Power Plant Engineering
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Lecture – 21
Hydroelectric Power Plants

Hello I welcome you all in this course on Power Plant Engineering and today we will discuss about the Hydroelectric Power Plants. We have amply discussed about the thermal power plants and now we will start discussions on hydroelectric power plants.

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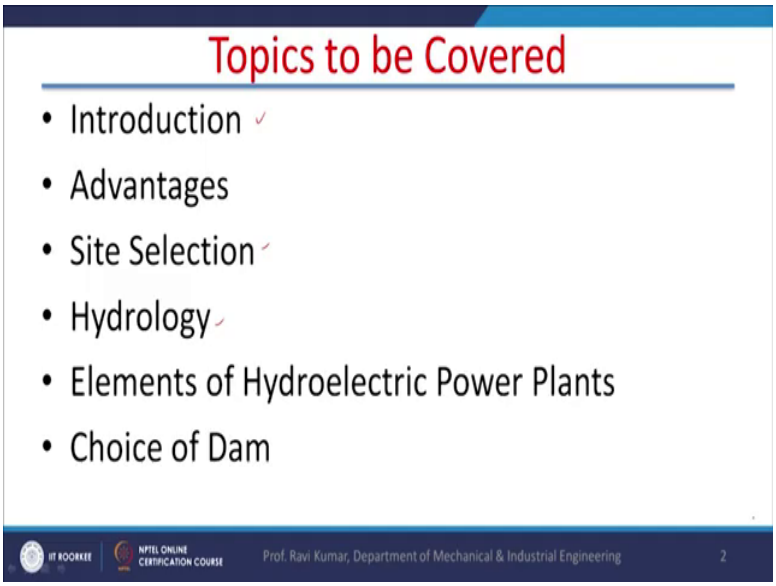

Now, topic to be covered in the present lecture are I will introduce you what is hydroelectricity, then advantages of hydroelectric power plants, how to select the site for hydroelectric power plant. Unlike thermal power plant there are several restriction on the site selection on for a hydroelectric power plant right. We will discuss a little about hydrology also

what is hydrology and elements of hydroelectric power plants what are different elements of hydroelectric power plants and choice of dam which sort of dam should be used for a particular location.

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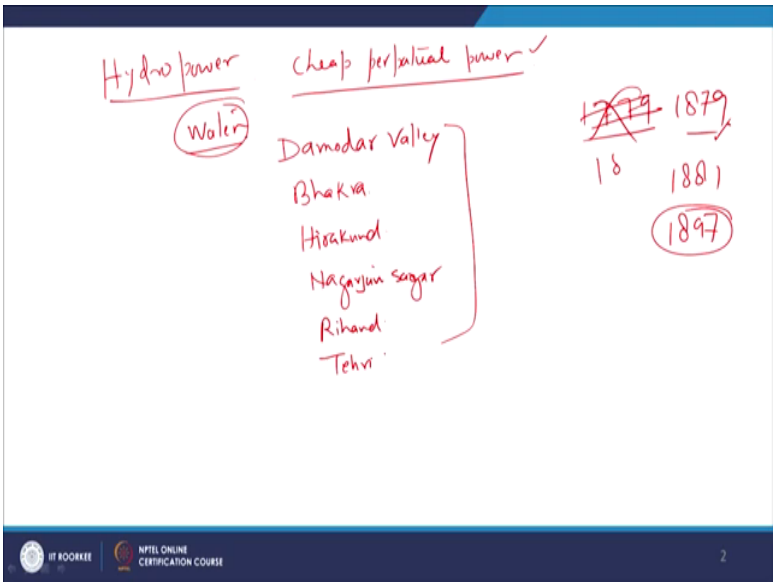

We will start with the Hydro power, hydro power first of all hydro power is very cheap. It is cheap because here the working fluid is water and water is available free of cost, unlike thermal power plant; thermal power plant we have to use coal or nuclear power plant we have to use some nuclear fusion material the fuel cost is high especially in nuclear power plants. But if you talk about a hydro power plants we are using only water as a working fluid ok.

So, the fuel cost is almost nothing or we can say cheaf cheap perpetual power right. The it is possible that the plant is designed for a certain capacity it is working on under capacity, but it will continue to work, it will continue to give you the power right. So, that is the benefit of

main benefit of hydro power. Actually in India the electricity was introduced in 1779, it was introduced in Kolkata and first thermal this hydro power plant it came into the existence in it sorry not 1779 1879 this is not 1779 1879.

