Course on Integrated Waste for a Smart City
Professor Brajesh Kumar Dubey
Department of Civil Engineering
Indian Institute of Technology Kharagpur
Module 09
Lecture No 44
Landfill Disposal (Contd.)

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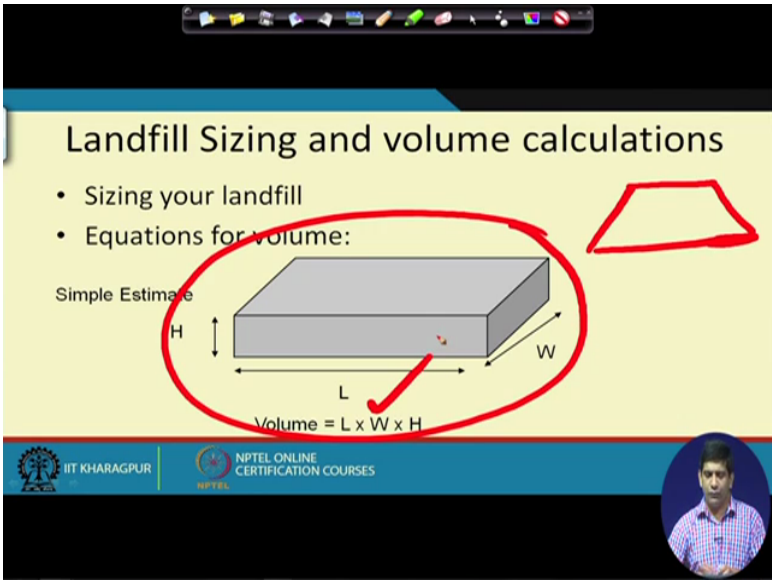

Okay so let us continue, I said that we will do some math in this particular module as I said in the towards the end of previous video. So let us look out some of this math and very simple, very simple calculation just to illustrate the concept and then we will have a simple calculation then will add up a more difficult one so that you see how things are work out.

So first of all when you try to design a landfill, it has to be we have to come up with a size, isn't it? We need to know the size of a landfill, so how we will come up with the size of a landfill. First of all say if want to design I am sitting in Kharagpur right now at IIT Kharagpur campus, so if IIT say if the Kharagpur town, IIT Kharagpur is too small place to for a landfill but if Kharagpur town wants to build its own landfill. So first of all it has to know how much waste is generated in Kharagpur town.

So we need to know what is the total waste generation in town? The population of town may change over time, so and will change over time, so how the waste quantity will change because I said the landfill is not designed for say 1 year or 2 year usually we are looking at a landfill design for 20 years 25 years. So we need the size of landfill based on those

projections of 20-25 years of population, 20- 25 years worth of waste generation, the waste generation rate may change over time as well.

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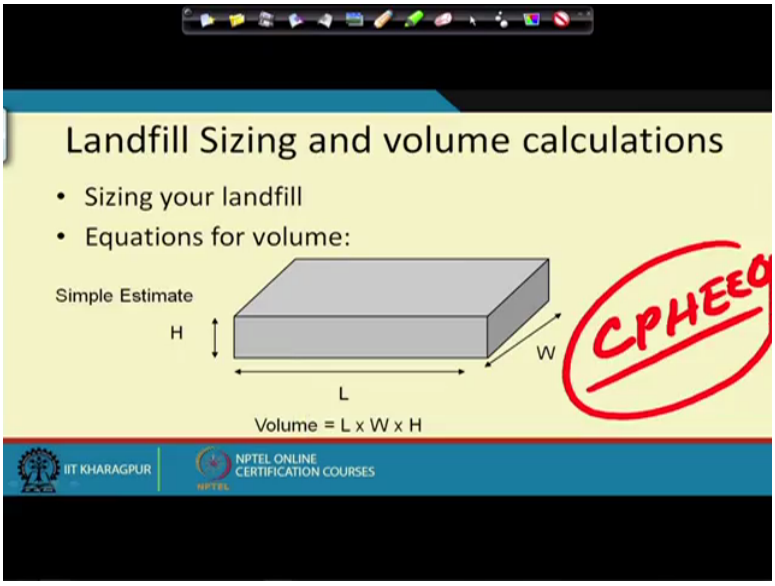

So for all these aspect we have a manual prepared which is known as you some of you who are working in environmental field you know those that we have a CP let us see we have the CPHEEO CPEHH CPHEEO Central for public and more something that is the organisation which put together the manual. It is that manual there for water to water, manual is there for the waste water, manual is there for the solid waste, so all these things are like it is incorporated in that manual.

So that they did talked about that size, but as per the CPHEEO manual the typical waste generation rate for Urban centre is taken as point 6 KG per person per day, so that is for the urban area for rural area it is less. So that point 6 KG has been arrived at based on certain calculation. So similar certain measurements on sites so that number has is proposed that number may not be seen throughout India even within the urban centre things may be different, so it is always better to do some calculate some sort of the selection on your own.

Say if you are going to design a landfill off course you will go for DPR the detailed project report, detail which needs to be repaired usually it is done by certain consulting firms, recently we were involved in looking at several DPR's from many ULB's in the country which I had a chance to review.

And that again some of them they had some issues off course as a waste management expert that is our role to identify those issues and highlight those issues so that DPR's can be improved. But most of these DPR that we have looked that had gone to look at the sampling, higher income group, lower income group, medium income group, different houses, different locality, different socio-economic status and all those you collect all the data you collect and then you come up with the per capita generation rate.

For most part you may find numbers to similar point 6 KG per person per day but not always you do see the numbers do fluctuate but so once say that we have that number. So I gave you that background because you will you certain so we have that number now we need to find out how much area we will require. So to find the area for the sizing of the landfill we have to know the equation the volume it is the volume.

