Course on Integrated Waste for a Smart City
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Module 10
Lecture No 46
Landfill Disposal (Contd.)

Okay so welcome back, so we will continue our discussion that have been doing on the permitting process, the design process, as-built drawings. Now we will get into the more details about the design process and then spend little bit more on the construction process because that is many of us does not have experience especially if you are an student who are still in the college and other stuff, you may have done internship but it is how what how the things happens at the construction site, so that will be useful information for you to have.

And although this information is being given under this landfill disposal chapter you can think about but it is not only for landfill it is true for any of the waste management facility for that matter any of the environmental facilities and if can go beyond many of the things that I am talking about is true for any construction activity. But I will but most and especially for environmental facilities it does not matter water treatment plant, waste-water treatment plant, air pollution control system or landfills these are all true for that.

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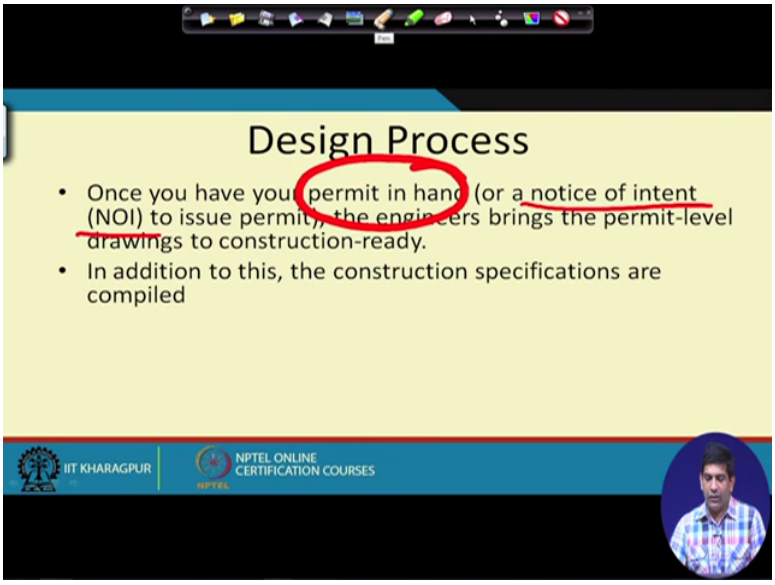

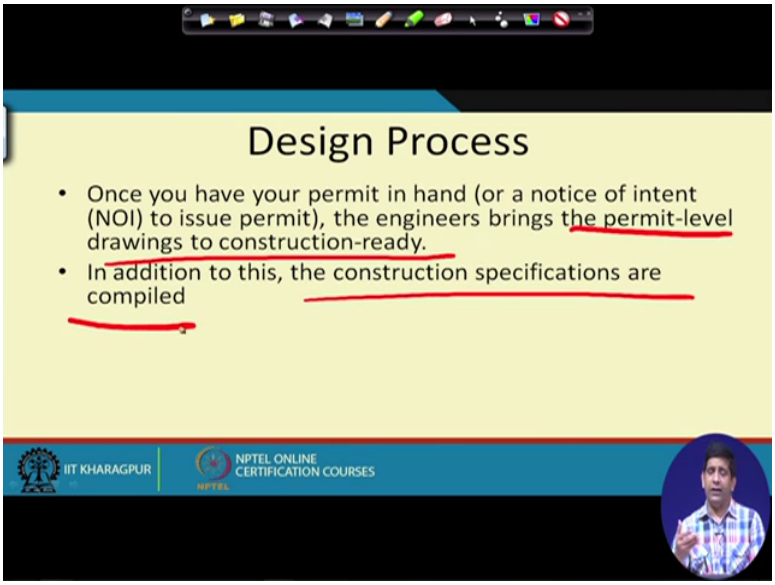

So coming back to the discussion that we are continuing, so we talked about the permitting process, we talked about the as-built drawing and then when we do this as-built drawing we have I basically do the design, isn't it? First you have to design then you then only you will produce the drawing. So once you have your permit in hand, once you get the permit you have received the permit from the permitting authority or a notice of intent or NOI which is again the same thing to issue permit.

So if you get the NOI to issue permit saying that you will get the permit in few days or few weeks. The engineer brings the permit level drawing to construction level drawing, so you start going from this permit level drawing to the construction ready, construction ready drawings have to have all the details in more details so that people can do the construction. In addition the construction specifications are also compiled to make a construction

specification, what kind of kind of material has to be used and all those details, the bill of materials, construction these things needs to be worked out and they are specified, they are specified they are compiled, so that is goes along with that.

One thing what happens is especially if the design team and the construction team is separate although they may be from the same company, but many times the design team for example, when I was working as a consulting engineer in Delhi in EIL engineers India Limited, we had a design team sitting in Delhi for MRPL phase 2 and then we had a construction team at site MRPL at Mangalore site.

Many times what will happen it will send the specialist since it was a phase 2 construction drawing was not very proper, so in that case what was happening is we had the issue of we will do some modification to the design, we will propose something in our design even the like a basic design process, but there will be issues on-sites then the letter will come to us, that those days there was not much email culture was not that popular so we will get a fax and then we will many times the fax will not be clear, things will not come very legible on the fax and then we will try to guessitmate that what they are saying, maybe call them on the phone and try to understand and then try to redo the design and send it back to them but then they again find that there is a problem.

To overcome those problem I do not know what is happening today in the industry but some of you may should shed the light on that those who are connected with the industries right now. But Indian context, but in global context what is happening and that happened even for MRPL project and also for some other projects and during that time with EIL that they made a mobile design team and people like me who are still bachelors at that time we were not married so we put on those mobile design team and we were taken. So we went to the sites and we were trying to solve this design problem at the site itself so that time is saved, so that is because client wants work done to be in a as per schedule. These days there are a lot of penalties if you do not meet the schedule and so those that was done.

So what you do once you have the permit ready you permit approved you get this permit level design drawing and go for more detailed design and then you do the detail design drawing for that. So that is the design process when you produce, at the end of design process what you produce is those drawings, drawings and specifications so that is the output of a design process.

So as a design engineers ultimately what you produce is a drawing and engineering drawings and also the specification, so that is why the engineer when you say engineering drawing, I teach engineering drawing class as well to my first years here at IIT Kharagpur. Engineering drawing is our language it is the language that you need to understand each other, so that is actually very-very important aspect of a engineering degree to understand those drawings that is very-very critical, so you can understand what the drawing is trying to convey.

So once the design processes then you go to the construction process, so once now that drawings are ready to start construction, construction job will be competitively big. So what we do? You bid the construction, so once the design documents are ready you have a technical you start you do a bidding process.

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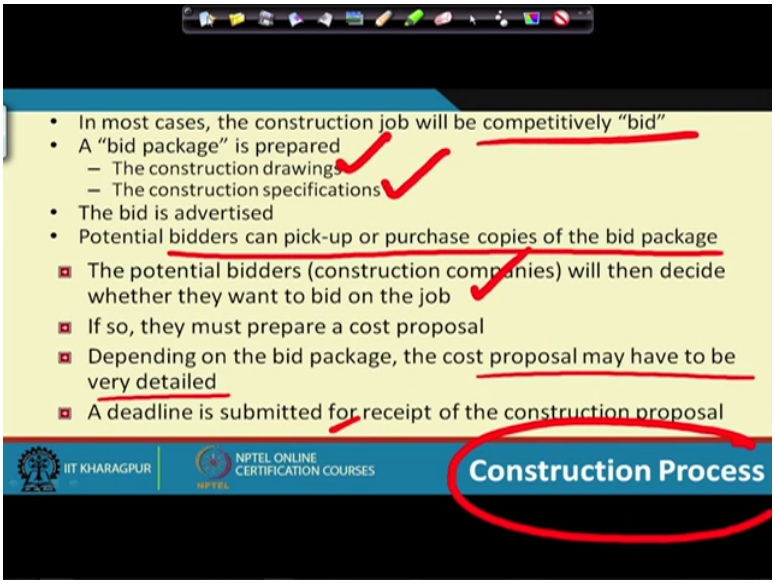

And as part of the bidding process you will have you will as part of the construction process first thing you will do is have a competitively bid of the construction. A bid packages prepared, so what you bid package will have the construction drawings and the construction specifications, so that is you will have those, you will advertise the bid. The potential bidder can pick up or purchase copies of the bid package, so they can do that. And the potential bidders which will be the construction companies will then decide whether they want to bid on the job.

So and so they prepare a cost proposal, so how much it will cost to construct that, depending on the bid package, the cost proposal may have to be very-very detailed. So in terms of and then the deadline is there in terms of receipt of the construction proposal, so you have a

deadline how and when you receive this construction proposal in terms of your like a for the bid evaluation, so you have a this construction proposal coming in.