So, it was introduced in Kolkata regular electric supply is started in 1881 and first this hydro plant was establish in Darjeeling which is in West Bengal in 1897 and since there we have number of hydro power plants we have Damodar valley, some of the famous plants are Damodar valley and Bhakra. Bhakra is a complete dam right and Hirakund Nagarjun Sagar and Rihand and the latest one of Tehri dam. So, we can these are the a few names, but we have number of hydro power generation units which are established in the country.

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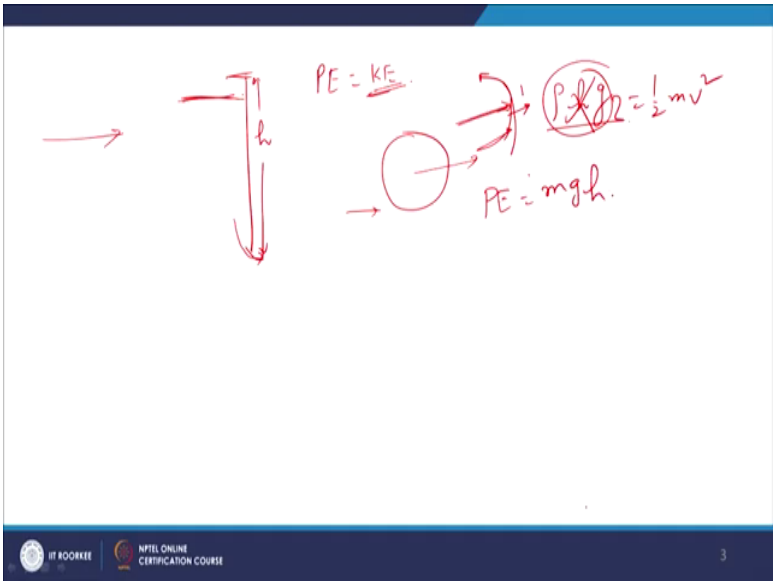

So, how the power is generated in a hydro plant it is simple, the potential energy of the water a dam is made in the suppose the height of the dam is h. The potential energy of the water

right which is coming from the bottom suppose this level is maintained, because water is coming from behind so this level is maintained.

So, the water which is leaving at the bottom will have high pressure and this pressure will be converted into the kinetic energy or pressure energy or the potential energy is converted into the kinetic energy. So, we get at the inlet of the turbine, there is a turbine hydro turbine there different type of turbines from the steam turbine right.

So, in these turbines the water enters with very high velocity right and same thing happens here as happened in the case of a steam, this they are the turbines have blades and energy is imparted to kinetic energy is converted to into it is exerts force. The change in the direction of the velocity of the fluid or sometimes fluid directly strike the blade, here in this case in hydro turbine sometimes what happens it directly strike the blade also.

So, the energy is imparted to the router this is how the energy is imparted to the router and the router starts the generator and the how the electricity is generated in hydroelectric power plant. So, the potential energy is h rho g h rho g rho g h. So, rho h and g this is the potential energy right and this potential energy is converted into and there is some efficiency also which has to be taken into the account. So, there is potential energy is mgh potential energy is mgh, the potential energy in hydro power plant is mgh and this mgh is converted into the kinetic energy.

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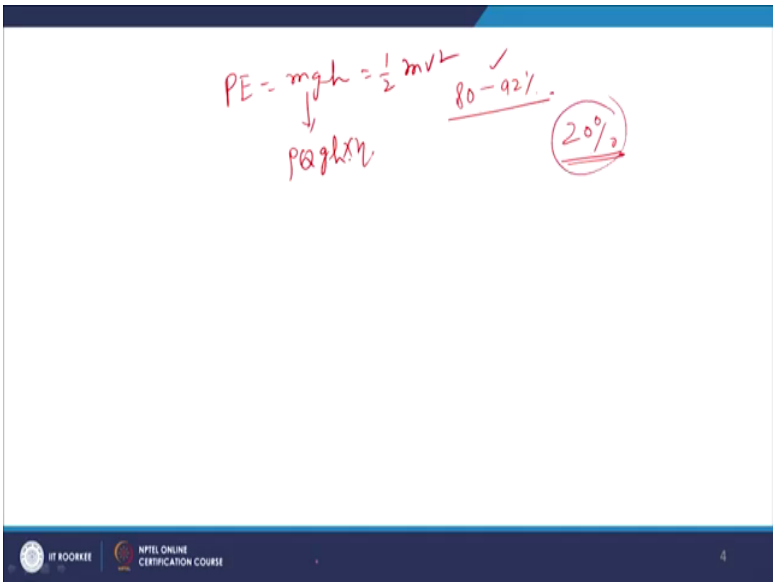

Now, this mgh is nothing, but rho Q g h, because when we are dealing with a water we always deal in terms of volumetric discharge. So, the volumetric discharge multiplied by rho it may have some efficiency also, normally hydro power plants have efficiency in the range of 80 to maybe it can go up to 92 percent or 94 percent. So, that is the efficiency of a hydro power plant. Now, nearly 20 percent of the power generation in the world 20 percent of the power generation is the hydro power plantation.