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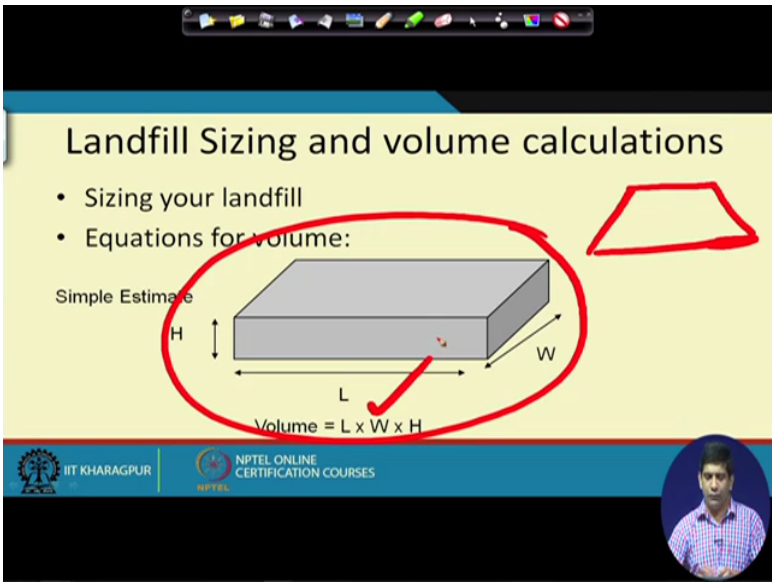

So just for a very simple rough calculation, this first problem is not actually what you will typically do in a landfill this is all this is a very preliminary calculation that you may do. So if you have this length, certain length, certain width and certain height and we are using more like a this particular shape and you very well know this is not a typical shape of a landfill, typical shape of the landfill is like this and then you will have like a base, base is different the width of the base and width of the height sorry width at the base and width at the top is not the same and there is side slope as well. But for a very simple calculation just to have a rough estimate of how much of acres is required, we can use this equation, use this approach. So you have the volume is length times width height which we which we know.

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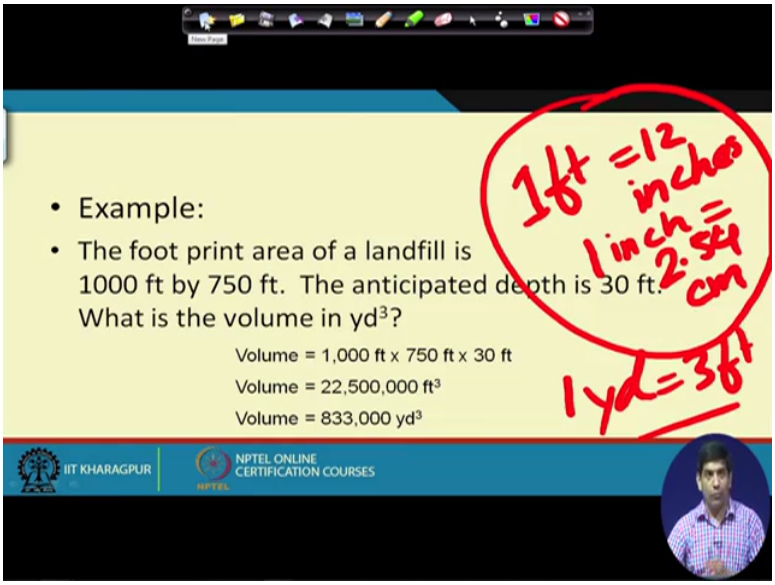

So that is and so based on, say if the footprint of the area of the landfill is 1000 feet by 750 feet, so you have 1000 feet length, 750 feet is your width, anticipated depth is 30 feet, what would be the volume in yard cube? So we can always convert that to meter as well so that is your job as your assignment for you to convert this from feet to meters. I could have done that but I wanted you to do it.

Because and I will give you some numbers here which you can use, 1 feet sorry we have 1 feet is 12 inches , is not it? And 1 inch is equal to 2.5544 centimetres. So that is 1 inch is 2.54 centimetres, so that is the 1 feet is 12 inch and 1 inches 2.54 centimetres, so you can convert from feet to this and 1 yard is 3 feet. So from that you can convert all these yard cube to feet, cube to inch, cubes to centimetre and meter and all those convergence can be done based on that.

So you can pause the video at this and wrote write down these numbers and then you can do all those calculation. So it is a this is the footprint it is given in this feet by this, anticipated depth is 30 feet, 30 feet is almost like a 3-storied building, so typically 10 feet is like a 1-storey building. So what is volume in yard cube? So we know length times width times height, so you got the volume, so this is the volume. Again we are using it no slope nothing just a very simple calculation just to kind of estimate the area.

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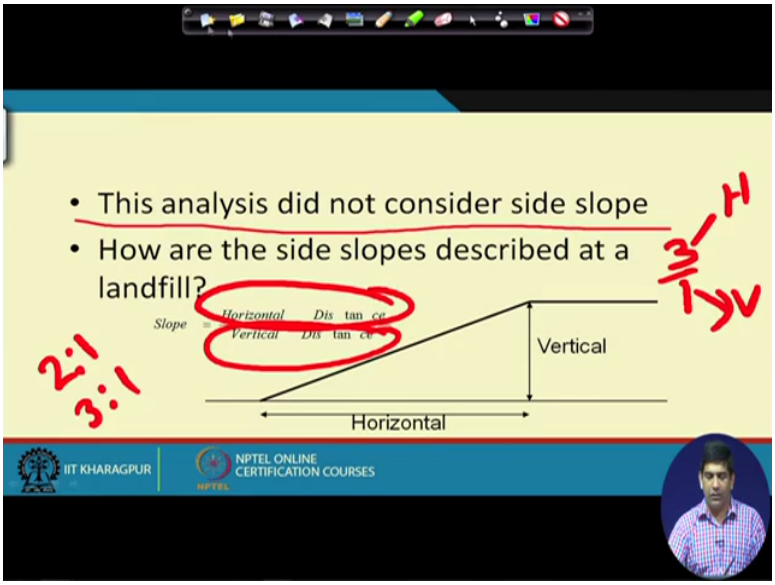

So we got the volume, now how we can use this volume? We can use this volume by so here we are not considering the side slope but in the actual condition when you will be doing the volume calculation you will have the side slope, isn't it? We talked about the landfill has a side slope. So the analysis that we did in the previous slide, we did not calculate the side slope, this analysis did not consider side slope, but actually the side slope will be there at the landfill.

So how we describe the slope at the landfill? It is that any slope as you can see is your if we do it actually in a reverse way. So when we say slope of 2 is to 1 or slope of 3 is to 1, essentially we are talking about as 3 is the horizontal distance, 3 unit is the horizontal distance when 1 unit is the vertical distance. So when we say 3 is to 1, 3 is the horizontal distance and 1 is the vertical distance and this is in units in any one particular unit. It could be 3 feet, 1 feet, 3 meter, 1 meter, it is a same, slope is the same. So that is the side slope and typical side slope is 3 is to 1, when you have 3 horizontal with 1 vertical, so that is a typical side slope that we use for a landfill design.