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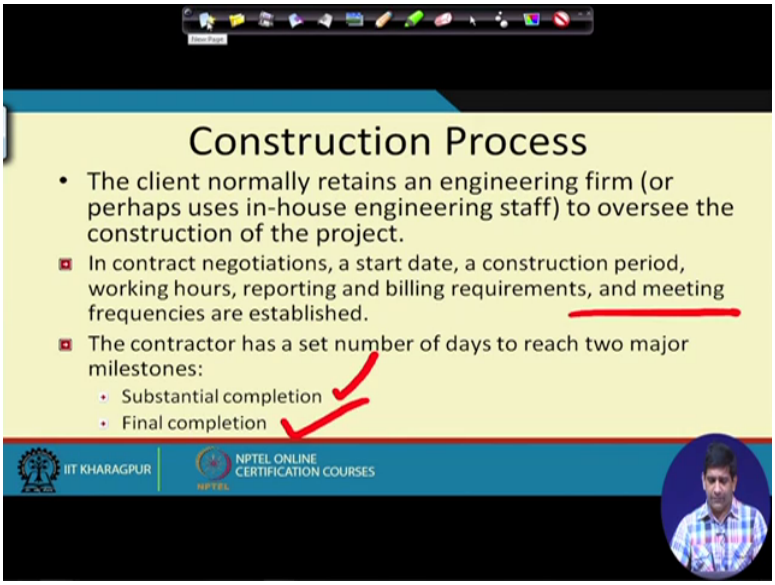

So once this is done the breeds will be reviewed by the engineer and the client, so engineers could be part of the client, like part of the client team, they have their own engineers or you may mostly this engineers could be those consulting companies who helped with the design process. And then the top bidder will be selected which top bidder this may not be may or may not be the lowest bidder, because there are a lot of other things is there as well because it has to meet they have to meet certain technical specifications and their qualifications, their experience, whether they have worked on similar types of job, so there are lot of conditions there and then you come up with those bidding. And the client engineer, the contractor then has to negotiate a contract, so you come up with a contract in terms of timeline, in terms of the payment schedule and all those different things so that they have to do.

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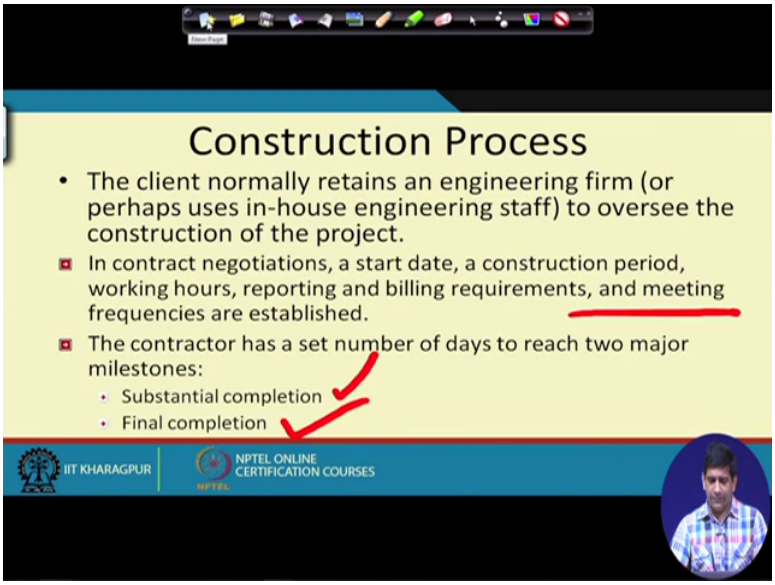

So the client normally what they do they retain the engineering firm or perhaps use in-house engineering staff to oversee the construction of the project. So there would be a project management consultant kind of PMC. So they will do this either the engineering firm which did the design, they can continue be there as a to help to oversee the construction of the project, I have seen that happening my times.

In contract negotiation what you will do? You have a start date, you will have a construction period, working hours, reporting and billing requirements, and all those things have to be worked out, meeting frequencies, these things needs to be worked out. The contractor will set a number of days to reach milestones, like substantial completion, final completion, so those things will be there, so there would be days where they have to reach this milestones and other stuff., so that is the part of that .

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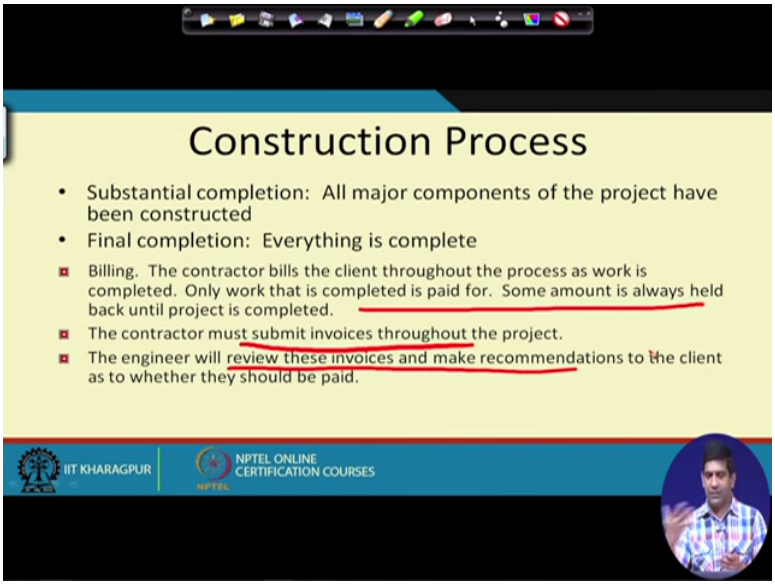

And substantial completion means all major components of the project have been completed. Final completion means everything is complete, so all the small-small like electrical works and all whatever many times even for a small building when they are constructed you see that although the structure of the building is ready but there are lot of work going on almost it takes several months to get all those like AC system and wiring, electrical wiring, plumbing, so there are a lot of small-small works that goes and those works takes time because you do not and it feels like it has been taking long time because you do not see the progress.

When the construction is going on when the structure is built you see level one, level two, level three floors are being built, so you see the progress physically, but the facilities of wiring, AC and duct and this and that, that does not really show much progress because it is happening within the same structure, so it seems sometimes too long. And the billing the contractor bills the client, so there will be billing to the client throughout the process is the work is completed. Only work that is completed if paid, some amount is always held back until the project is complete.

The complete contractor will submit invoice throughout the project, the engineer will review these invoices, make recommendations to the client whether they should be paid or not, that should be paid, so those roles you have to do as working as engineer in EIL we had to do these kind work as well especially when I was at the construction site.

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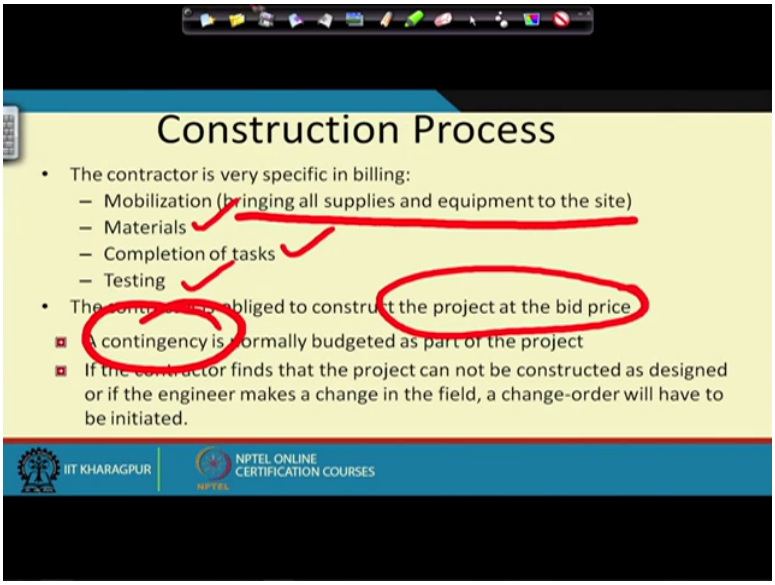

So and then the contractor will be very specific in the billing, many times it is all depends on how you negotiated the contract and the mobilisation. So mobilisation they get some money for that bringing supplies and equipment to the site, the materials, completion of task, testing and those things is done. The contractor is obliged to construct the project at the bid price unless you can always go and ask for more price in case something delay has happened. But if the delays happen from the client side they request may be looked into but the delay is happen from the contract side it may be refused that it is normally maybe refused and then the contract has to build the things as per the code that they have submitted.

So for that many times what they do they put a contingency, there is a contingency is normally budgeted as part of the project. So if the contractor finds the project cannot be constructed or as designed or if the engineer make changes in the field, a change order will have to be there, so you can you have to initiate a change order. So because of any change in design based on what was submitted earlier as part of the bid package. So the construction company has a right to go for a change order and then if the change order is approved the price will also they will have some additional cost for that.

