveyor belt goes up like this and then it falls and here it will form a conical heap and this height is about fifteen meters.

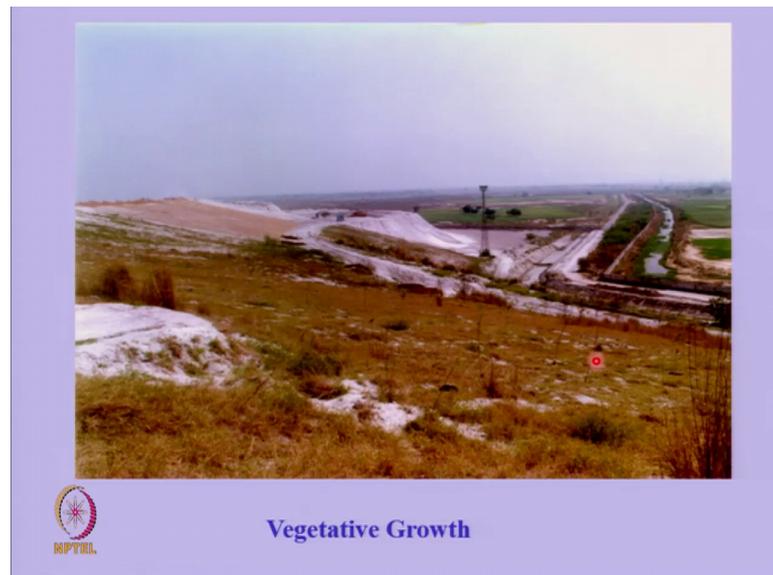
So, this boom spreader will spread this 15 meters high and just so that you get the idea, this is US people were 2 meters high. So, definitely this is about 15 meters high and that is the conveyor belt on which the ash comes.

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So, the ash is not coming in the form of a slurry pipeline, it is not coming on trucks, it is coming on a conveyor belt, the question you would like to ask is what happens when it is raining because conveyor belt is not covered. So, if you have fine powder and its starts to rain very heavily, what will happen? It will starts to get washed away to the sides.

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So, you have to take many educate measures, what happens once the mound has been completed, this is goes to be a 50 meter high mound then you can grow grass on it by putting some soil cover.

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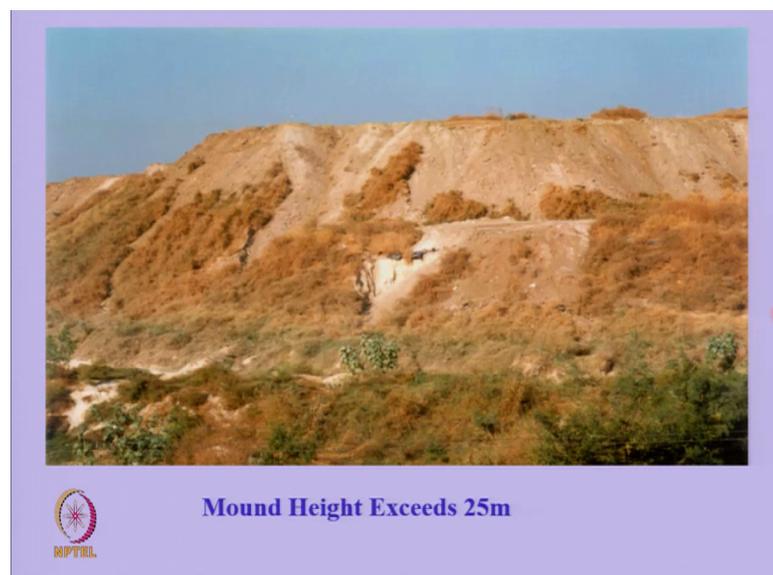
And give it a green look, all the visitors go here for a very nice green look of the ash mound, but I would like to remind you that a person walked to my office, the several year ago and he said sir, I have come from this-this place, can you tell me what to do about this. So, this is also I do not know.