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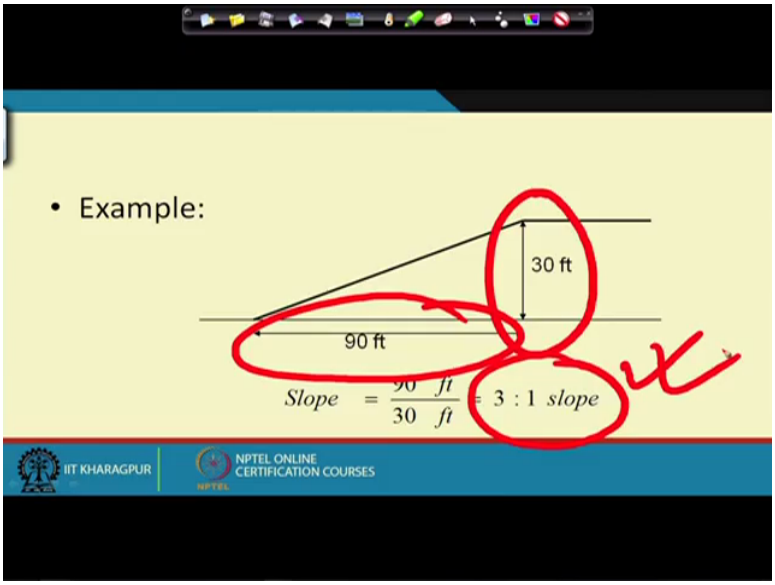

So here as you can see, you have 30 feet so we have 30 feet here so this would be 90 feet in the horizontal, so it is a 3 is to 1 slope and 3 is to 1 slope is what you will see the most common. Say in the exam problem any exam taking where the side slope is not given for the landfill you can take 3 is to 1 as the side slope, because that is the most common side slope used in landfill industry throughout the world.

Right now the Bhalaswa landfill actually is almost is like 1 is to 1 side slope, which is really dangerous the way during the every rainy season some of these landfill that we I should not take I am using a wrong word, I should not call them landfill they are the dumb sites, because since we are teaching the engineer course here that is from the engineering point of view they are sincerely dumb sites.

So some of these dumb sites the slope is almost like this, so it is almost 1 is to 1 and that every rainy season I am really worried about as a citizen of the country I am always worried with of some catastrophe that may happen from those dumb sites. Because if it rains a lot it luckily, say for example in Delhi that it does not rain as much as rain in Kharagpur or in Cochin, so we do not see that thing happening, but if it rains a lot that this slope can collapse anytime.

This past rainy season we had that incident happening in Ahemdabad where those dumping sites actually collapsed and garbage came on the roads. So that no fatalities but some of places it can cause fatalities as well, so it does we need to be careful. So here 3 is to 1 slope

that was that is used as a typical slope you can if slope is not provided in your math problem you can use 3 is to slope, that is a there is no harm in you can do that.

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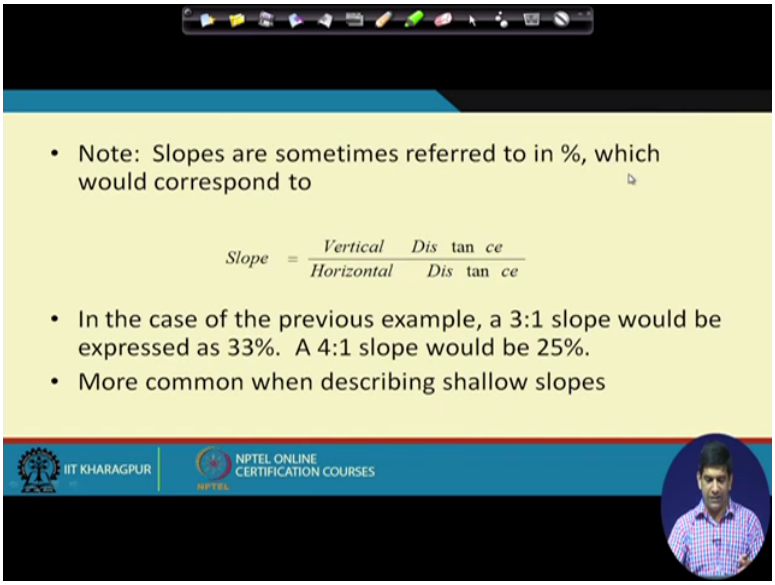

So and then it is a slope are sometimes referred also in percent, so that is another way of putting percent. So 3 is to 1 slope we call it 33 percent, 3 is to 1 slope is 33 percent and 4 is to 1 slope is 25 percent, so it is slope 3 is to 1 slope will be 33. So more common when describe in the shallow slopes when you have a shallow slopes **(())(10:48)** it is more common to describe in that way, so that is a it is 3 is to like a 3 is to 1 or 4 is to 1 it is such describe in a shallow slopes.

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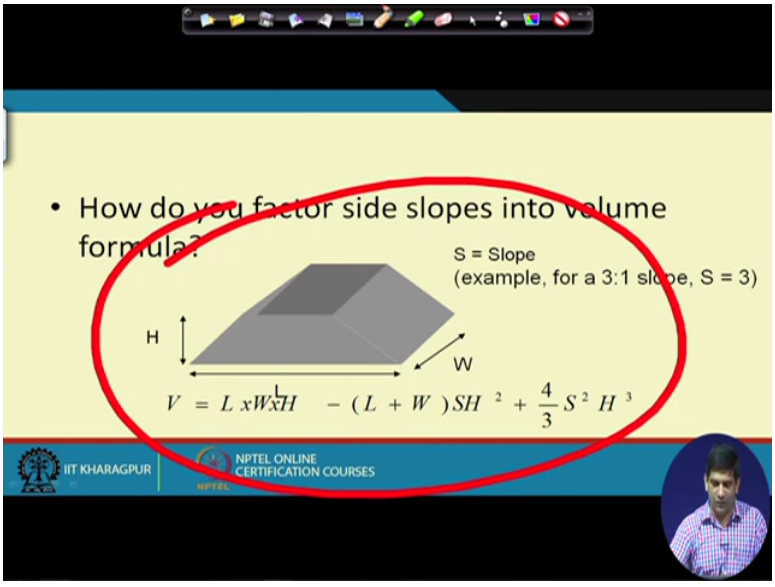

So how do you factor side slope into volume? So this is how the typical volume, I initially when I told you that LWL times W times H that is the very simple way of just doing a rough estimate, but we are when you are doing the actual problem this is what we will do. This is the actual so when we are trying to do the actual problem this is what we need to do. Where this is the this is how the landfill looks like this what you see on this picture and then you have the length, you have the width.