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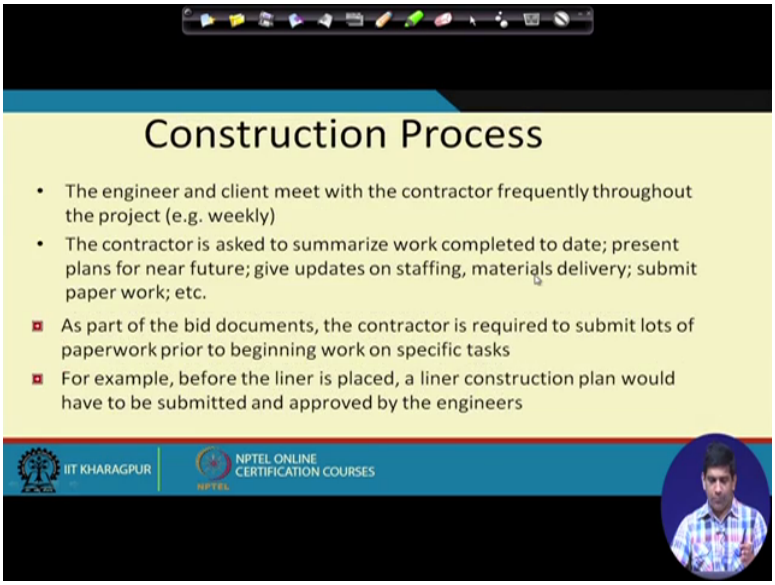

So then the engineering and client will meet with the contractor frequently throughout the project, there is a weekly meeting contract asked to summarise work completed, present plan for near future, brief update on staffing, material delivery, submit paperwork, it is basically you do all sorts of things that like a construction supervision and the quality assurance, quality control all those things needs to be done. And as part of the bid package the contractor has to submit lots of paperwork prior to beginning work on specific task.

For example before the liner is placed for the landfill a liner construction plan has to be submitted. So there has to be a liner construction plan, how the liner will be constructed? How this clay will be compacted when you act as you remember that I told you that they will add some moisture to increase to get that optimum moisture content so that you can have a compaction better, so how the moisture will be added after compaction how the testing will be done which lab will be contacted for testing, who will do the test, and then after you put the liner HDPE the welding, the welding has to be tested after welding and everything is done in the next level you go for piping, so for piping you have the pipe material, pipe schedule so all those different things you need the details.

So contractor will submit all these details prior to starting the construction over there and as a construction engineer or as a consulting engineer helping the client your role will be or your role could be on the construction site too. So depending on the which role you have either you will be preparing all you will reviewing all these details to make sure it is done properly as per the design, so that things meet the required function which is supposed to made.

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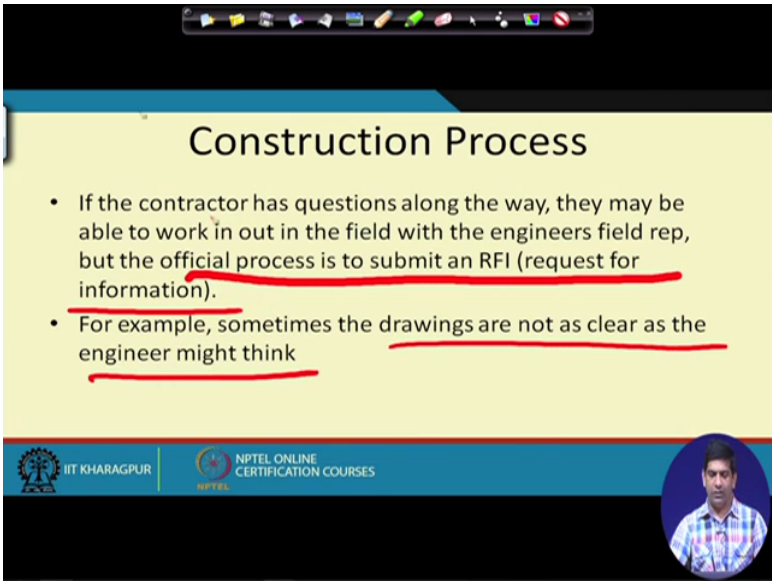

Questions along the way, they may be able to work out in the field with the engineer's field rep, but the official opposition submit an RFI. So if the contract contractor has some questions they can usually you can have a informal discussion as well but if there is something substantial which you want to document for later on for billing purpose and other stuff. It is there is official process is submit an RFI, so your request for information.

For example, sometimes the drawings are not as clear as the engineer might think, so there is might be certain confusion on the drawing by the construction team. So they can submit a request for information and the engineer, resident engineer the client side will help resolve this question, so that is those things does happen in terms of construction process.

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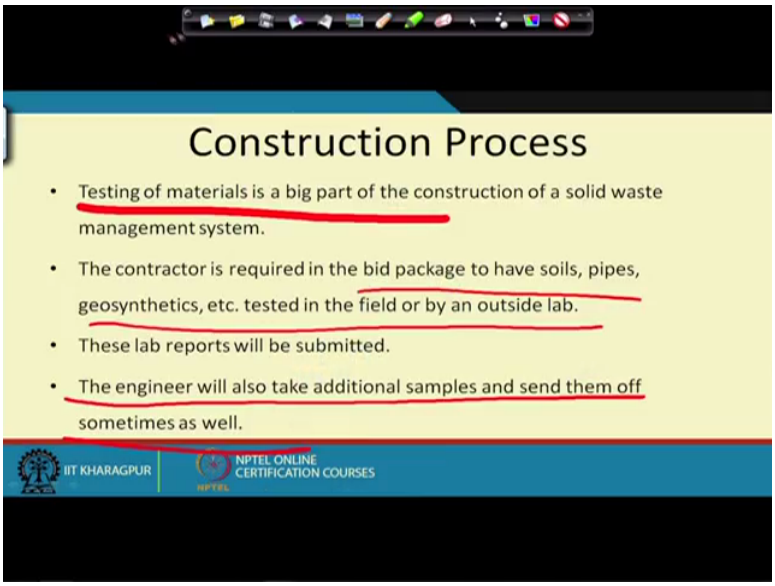

So and then the testing of material, that is again kind of I hinted that during the liner construction discussion that we had just a few minutes back, testing of material is a big part of the construction of a solid waste management system, so testing is we do a lot of testing of the part of the material. The contractor is required to have in the bid package to have soils, pipes, geo-synthetic, etc. tested in the field or by an outside lab and that lab is has to be certain certified lab then it cannot be the lab that which the contractor construction company we can just pick, it has to be agreed by client that lab will be used, so these lab reports need to be submitted.

The engineers from the client side can also take additional samples and then sent off sometimes as well, just as a crosscheck and that is always a good QA, QC, quality assurance, quality control practice to check whether the lab which you are sending samples to and if you send it to some other lab whether the results are matching are not, so that is always a very good idea because most of the construction what you are doing it is like a multi-million dollar project you want to make sure the things are done properly.

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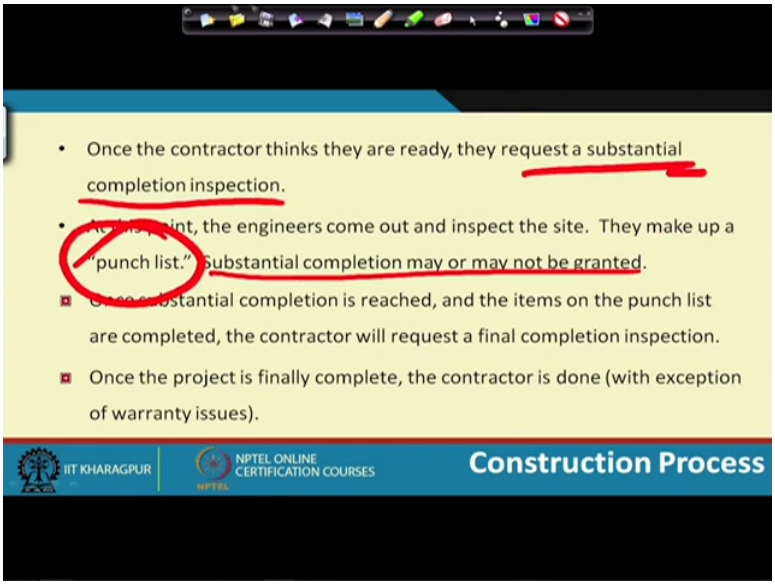

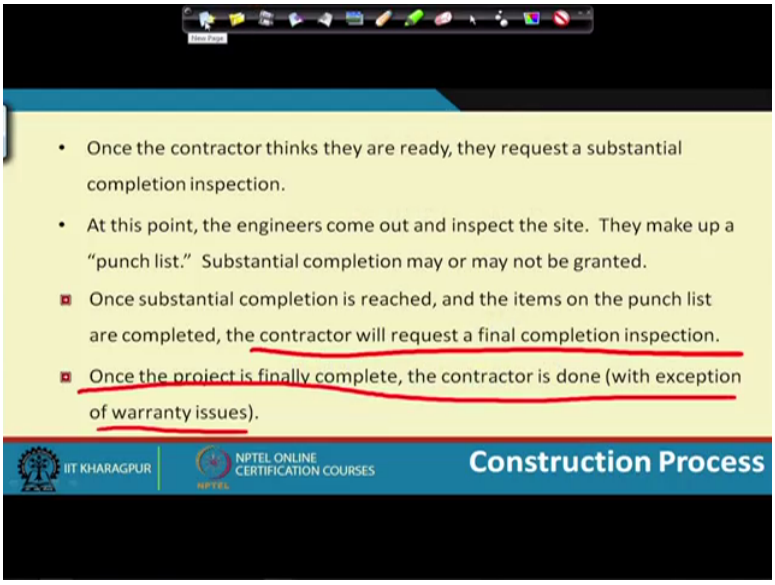

So testing of material it is a huge component of solid waste construction of solid waste management system or any construction. So once the construction once the contract thinks that they are ready they request for substantial completions inspection. So there will be substantial completion inspection, that is they will so the engineers will come in and they will inspect the site they make up what is known as the punch list.