Some of the country like Norway, Norway is an Scandinavian country close to the North Pole or Switzerland they have 100 percent hydro base power generation, they do not have any coal base plant or nuclear power plant. So, the power generation is 100 percent hydro based. There is a beauty of hydro project that it is multipurpose it is multipurpose.

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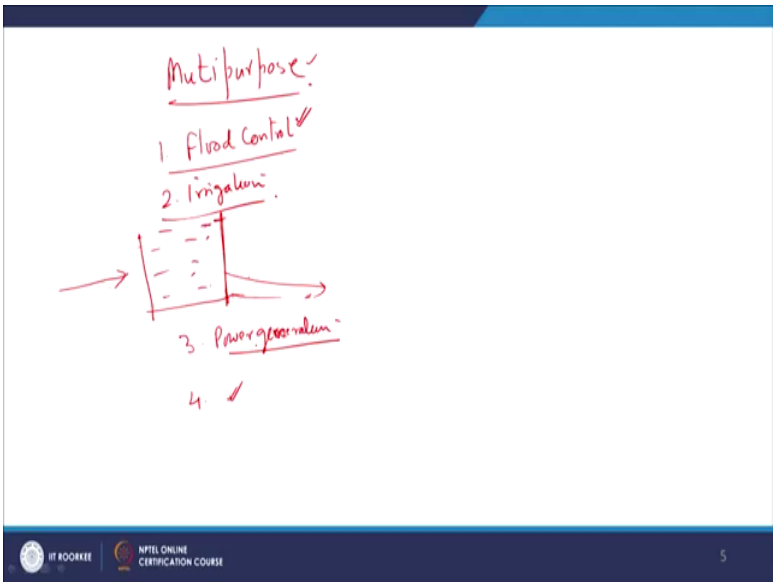

If we look at a thermal power plant the sole purpose of the power plant is to generate electricity right. Nowadays, fly ash we are trying to make bricks or use the fly ash, fly ash is also used in cement industries and fly ash bricks also we are trying to make, so that the fly ash can be use which is byproduct of thermal power plant.

But regarding this hydro power plant it has many uses, in addition to the power generation is one of the use one of the major use is flood control right. Flood control because a reservoir is made suppose there is a water is coming from this side reservoir is made of water right, when there is a excess of water it can be stored in the dam. So, on the downstream the flow rate can be monitored, but if the dam is full sometimes the water has to be discharge irrespective of the fact, there is a plenty of water on the downstream side right. So, this is a very good flood control instrument.

Now, irrigation right irrigation because we can control the flow of water right. So, dams are effectively used for the irrigation purpose in the mainland right. So, this is another benefit of having hydro plant, third one is power generation is here. Now, in addition to the power generation the hydro power plants are also use for the pc culture where fish are grown ok. Now, we will go for the advantage and disadvantages of hydro power plants.

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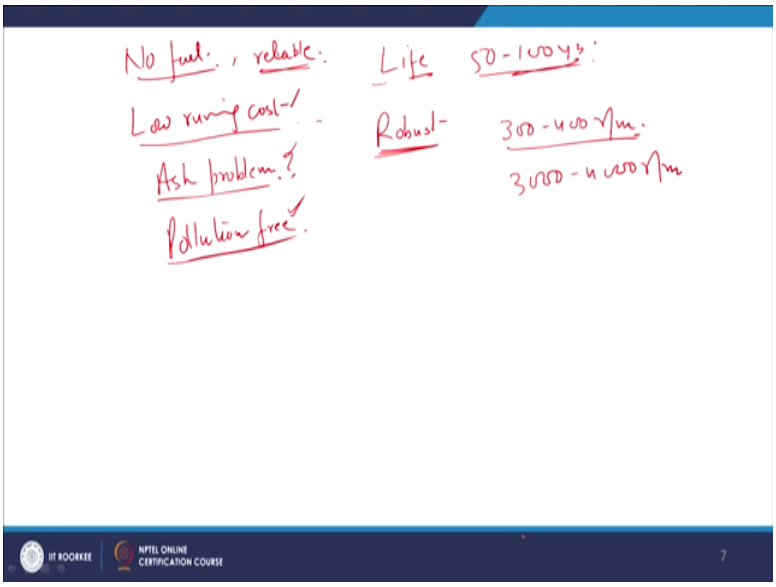

First of all biggest advantage is no fuel is required, no fuel is required in hydroelectric power plant and it is quite reliable. Efficiency of the hydroelectric power plant does not change with time, if you look at the efficiency of thermal power plant or any other power plant or any other machine it deteriorates with time. But efficiency of the hydroelectric power plant in general does not vary with time, I mean it is though if you operate plant for very long time it will change.