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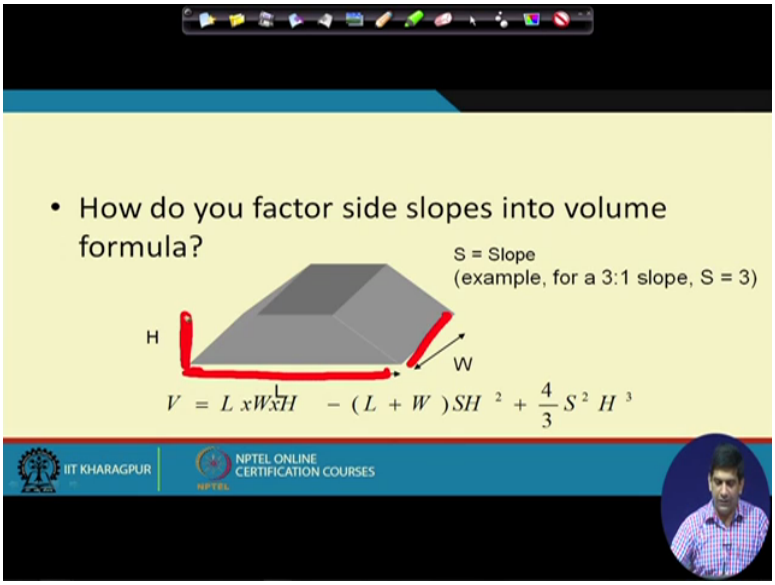

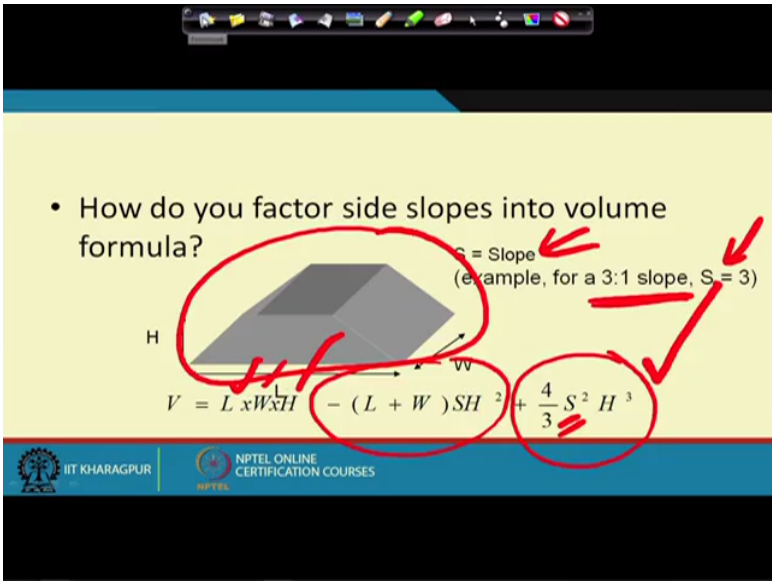

So we have the length of the landfill, we have the width of the landfill, we have the height of the landfill, so we take all these 3 and based on. So this L times W times H that would be if

there was no side slope and the top was same as the bottom in terms of the width, but since the top and bottom is not the same we have a certain negative factor and then certain things has to be added. Again you can if just draw the geometry and then there are the derivations formula out there and you can derive it by yourself or you can just my word on it and you can do this but this is a simple geometry here.

Simple geometry where we have here since we have side slopes we are losing some space, where the top is not top length and width if width is the same top length is not the same as the bottom length, so we have difference is there as well. So based on that we can calculate and this is how this will be the for this particular shape this is what we get in terms of the volume calculation. So here L is length, W is width, H is height and S is the side slope. So this S number we call it for 3 is to 1 slope where S is 3, so if 3 is to 1 slope s will be the three.

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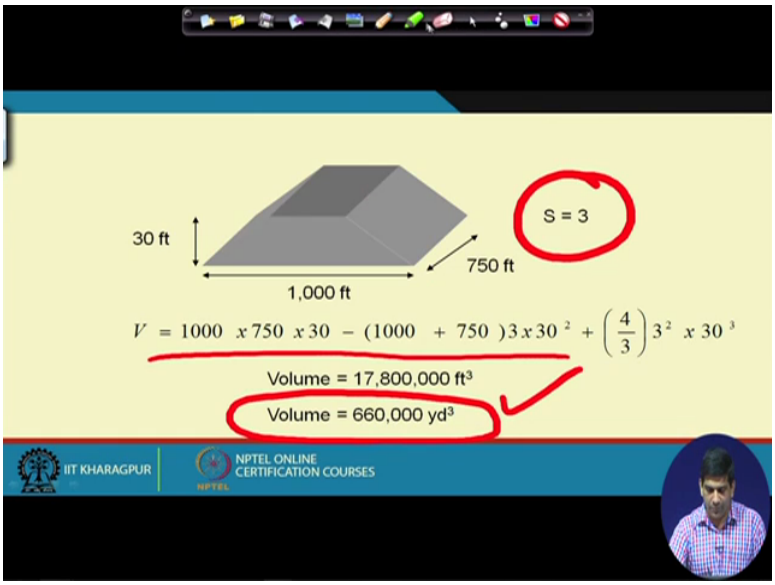

So now using those information if we can do this calculation again here we had 1000 feet length, 750 feet width and 30 feet long with the s of 3, with a slope of 3 we get sorry with a slope of 3, what we are getting here? Is if we can plug the those numbers in here we get volume as 660000 yard cube.

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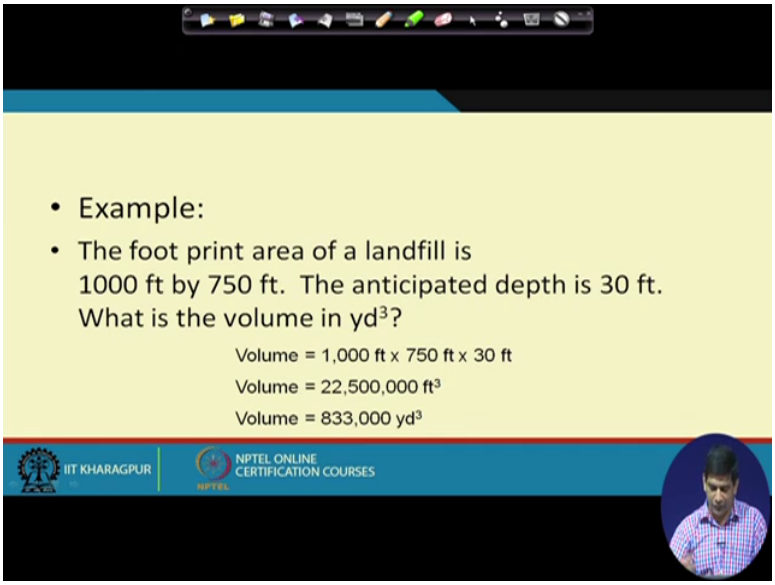

If you remember from the previous slide that we did for the very rough calculation, if you go back to there and here we got the value of 833, so it was much higher, isn't it? It was higher almost but still get a rough estimate not it is a but it was much higher 660 and a 820, so almost like 27 percent more but it gives more, we know that it will give more but it will not give will actual will be less for that way we have some control, so in terms of width we are more conservative in those calculations.