So the punch list is which has a list of stuff which is still left to be worked on so there is you will write down each and every item you go through each and unit and write-down for different items what are the works still left, so that is called the punch list. And based on how big the punch list is, what is the status of the construction, you may give substantial completion or you may not be it may not be granted.

So if you are like a if a project management engineer from that client side it is you will go through their stuff and based on the punch list if you feel like it is not substantially completed, feel like means it cannot be just your gut feeling you have to go by the rules and go why the practice and then you can come up with whether it is a substantial completion or not. Once it is reached once a substantial completion is reached the items on the punch list are completed then the contractor will request for the final completion inspection.

So once they have gone through the punch list, they have addressed all those issues, so when the project is finally complete, the contractor is done with the exceptions of warranty issues. So usually they will be like 6 months, 1 year, 2 year, 3 year depending on the project, different project has different and what there in your bid package what you have agreed as

part of the contract, so that is it is once that your final project is complete and but there is a warranty issue there.

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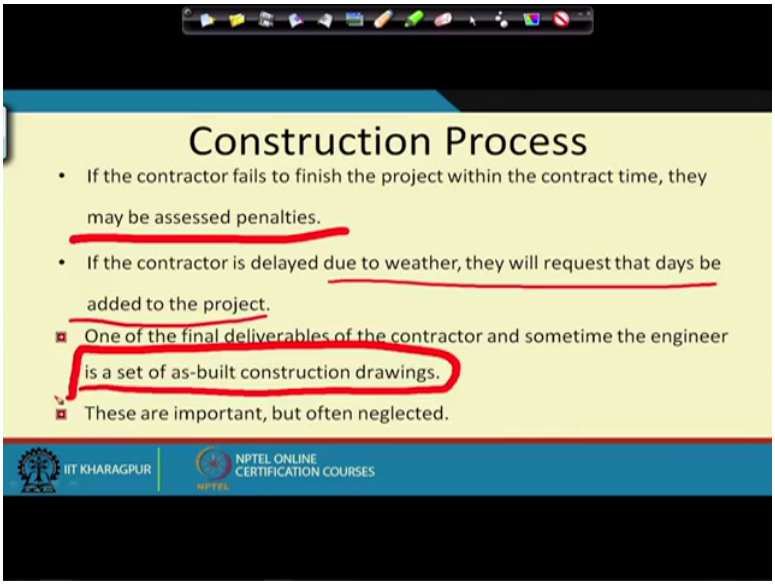

So if the contractor fails to complete the process within the contract time, they may be assessed penalties. There might be penalties if the contractor is delayed due to weather, they will request days added to the project. So that because of anything unfortunate event that maybe they will asked for request that days be added. And then one of the final deliverable of the product and sometimes the engineer is set of as-built construction drawing which we have been talking about earlier as well in the last video.

As-built drawings are very-very important especially if you want to go for the next phase of expansion which will happen at some point of time in future anyway. These are very important but these are often neglected, because what happened is you are kind of at the end of project you are so tired by the time then you feel like that okay so that is you are you get more relaxed then it does delayed it does get sorry it does get neglected and that is which we try to avoid that as a good construction practice because since next phase when you go for an expansion those as-built drawings are very-very important.

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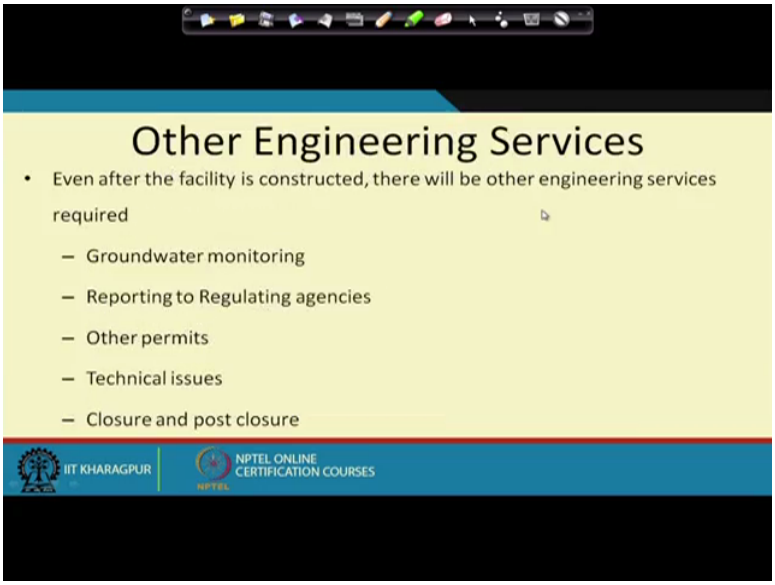

So there are other engineering services which is used in terms of good solid waste management facilities, you will have groundwater monitoring, which we talked about in the landfill true for other facilities as well, reporting to regulatory agencies, other permits, technical issues, closure and post closure we talked about that as well for the landfill, so there are other engineering services which is required in terms of any solid waste management facility specially for landfills.

So that is I was kind of giving you a big overview of how construction a process how a design like a project, it is more like project management basics for a more focused on landfill bit discussion since it is part we are talking about in the landfill but it is this concept is the same for whether you go for the composting anaerobic digester or waste to energy, some of the terminology will change but most part it will be the same.

So that is having done that some of the aspect of landfill is still left which will I will try to cover in rest of this video, one of them was to predicting the leachate generation, we said that we will predict leachate, because now you are doing this construction we talked about all this construction has to be done you have to do one of the construction was the leachate collection system.

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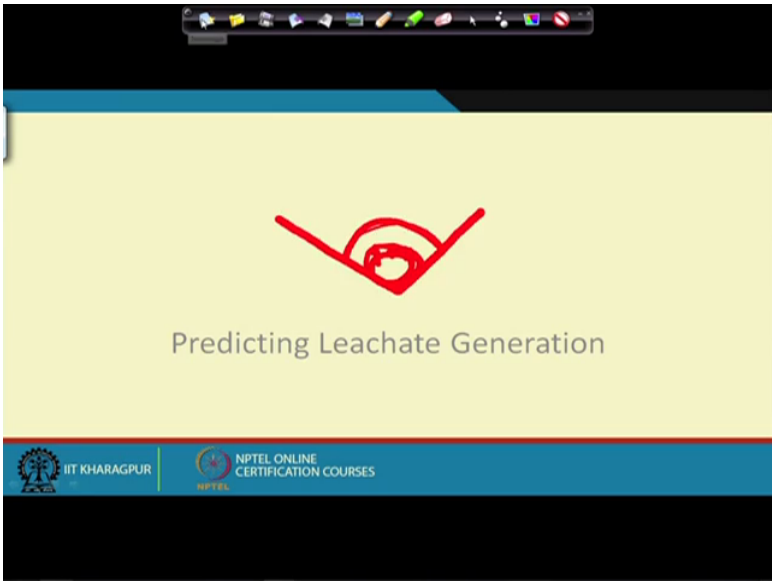

So that leachate collection system if you think about the leachate collection that we had we are talking about like a saw tooth design. So saw tooth design where you had something like this and then you had a pipe in the middle, the pipe has a perforations we talked about, there was a geotextile on top. So now how to know what is the pipe diameter? How much pipe we need to use? We that we need to first predict the leachate generation, how much leachate is actually produced. So based on the leachate generation we will know what would be the how much would be the diameter of the pipe, so how we do this leachate generation calculation? What you do is essentially a mass balance for water, so we call it a water balance.