But the dependence time dependence of the efficiency of the hydro power plant is the least we can say. Low running cost because maintenance less maintenance is required, hydroelectric power plant does not have something like boiler condenser less machines are there. Already there is a dam headrace tailrace water comes from the dam it exert on the turbine and it goes out from the tailrace.

So, minimum number of equipment is there minimum maintenance is required, so running cost is also low for hydroelectric power plants. Ash problem is not there because, if you go for the nuclear power plant then nuclear fuel disposal problem is there, if you go for thermal power plant then ash problem is there right. But it does not have any ash problem and it is clean energy clean renewable energy.

Pollution free though it has impact on the environment, because we have the hydroelectric power plant is constructed it effects the fluoroflon of the surroundings right. But when the plant runs in that during that time there is no pollution to the environment, so it is a pollution free. So, from hydroelectric power plants we get pollution free renewable energy at no running cost, one of is very easy in a if suppose we have to start a thermal power plant.

So, thermal power plant you will have to first prepare the water for the boiler, feed water for the boiler and then you run the boiler it start up a boiler will take some time for a huge I am trying out the large power plant. Then it will go to the steam turbine in steam turbine immediately it will not start some timing will there, so it will take a lot of time.

But in hydroelectric power plants switch on and switch off is easy, simply you have to supply the switch just open the gate water will enter the turbine and turbine will start producing water right. So, switch on and switch off is easy for hydroelectric power plant and it is the self contained unit right and less skill man power is required, less is skill power skill is because, if you operating thermal power plant say boiler operator is required boiler operator has to be a certified boiler operator, so number of operations are there.

But in hydroelectric power plant less skill they were can also be a I mean can also work for the hydroelectric power plant. Life is longer life expectancy is 50 to 100 years right, for thermal power plant it is typically it is 30 35 or 40 years, same is the case with the nuclear power plant. So, life expectancy is high for a hydro power plant.

It is a robust structure that is why the maintenance is low low running cost and low maintenance because it is robust. At the turbine runs the run on let us say 300 to 400 rpm or 450 or 500 not more than that right. If you go for the steam power plant or in that case the rpm is 3000 to 4000 rpm is high, when the rpm of the shaft is high wear and tear will be more and maintenance will be more.

Same is the case with the nuclear power plant, because nuclear power plant only generation of steam is different from a normal thermal power plant as for the cycle is same it also works on the Rankin cycle. So, in the so in hydro power plants because the rpm is low, how we are managing with our low rpm that is a reason being the density of the working fluid is high, in the steam power plant we are using a steam in nuclear plants we are using a steam.

But in hydro plants we are using water which has thousand time higher density more than 1000 time higher density than steam right. So, these are the certain advantages of, second thing is it is quick to response also if there is a change in node the hydro plant is quicker in response.

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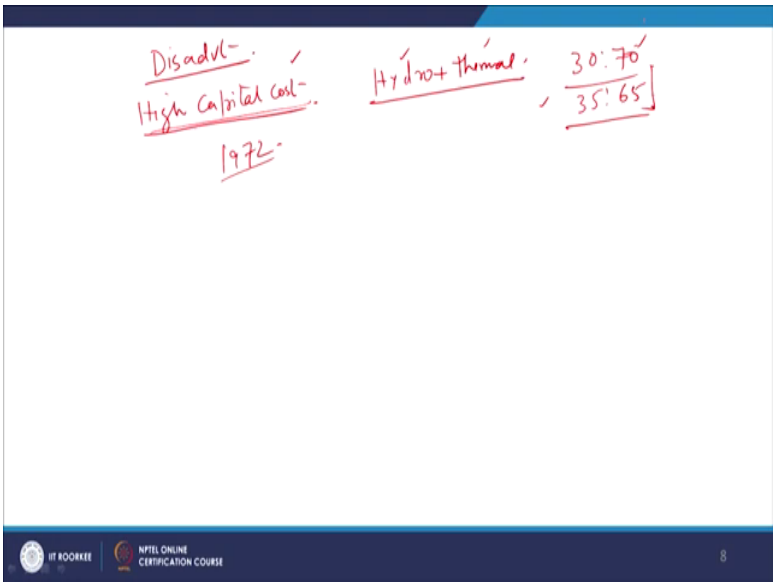

Now, if you talk about the disadvantages, now disadvantages is now disadvantages are first of all high capital cost. Because a lot of civil work has to be done in making hydro power plant, so it has very high fix cost very low running cost right. So, for so the capital cost is high and we do not get return on that capital cost though power generation is cheap, but it cannot compensate the high capital cost which has been made initially.