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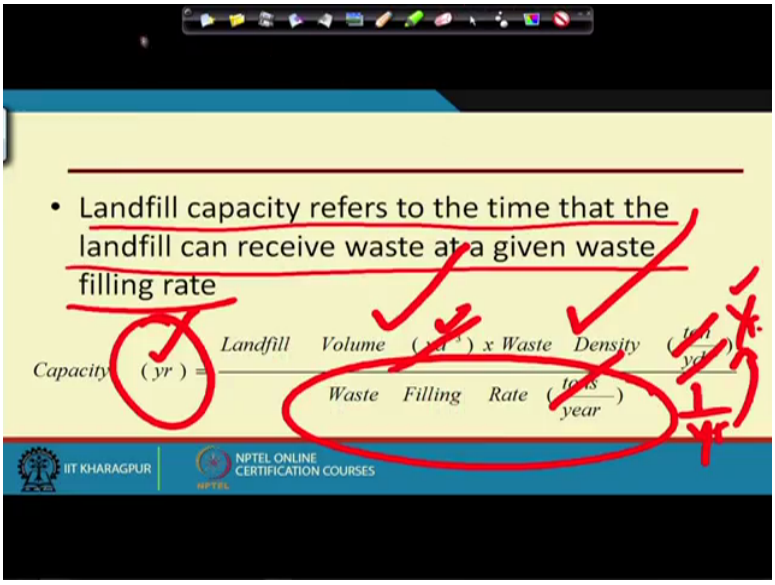

So that is once you have the volume then there is another term which is known is called landfill capacity. Landfill capacity term is used in many calculations. It is essentially that year is a time that the landfill can receive waste at a giving waste filling rate. So we talked about

the waste filling rate earlier that as per CPHEEO manual point 6 KG per person per day or as per your calculation that you do or as you if you are a city or if you are a like a big metropolitan area, whatever your agency you are if you are a student who essentially work on those departments you can you will get the DPR's made or either you may be making a DPR as a consultant.

So based on what role you play, we once we know the actual way to generation rate and also predict how the way generation rate will change over time and there is a way of doing it and then we come up with what is the waste filling rate, so how much waste will get fill per year in the landfill. So if you know the volume of the landfill and so we know the volume of the landfill, we know the waste density because waste would be compacted, so what would be the waste how much tons will be in one yard cube, because we do the compassion on top of the landfill and then if you divide it by the waste filling rate that gives us the capacity in year.

And always when you do this type of math check the units, so here we have yard cube that is the volume is given in yard cube. Here tons per yard cube, so this yard cube and this yard cube will cancel out. We have tons on top, so this ton and this ton will cancel out and since now here we have 1 upon year, so this year will go on top of it will basically become year on this side and then we have year on this side. So units on both sides have to be the same, so that is this should check it.

So landfill volume times the waste density, essentially on top what we have?WWe have the mass, this is the mass and the bottom what we have? In bottom we have the mass that is coming per year. So top we have the total mass that the landfill can take for the volume it has, bottom we have the waste how much waste will go into the landfill per year, so you divide it you will get the year of capacity in terms of the year.

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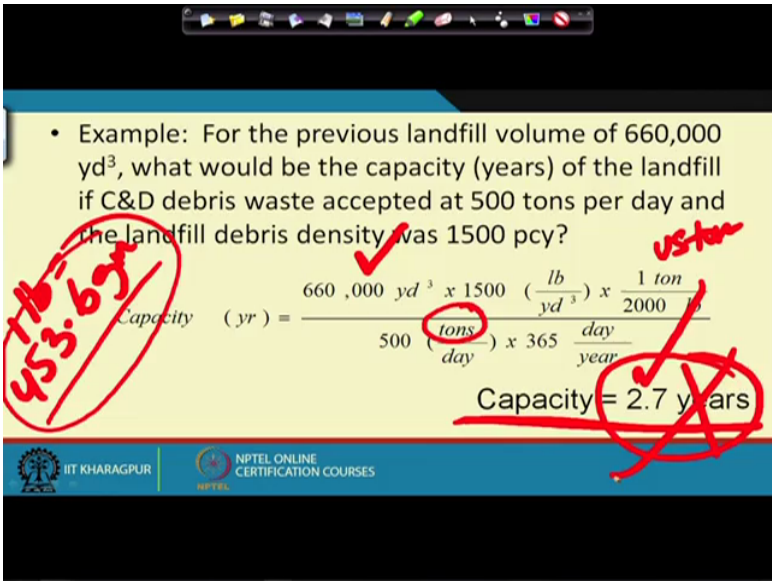

So in this this calculation if we do a math in terms of a hypothetical scenario where for the previous landfill volume with 660000 yard cube, what would be the capacity in terms of the year of the landfill if C and D debris waste, this is the C and D landfill for example, accepts 500 tons per day and landfill debris is density is 1500 pounds per cubic yard? So we have pounds per cubic yard, this is the density given to us, we can again you can convert but everything to KG per metre cube and all that I gave you the conversion unit. 1 pound is for 453.6 grams or one pound is 453.6 grams.

I will in the solved example problem that we will have the TA's will do it we will use the SI units, so do not worry and this is the only problem where we are using the British unit just to I want you to practice that as well because in most of the books that you will get because most of the books written in US or they still use these units. So you just to make you familiar with this units system we are using in this problem but before in the previous video that we have already seen we have all always used SI unit and the later we will also use SI units but just to give you a feel of there could be other units out there when you are doing problems, how to convert I want you to work on the conversion on your own and you should get the same answer because if your conversion is correct.