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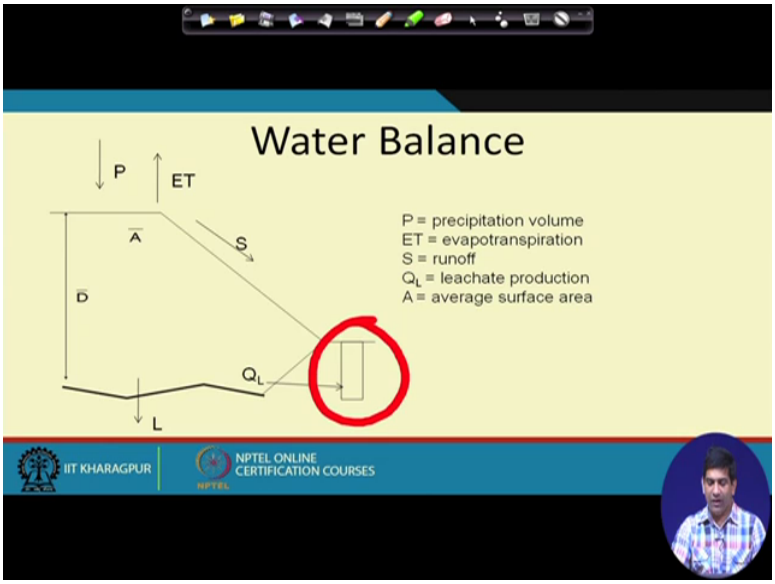

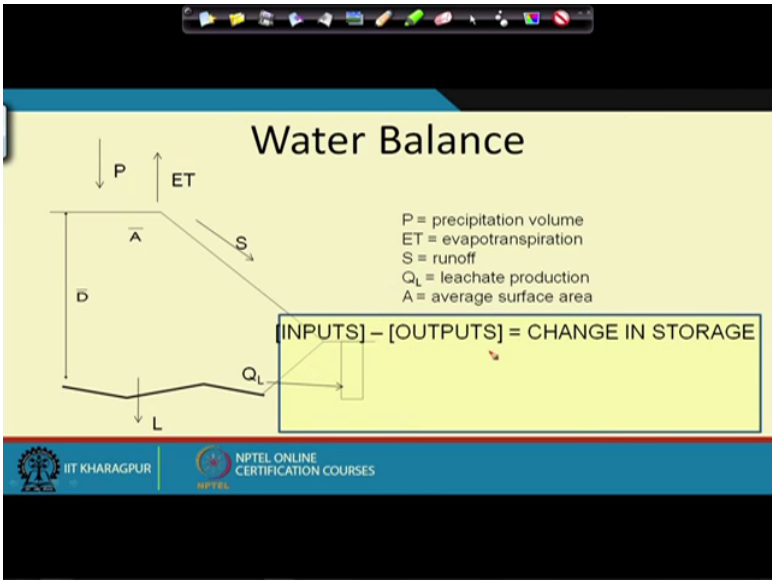

So say if this is a part of the cross-section of the landfill and then on the side here is our leachate sump, we have leachate sump right here and but we are what you are trying to do is we are trying to find out in terms of so we have a precipitation, that is P coming in, then we have some evapotranspiration going out, we have surface run-off which will go through the system, you will have some leachate that is produced that as spell as QL, then we have some there might be some leakage, if it is a well good design, engineered landfill nicely constructed there should not be an issue but theoretically yes, L is possible, L could be 0 in most cases but it is possible.

So P is precipitation volume, E is evapotranspiration, S is the surface run-off, QL is the leachate production, A is the average surface area that we have. And so in terms of the calculation what we can do is, input minus output is the change in the storage, we know that. So all the input that is coming into the landfill and all the output which is going out of the landfill if you subtract that, that gives us what is the change in storage in terms of the landfill.

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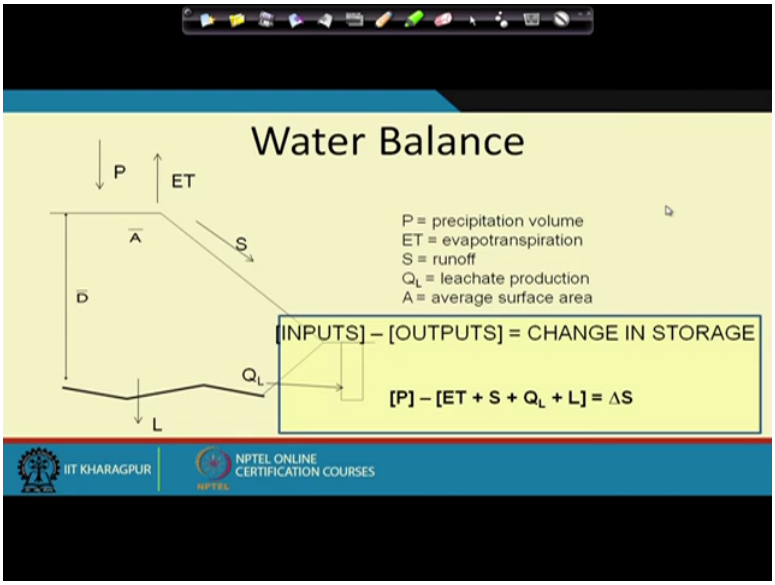

So here P minus P is the input minus evapotranspiration so in terms of in the bracket we have surface runoff is also going off, leachate is going out of the system, leakage is also going out of system, so if you do that that is your delta S, delta S is what is being stored inside the landfill.

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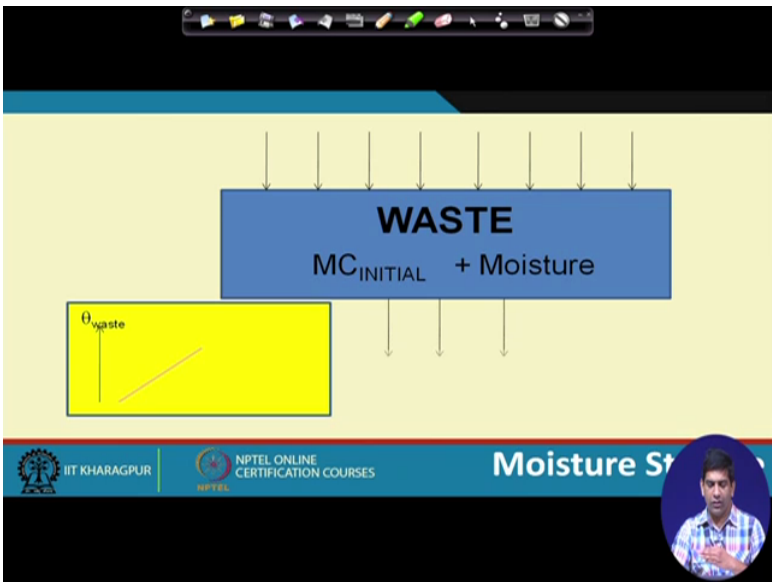

So waste we have some initial moisture content so you add some more moisture will be added to it because of the waste degrades, it produces moisture, there could be a rainfall which has going through and then as the waste moisture content goes up there is a point that after that it cannot really hold the moisture and that is it is called theta FC, theta here is showing the moisture content in a volumetric terms.

So it is a volumetric moisture content which we talked about earlier as well as in this part of the characteristics slide that you can express moisture content as a volumetric moisture content, which is a theta, which is volume of water divided by the total volume. So theta FC is the field capacity, it is the maximum moisture content that the garbage can hold against gravity, so anything more than that you will start leachate leaking out from that waste stream.

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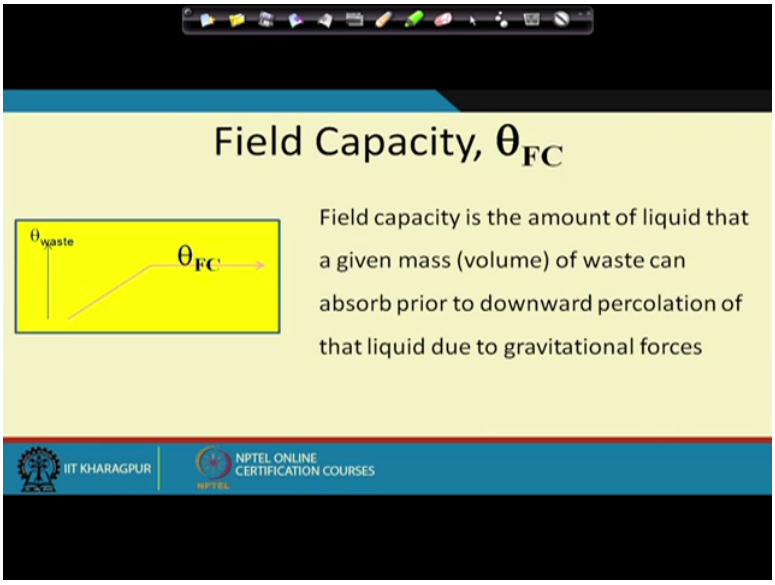

So we have to the field capacity is the theta FC, where the field capacity is the amount of liquid at a given mass of waste can absorb prior to downward percolation of that liquid due to gravitational forces, so that is what I was trying to explain. So it is you all the pore spaces are filled up and then you have the gravity is being applied to that media, so once you see the first drop of water coming out that media cannot hold anymore, that is the moisture content at that for the media is the field capacity.