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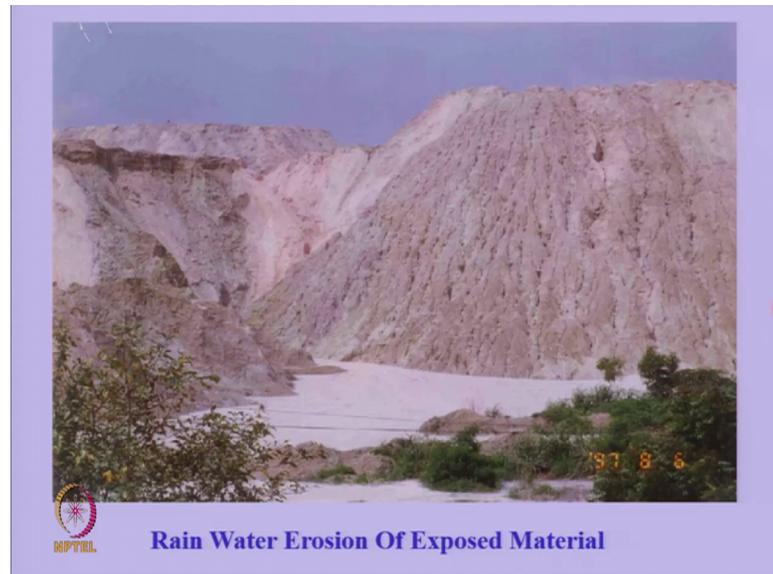
What this is? This is also some powder which looks very much like the mound that we have got we the Dadri, this is also powdery, this is the old thing where they have done vegetation, this is the new waste being deposited and here you can see some failures.

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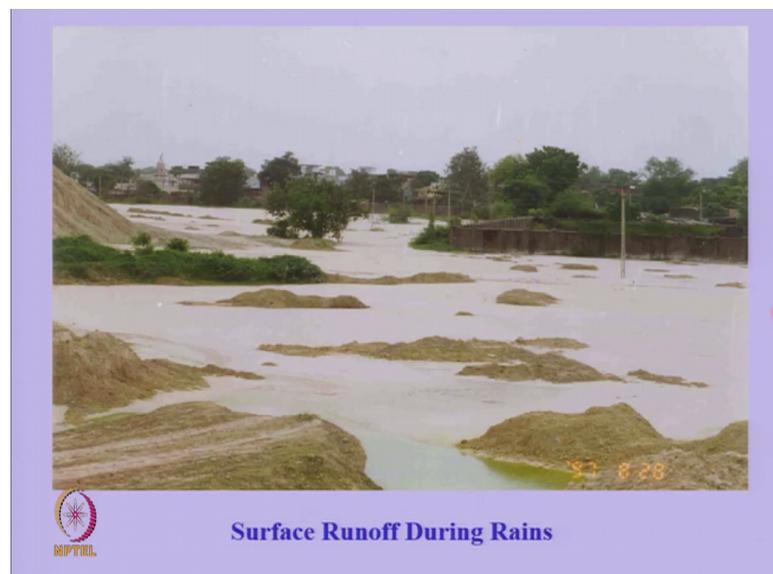
So, he said [FL], but what happens when it rains?

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So, it looks so simple, you know it looks so easy to deal with and when it rains more.

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So, this fine particles start to move with water and once they move with water, they will come down the mount and here this the gentleman who had come from some village; you know.

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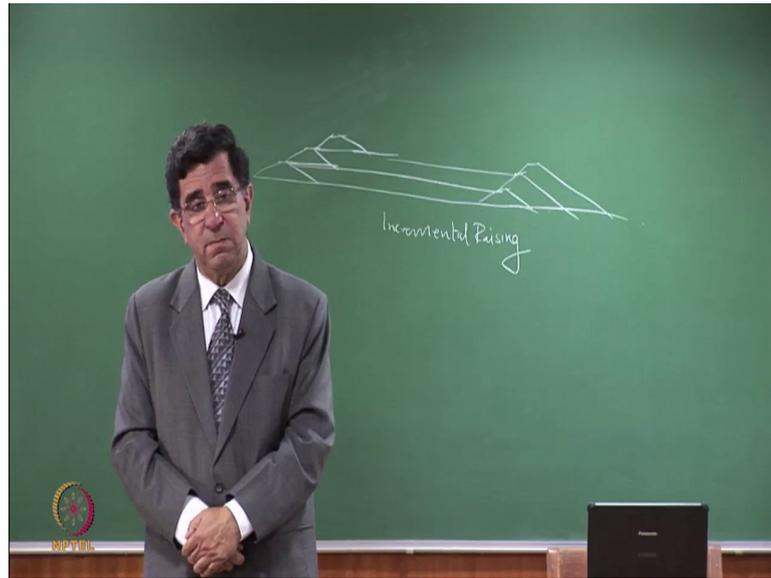


So, this water was coming down and it is going in to the village. So, issue is fine particles are very erodible you want to contain them again we have to give them a proper cover with proper vegetation otherwise they are prone to erosion by water.