So here we have 660000 yard cube, so that is the volume of landfill that we have, 1500 pounds per yard cube that is the it is a that is the density and then 1 ton is 2000 pounds that is this ton is a US ton, so US ton is actually smaller. So actual because 2000 pound will be close to 900 KG not 1000 KG, so based on our conversion rate here. So it is the US ton is the

smaller ton, so 1 ton is 2000 pound, so it is based on US ton because this is also based on US ton. So you have 500 tons per day and then 365 days in a year, so if you do this maths you get the capacity as 2.7 years.

Now 2.7 years, does it really sound ridiculous, isn't it sound ridiculous? Because what I have been saying so far we make landfills for 25 year, we make landfills for 30 years and here I am coming with a value of 2.7 years, this was done on purpose. This the numbers that I choose this as I said this is hypothetical scenario, the number I chose was on purpose to illustrate this point.

Actually in a classroom seating high expect the student to raise their hands that this is insane, how can you have a capacity 2.7 years? And that is because you will if you are designing something for 2.7 years it is really bad, it is a bad design because it takes a lot of effort to design a landfill and you do not want to do it for 2.7years, you would rather do it for 25 years or 27 years. So but the numbers chosen in this problem was to illustrate this point that is a as we need to think as an engineer, but as an engineer as a math this question is correct but as an engineer this numbers does not makes any sense, because 2.7 years is ridiculous in terms of the capacity of a landfill.

So just to illustrate that point and because what happened is even as I teach several engineering courses and I see people designing certain things and then they will round it off and when you round it off, say diameter of pipe came as 25.4 millimetres or centimetres and then they round it off to 25 millimetres, so you cannot do that, you can make a 26 but you cannot make it as 25 because 25.4 is what you need so you need you can go higher.

So as a math question you can make a 25 from 25.4 but as a engineering question you cannot make it as 25 you have to actually go to 26. So those to illustrate those kind of concept here the numbers were chosen to tell you that it is a bad choice of number. And in a real-world if you see this kind of data coming out you have to really go back and check your math, it should not come out.

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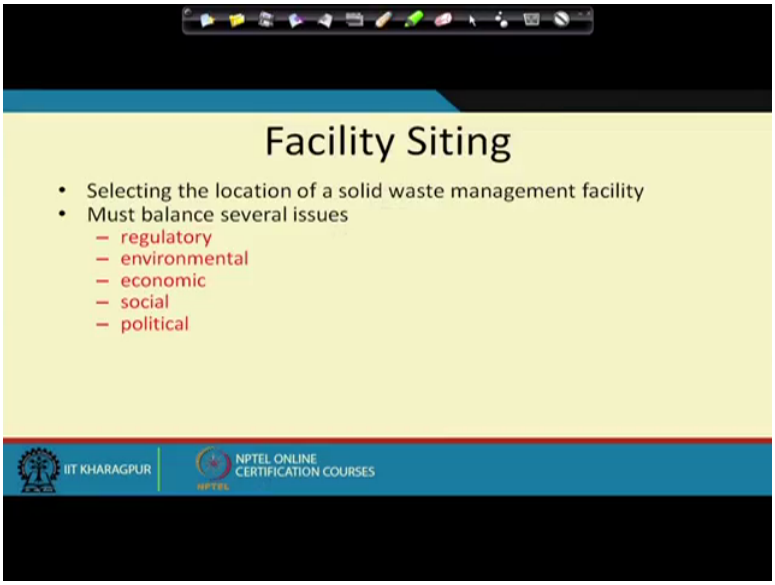

So being said that will look at some of the other aspects of, so this was some of the basic landfill design and again we will have some more math problems coming up as a example problem later on. So now we will look at into more in terms of management part or the regulation part. So when we try to site the landfill there is a facility siting we have to select the location of the waste management facility. So it is there are several issues there are the regulatory issue, there are environmental issues, there are economic issues, social issues, political issues and all those things different factors taken into consideration when we are trying to site a landfill.

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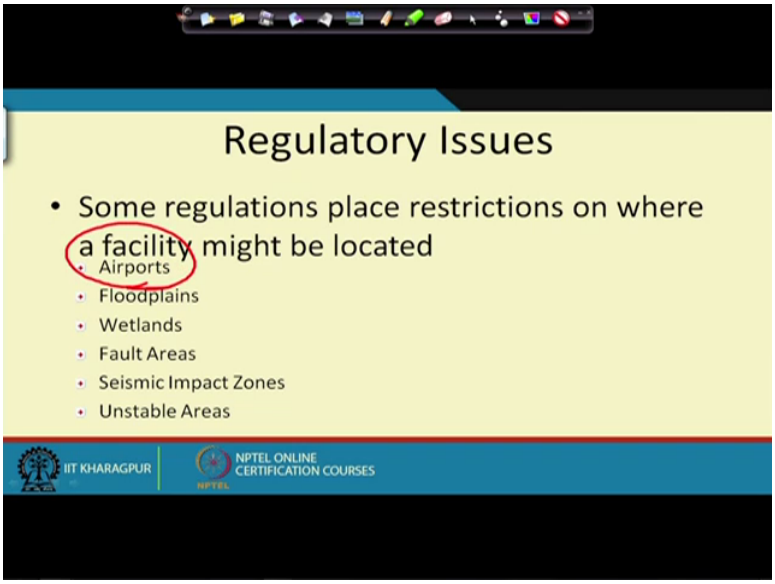

And so it is a in terms of regulatory issues, so there are some regulations place restrictions on where the facility might be located. We do not want it close to the landfill close to an airport because airport is totally no-no, we do not want it close to an airport. Not close to a floodplains, wetlands, fault area, seismic impact zones, unstable areas, so for all these different place for some it is an obvious thing we know that we do not want it near the seismic impacts zone, if sometimes we do not have a either choice we do have several dumb sites in India which is on seismic impacts zone or in unstable areas or even close to wetlands but as per regulation we should not have when we are going for these engineered landfill as per the waste management rule of 2016 it has certain restriction on where the landfills could be.

So airport why it will why we do not want closer to the airport? So if you go to an airport you have so many if you go to a land like the waste disposal site it attracts lots of birds and these birds can create a nuisance for the aeroplane flying in and flying out, so that is why we do not want it close it to an airport. So most of the stuff whenever you again I keep on saying this again and again in all the classes that I teach, whenever you have any anything put forwarded in front of you, always think about what is the rationale behind it, why we are doing it, what is why not closer to the airport.

What is the problem with the floodplain, the problem with the floodplain is that the you will have the water coming in there and the water will percolate into the landfill and then you will have the huge leachate problem and you those you will contaminate the surface water, so do not want closer to those places where it there is lot of environmental nuisance, because the job of the landfill is to have a environmental control, so we need to select those areas which are more suitable.