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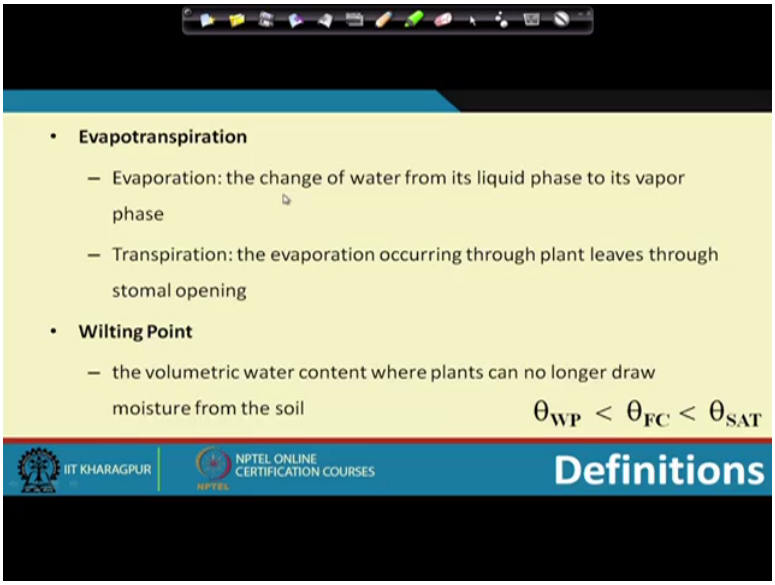

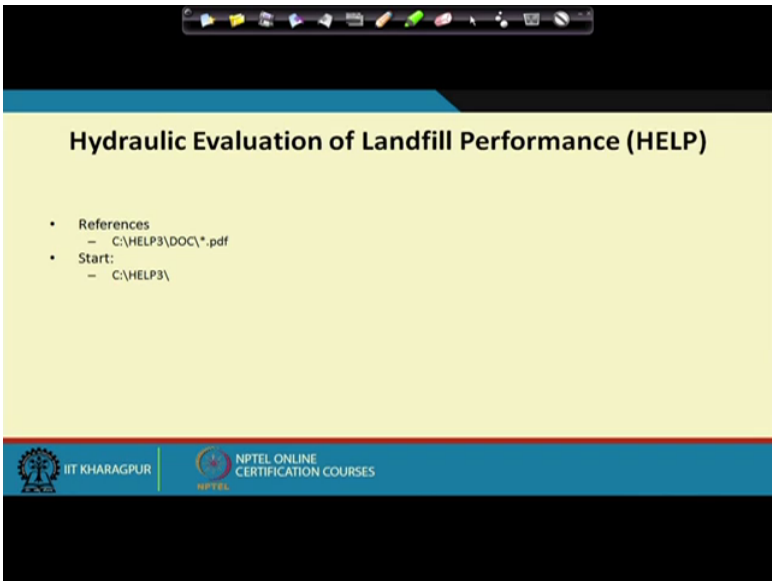

Then evapotranspiration is the change of water from its liquid phase to its vapour phase. Transpiration is the evaporation occurring through plant leaves through stomal opening. Wilting point is another moisture content which is the volumetric moisture content where the plants can no longer draw moisture from the soil. Then there is another thing like it is a whole information that we are talking about this mass balance model for the water they can be done through a done by doing it in as excel spread sheet and other stuff we have a model which is called help model which is the hydraulic evaluation of landfill performance.

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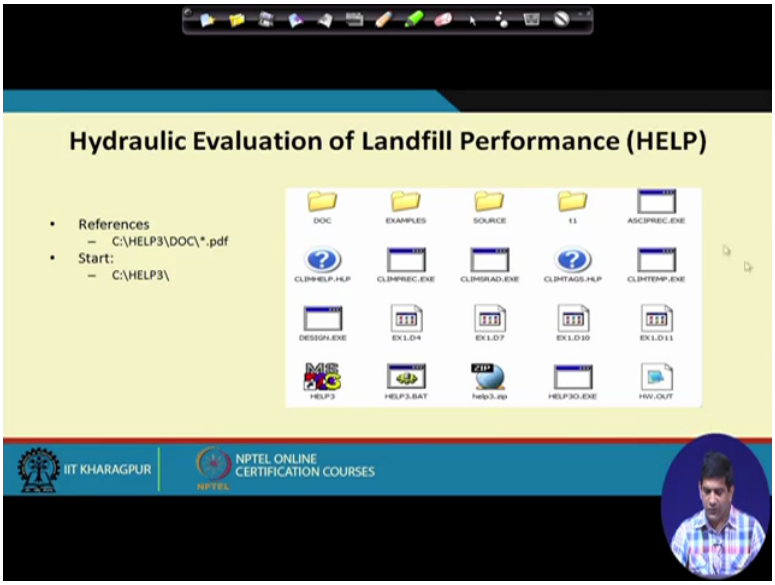

So if you go online and try to you can download this help model and I think previous versions are available for free. Develop by army core of civil engineers so they have done this development of this model. So in terms of how you can start from this model this is how once you install it this is how the software looks like, it is still a old version of software works on MS-DOS. This is that it is a free version the newer Windows version I think it costs some money and if you want to get that.

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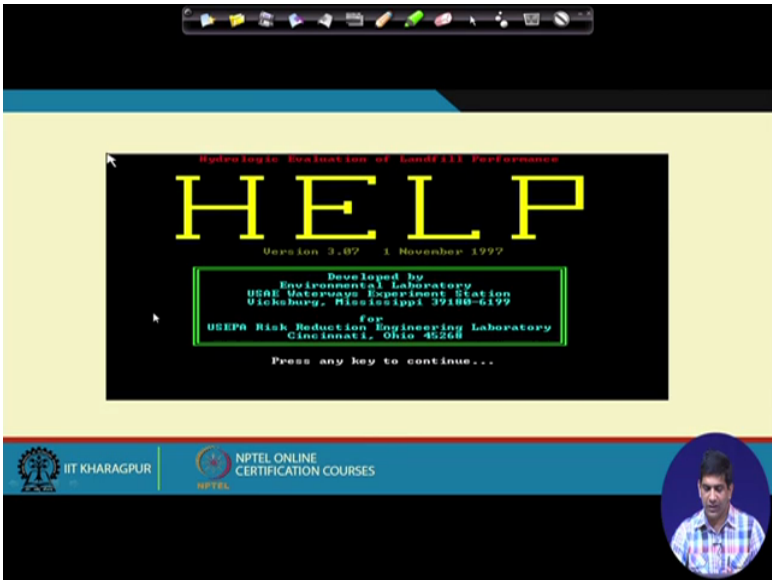

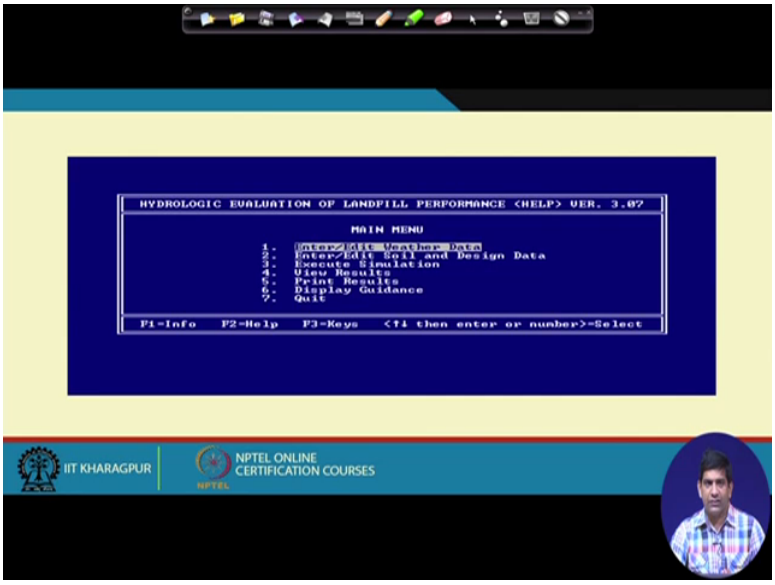

So you start with this particular file and then what you get is something like this which is hydrologic evaluation of landfill performance. It is developed by US army of engineer's long back, and then it was actually done for US CPA. So here as you can see you have several you can several data that you need to enter, you need to enter the weather data, you need to enter the soil data, design data, execute the simulation, give the results, print the results, display guidelines and you may have to come back and redo it so those that is how it is done