So, most of the fine powdery wastes which can be transported in the form of a slurry are transported in the form of a slurry its only the larger heterogeneous waste which come to you in the form of a truck. So, I have just opened a new new world about slurry wastes for you we have to design these waste disposal facilities. So, that they remain and they perform without affecting the people around it and the real challenges is that because they are in the form of slurry, if there is a breach, they flow out? No, that that kind of problem does not exist in the landfills that we are dealing with. If our municipal solid base landfill, it will breach, it will come down by 10, 15, 20 meters, it will not travel for a kilometer, but many slurry points have breached where the ash is gone down a few kilometers like water. Now it is like a pond has breached and then it is affected human being and houses on a dark flip side.

So, the challenges here are how to design a system since it is slurry waste it has to be deposited between embankments.

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So, that it does not flow out, but the larger challenge is nobody wants to design to the full height in one go because suppose my design life of my minus 25 to 30 years and I make an embankment which is required for 25 to 30 years, it is a lot of investment to build, it is right in the beginning because it is going to fill up slowly. So, what happens is we make embankment which will last about 5 to 6 years, make that investment and then raise the height of this embankment. So, this is very different from a dam design, in dam designs, we make the embankment in one go whether it is a dam or Ramganga dam; they 100 meter high in one go in a year; 6 months to year will make the dam here we have to either to do this and go up when this fills up this is called the up string method or you will use a method called the downstream method when this fills up.

And so, there are different method, but this is called incremental raising of embankments. So, this design is something new.

So, first slurry deposited waste and the important thing is incremental raising. So, over the next few lectures, we are going to first study what are the properties of this material specially; what are the geo technical properties then we are going to look at how we decant this water, we are going to look at how do we ensure the stability and how the roll of the lines. So, critical in the stability of the structures, we are also going to look at how we can reuse this material because we do not want to be creating more and more ponds which are occupying more and more land.

So, we look at reuse of mine tailings; reuse of coal ash and finally, we will also look at what environmental control measures are required; I showed you a huge ash pond which was dry and every summer there is a you know artificial clouds of dust because high wind speeds surface is totally dry very simple to say; oh; let us put some sprinklers on it, but 24/7 sprinkling of ash is tough to keep the ash below water you need a lot of water which may or may not be available.

So, how do we balance the problems of environmental impact to the people adjacent, I mean, you make a thermal power station at a place and you bring in a lot of water for cooling the thermal power station and also for making the slurry ponds. Now the water table was below by putting water on land close to that area, you have gradually effected the ground water regime of that area, how does that effect people, how can we prevent that. So, these are some of the issues that we will do over the next 6-7 lectures on design of a slurry ponds; any questions which come to your mind about slurry ponds.

So, we will find that there is lean slurry with which we deal the one; which I have shown you more and more, we are going towards medium dense and high concentration slurries; that means, the quantity of water in this slurry is being now reduced because of less availability of water. So, you have the dry mound on one end and the lean slurry at the other end in between you have medium concentration and high concentration slurries. So, we will also look at what are the developments taking in that area that if the slurries coming out to you in the form of a paste then how do you design that facility.

So, the difference is just intuitively lean slurry flows by itself; therefore, the ash spread by itself water comes out; where will the water go? It will go in the direction where the ground is sloping. So, the slurry will gradually deposit the material you do not have to send the dozer to depositor; slurry come waste comes on a conveyor belt, it goes to a boom spreader, does it spread itself? No, it is deposited in the form of a conical deposit. So, dry waste will not spread itself, you will have to either spread it or you will have to move the boom. So, that the cones are consequently formed. So, in between them; between dry and lean is the paste the high concentration slurry there also the paste may not spread a lot, but it will spread more than a cone of a dry powder.

So, these are the new technologies which are coming up and these are called high concentration slurry disposal will look at that also as a part of a design exercise.

All the best, have a good day, enjoy yourself.