Wetlands again very close to a water, it is better to avoid that. Fault area, seismic impact zone, unstable areas, again those can create landslides, the garbage-slides, so you will have a huge garbage slide happening because of a earthquake or something happening in that area. So those things we need to take into consideration in terms of this that is why from the regulatory point of view we have those things in like highlighted over there.

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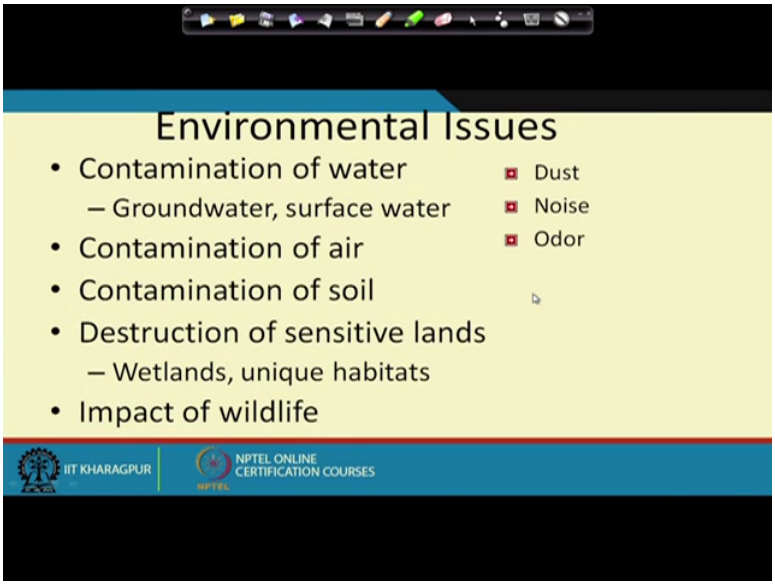

So that is the regulatory issues, and then there are environmental issues. So in terms of environmental issues we have contamination of groundwater, contamination of air, contamination of soil and destruction of sensitive land, so all those things are that that which is which we need to look at in terms of how to so in terms of there impact on environment. So contamination of water, contamination of air, contamination of soil those are very-very important. Contamination of water, groundwater, surface water and that is it is like a critical in terms of those in terms of evaluating the environmental performance.

So we have to be careful in terms of groundwater contamination, we have to be careful in terms of surface water contamination, air contamination, soil contamination and also destruction of sensitive lands, that is why we do not want it closer to a wetland, unique habitats, wildlife, dust, noise, odour, smell, so all these environmental issues has to be taken into consideration when you are operating a landfill.

So that is for a contamination of groundwater, contamination of water we have this groundwater monitoring system, we have this storm water protection system in place which takes cares of that. Contamination of air, you have gas collection system and at many places we have some odour removal system as well. Contamination of soil, especially the subsurface soil if the leachate collecting system is working properly, if the liner system works properly we should not have the soil contamination issues and we do not we have to be careful in terms of the sensitive lands, wetlands and all that and the impact on wildlife. So those things are always has to be looked into.

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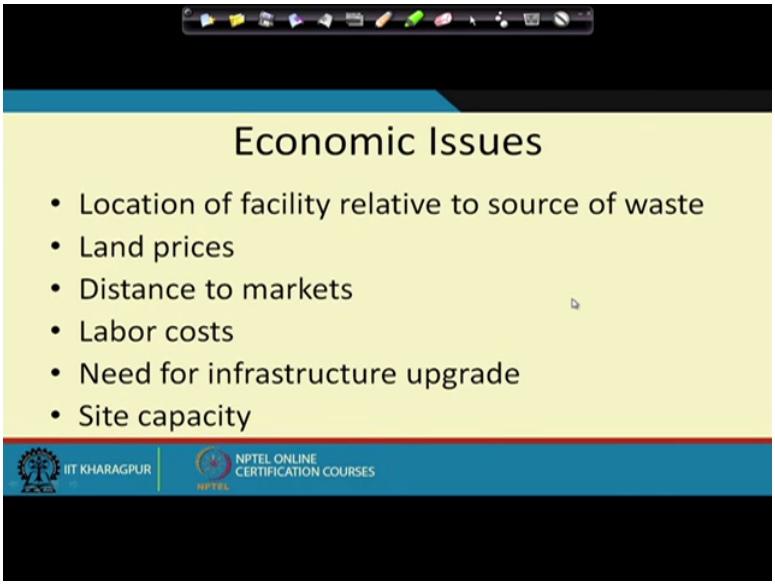

So that is in terms of environmental issues, then we have the economic issues. like you have you want this location closer to the waste because as we have been talking about the collection of garbage is one of the most to the waste collection is one of the most costly affair, so collection of the waste is one of the most costly affair in terms of as part of the waste management system.

So the economic issues, in terms of location facility related to the source of waste, the price of land and if you are producing certain material, what is the distance to the market? So those things has to be looked at. The cost of labour, infrastructure, if you have to improve the infrastructure a lot, if that site if you have a site which have some clay which can act as a liner but may not be very suitable, but you have another site which seems to be little bit better suitable but you have to spend a lot of money in terms of bringing the clay in.

So all those things goes it is impacts your cost impacts in terms of the economic issues, in terms of the and if the site capacity say if you are trying to design a landfill for 25-30 years and but the landfill you cannot design it for 30 years because you do not have that much land available. So all these land prices if land prices closer to the city area the land prices are more and if you go further from the city area the land prices are less. But if you go further from the city area your transportation cost goes up. So you have to do a very detail economic analysis in terms of for the selection of the site.

So location; how close or better, the price of the land, market distance; if you are producing if at the landfill site if you are producing the gas, so landfill gas if you are trying to have a

landfill gas to energy and then you are trying to connect it to the grate or supply to a local market, so you should have local market you are trying to use that landfill gas directly for some purposes, so gas it should be the gas should be so the market should be available so this things goes in consideration in terms of selecting the site.