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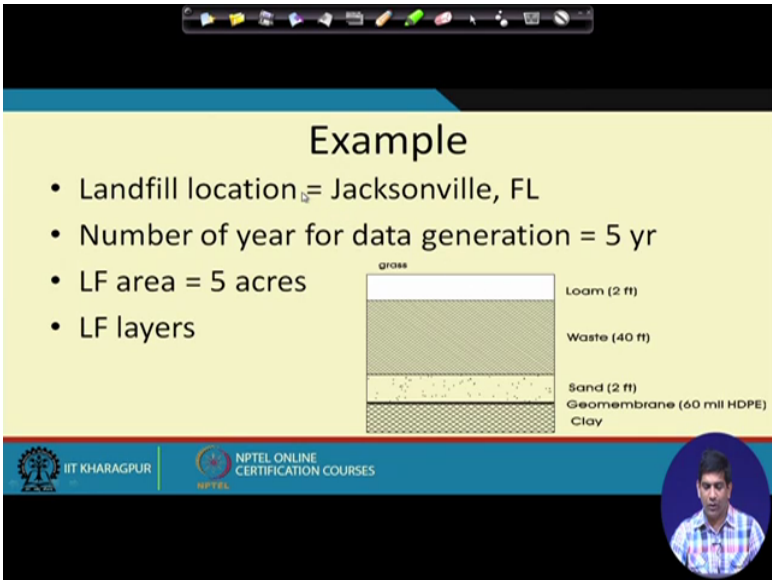

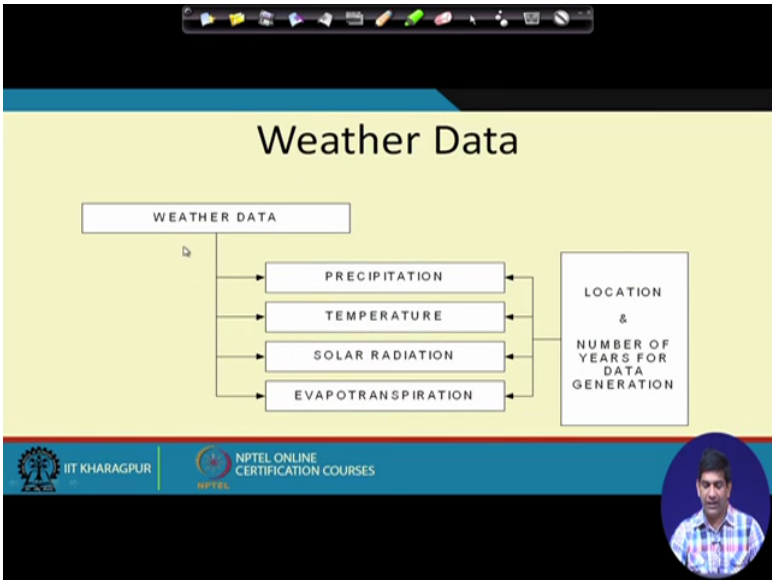

So look at one example, so this is one location Jacksonville which is in Florida. So if you have the number of your data so if it is 5 years, landfill area is 5 acres we have different layers of the landfill, loom, waste, sand, geo-membrane clay, so this is all is there. So we can get the weather data, the precipitation data, temperature data, solar radiation, evapotranspiration, so we can get location and number of years of data generation.

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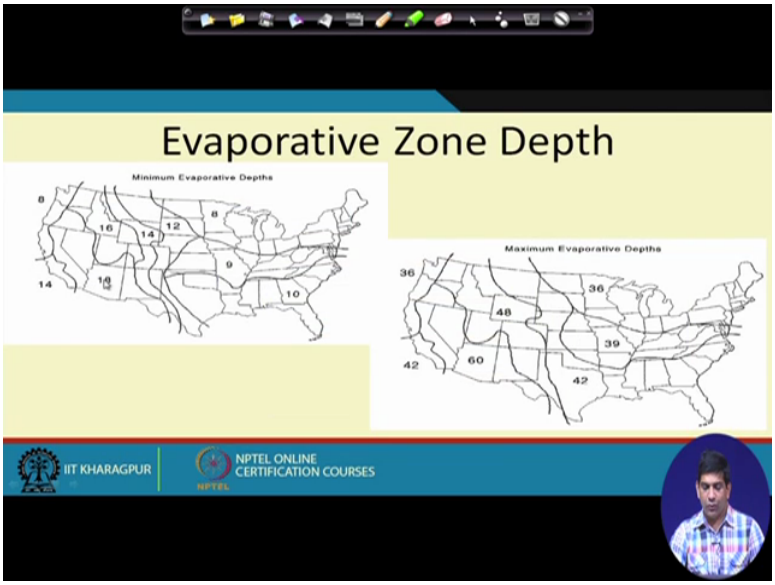

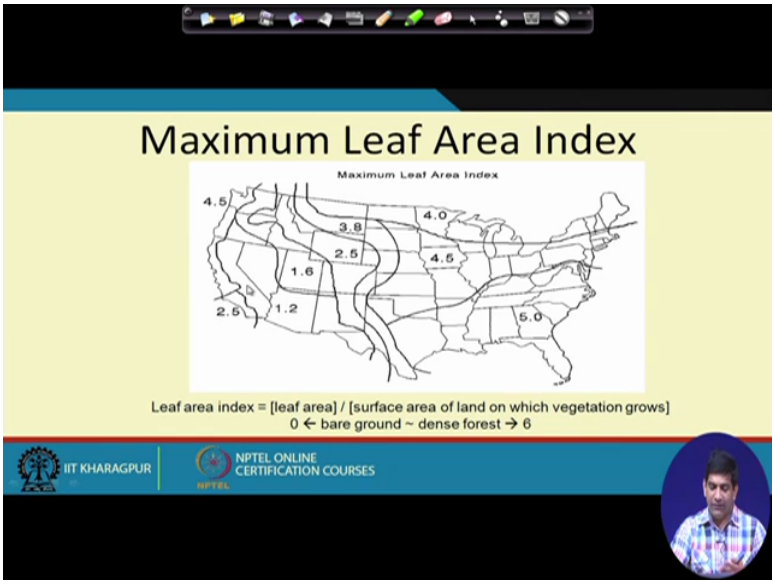

So in terms of the evaporation zone depth every country has this kind of map crave you can find out what should be the zone for certain area of the country and use that. So there is a maximum leaf area index, why it is important? It is important for evapotranspiration. So again what is leaf area index which is leaf area divided by the surface area of the land on which vegetation grows. So it is 0 for bare ground, 6 for dense forest, so other things will kind of in the middle, so you use that as well.

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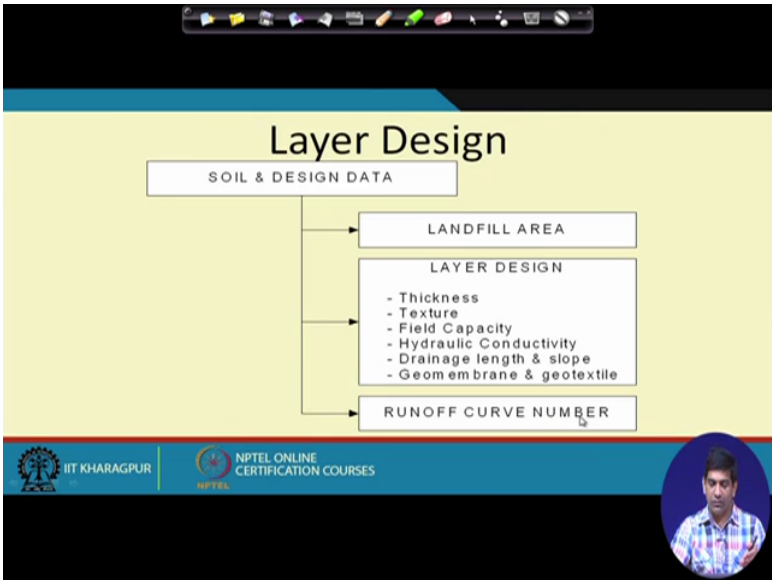

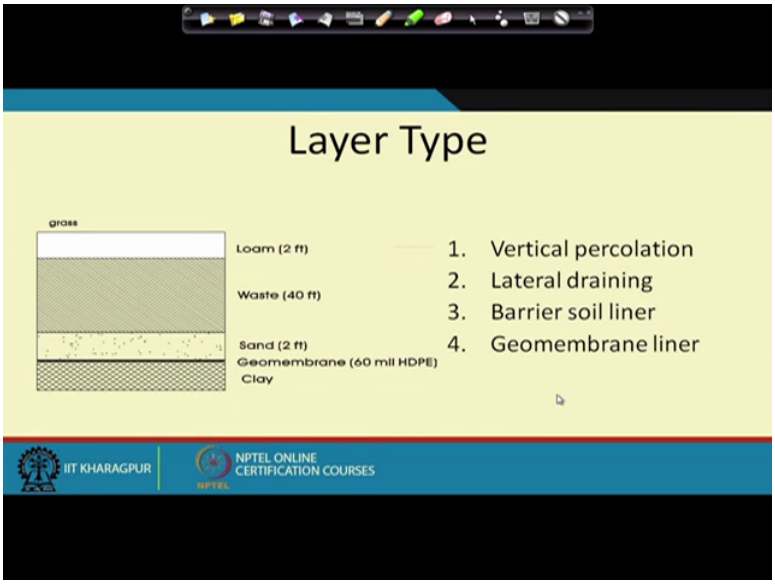

Then you have the soil and design data which you have the landfill area, you have the landfill design in terms of the thickness, texture, feild capacity, hydraulic conductivity, drainage length and slope, geo-membrane and geotextile, run-off curve numbers all those value you need to have there. Then layer type it could be vertical percolation, it could be lateral training, it could be barrier soil liner, geo-membrane liner, so those are different layers which is available.

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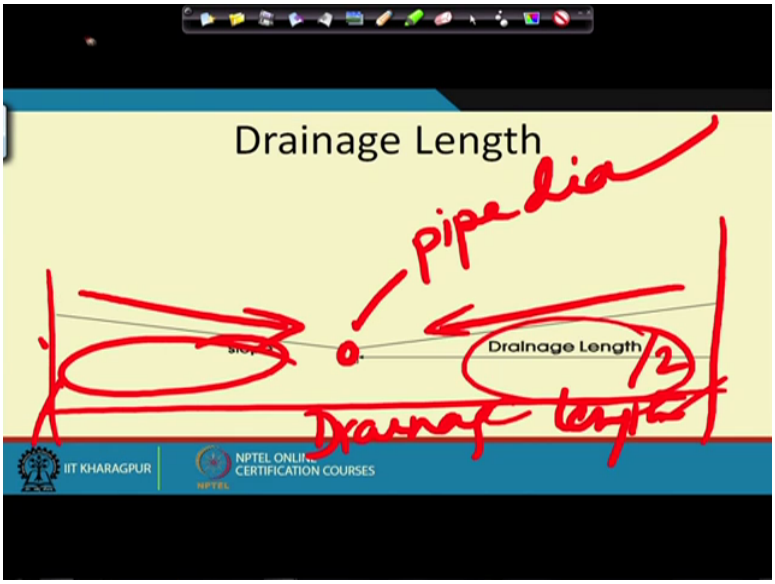

So based on these conditions what we are and we also look at the drainage length so our pipe is sometimes actually is in the middle over here, so the pipe is will be in this particular point and we have the leachate coming from here, we have the leachate coming from here, so that is your length, catchment length actually, that is the drainage length this is the drainage length

of half and then the similar drainage length is on the other side so it is you have half over here similar half is over here, so total this is your drainage length. So this based on drainage length and the amount of leachate coming into this drainage length, we have to decide what should be the pipe diameter.

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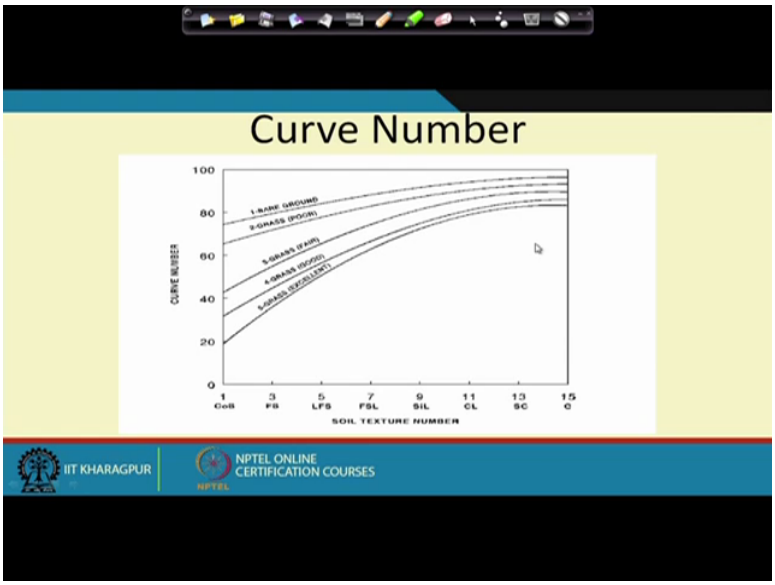

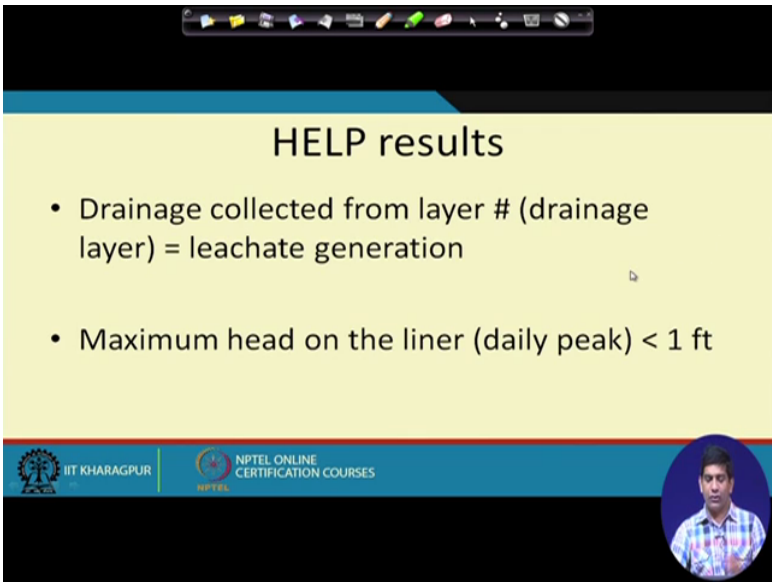

So those are done based on that, so you have this drainage length you have this curve number, soil texture curve number, you need you get all these information that different USD classification, also porosity, field capacity, wilting point and all that saturated hydraulic conductivity. So you get all these values, you insert this in this help model and then it gives you the amount of leachate generation and then we have to design in such a way so that maximum head on the liner daily peak should not be more than a feet. So when we run our

help model our one of the criteria is to not to have more than a feet on head of the liner, so that is the important that is how we do iteration.

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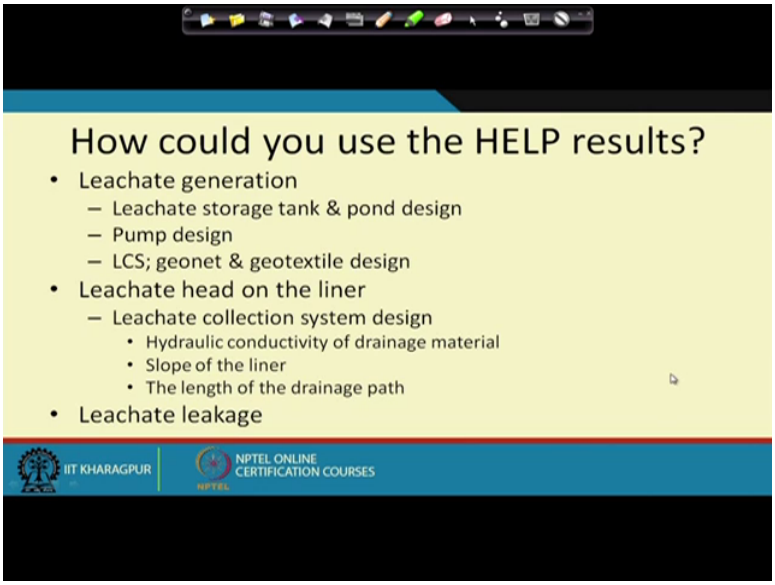

So how what you could do with the help results? You can look at the leachate generation it helps in designing of the leachate collection system, helps in the geo-net and geotextile design, pump design, leachate stored tank design, leachate storage pond design, so all those things are important. Leachate head on the liner system, hydraulic conductivity of the drainage material slope of the liner, length of the drainage path, those things are we can work with those numbers to come up with head less than a feet. Then there if we can also predict some of the leachate leakage is there, so those are also when we do that we can kind of look at that number.

So with that let us conclude this particularly video, only aspect among this landfill chapters left is on we have predicted the leachate collection the only part if you remember from the beginning of this landfill class we talked about that the leachate collection system and the gas collection system those two are important parts. So we talked about the leachate, how to predict leachate and next we will talk about how to predict gas. So that is the only thing left in terms of landfill disposal and then we will move to construction and demolition waste and the electronic waste, so those other two big topics which are still left recovered in this particular course.

So I hope you are enjoying course, we are already in week 10 so this is the I think this is the week 10, first video we just completed that so we will have the second video coming up.

Again any question put it on the discussion forum you can that is forum we are looking at every day and I hope you are enjoying the course keep learning, keep passing us good intelligent questions, so we will be happy to respond and looking forward to see you again, thank you.