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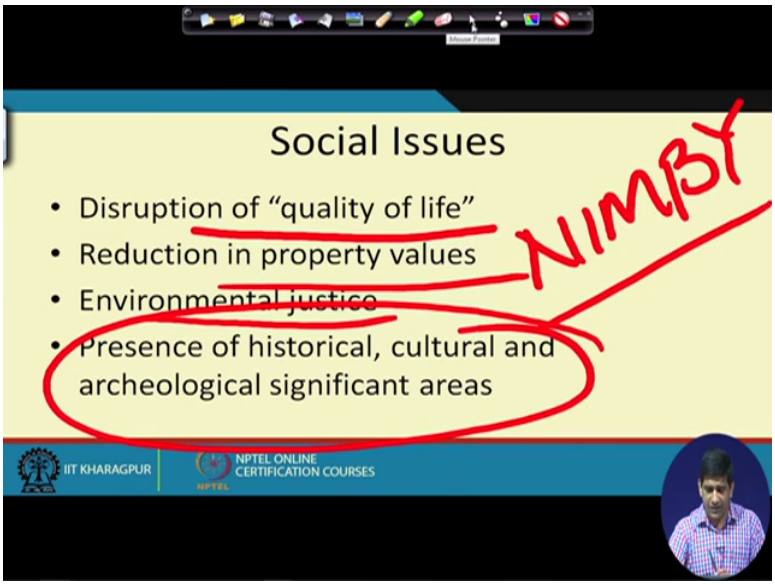

Social issues less disruption of quality of life, since people are there are around it so you want less disruption. Reduction in the property value; so if you are making closer to a place where people do not want it that is a nimby syndrome not in my backyard is one of the major reason is people do not want their property price to go down. Because if you build a waste disposal site or the waste treatment site it gets a although most of these sites can be run in a very professional way with a very limited impact on the surrounding area and if you go to a country like China they have done that and it looks and even in many-many European countries which I showed you some pictures of waste energy plants in Austria and another places which is kind of in the middle of a downtown or middle of other things happening around it.

But there is a still negative mind-set that if you have waste disposal then it will be dirty, lots of trucks and some of them is true, so lot of truck coming in and coming out, waste may be flying around and you will have a smell problem and all those kind of things, and that is what people are worried about in terms of in terms of their quality of life, property values. So that is why the NIMBY that we have been talking about which I have mentioned earlier as well that NIMBY syndrome not in my backyard syndrome is there in terms of waste disposal.

Then environmental justice, you should not throw the waste in area which is less where like a vulnerable population is, poor people are there and so that is not proper to do it. Say it is that should not be done because everybody has to should have access to like a clean air, so if you do not want to dump like that is happening, like you the whole issue of Bangalore landfill at the outskirts of Bangalore the villagers are protesting that is because that is an environmental justice issue.

Similarly in Kolkata near the Dhapa area the new settlement of many people which have moved from new town and another places to this area and that is even when you drive by the car there you smell so much, so think about people living close by. So there is a environmental justice issue also there in terms of waste management. And then you have to make sure there is you do not destroy any historical, cultural and archaeological significant areas, so those things are also very-very important.

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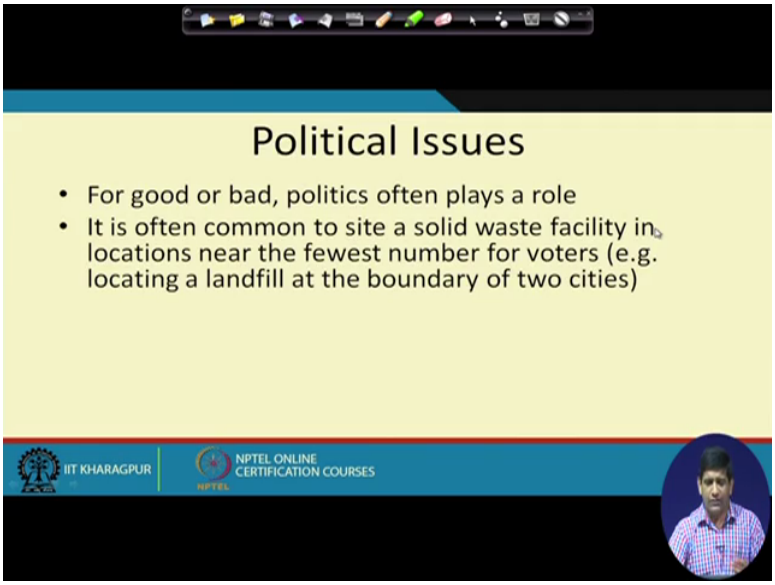

So these are different issues that needs to be considered when you are trying to select a site. And off course there is a political issue we will not talk about too much because good or bad politics play a role. It is often common to find the solid waste facility that is true globally, facility location with the fewest number of voters which is and one-way it is I think there is no problem as long as it does not impact the people, if as long as the other technical and other consideration is taken care of, because every whichever political parties is in power they will like to take care of the interest of the people which votes for them.

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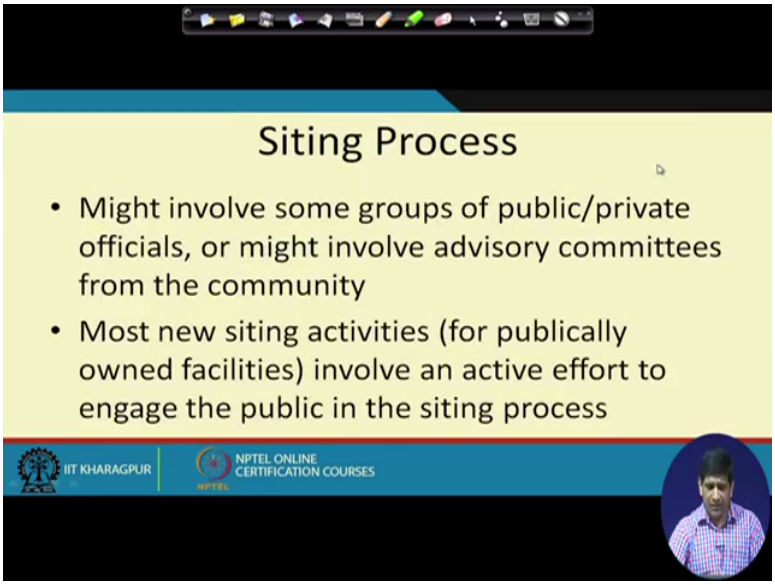

So then we will go into the siting process in the next video so let us grab this video here. So what we have been, we have been talked about in this particular video we did the math, I showed you a very simple calculation which was way of almost 25 per cent of but it was a higher number so at least you get some idea of what is the requirement of the area.

And then we did the actual calculation for the volume, we calculated the volume then we also looked at the hypothetical scenario of a C and D waste disposal, where we calculated the capacity, the capacity number was absurd. So you will not have that kind of capacity coming up, if it comes up you need to revise your design that is not. So I highlighted that very clearly in the video and then we talked about how to do the siting, so then how to select the site and we are in the kind of middle of that, so will continue that discussion in the next video as we continue. So with that let us close it here and I look forward to see you again in the next video, thank you.