So, that is the one disadvantage, second is it dependence the power generation dependence upon the quality of water. In rainy season a lot of mud suppose a lot of mud is coming with the water that mud may damage the turbine. So, those days the turbines are not operative right. So, it dependence the power generation depends upon the quality of the water as well, site selection is very typical I mean anywhere you cannot establish a hydro power plants.

So, there are certain guidelines for the site selection those guidelines have to be followed for going for any before going for any site. So, site selection is typical, election time is quite I mean long normally it is say ten year, but in our country it goes let us take a example of Tehri dam it started in 1972 I think 1972 or 1973 and it finished in late nineties. It took around 35 to 40 years to for Tehri dam to for the construction to be completed right. Election time is quite high for during that time the cost escalation is also there due to inflation cost escalation is also there.

And the last one is disrupt the ecology of the area, that is the main disadvantages of a hydro big hydro power plant. Now, people say that instead of a big plant we can go for number of a small plants or run of plants. But the issue is if you compare I mean a large number of a small roads cannot be replace a big broad road or a highway.

Similarly, if you put small capacity plants they have their own advantages, but the large dam but they cannot replace the advantages of a large dam right. So, it depends upon the site also, sometimes many things which are not in the hands of designers it depends upon the dam site also right. So, sometimes what happens the dam size the site size that we cannot go only go for the large dam we cannot go for the smaller size of dam.

Second thing is especially in our country the rain fall is only for a short duration of time maybe two months or three months times. So, we do not have any uniform flow of in the river, the rivers they do really get ride up during the summer season. So water huge water is I mean reserve is required for hydro power generation right.

Now, if we mix hydro and thermal, so mix load sharing type of system is very suitable for our country. Suppose we mix hydro and thermal, I mean part of the load is through hydro and part of the load is through thermal and the ratio is let us say 30 into 70 that is a good mix which is happening in India and this and we can go is not very rigid we can go 35 to 65 also right. So, this is known as power mix.

So, base load on type of plant let us say hydro plant it will take the base load right and the excess load can be taken care of the thermal power plant something like this. So, it gives very high utilization, such type of arrangement it can give a very high utilization factor for hydro power plants.

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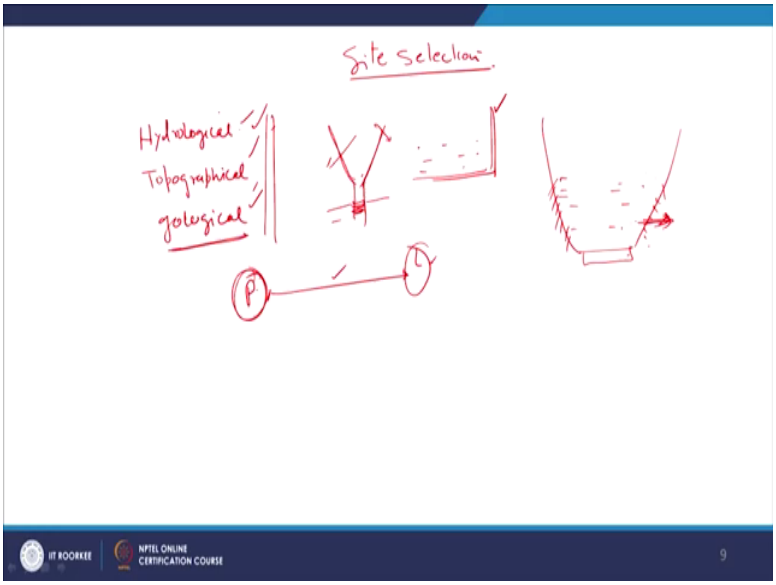

Now, let us come to the site selection site selection, it is not an easy job as I said earlier right and we have to do the hydrological topographical and geological survey first. When we are going for a site we should ensure what is the nature of the water which is flowing on the site, what is the flow rate and what is the duration through which an I mean for each month what is the flow rate we will discuss about the hydrology later on. I mean what is the annual flow rate pattern in a particular site right, this has to be ensured right.

Topography of the site whether it is a flat plate or a gorge or a I mean I mean narrow or is a confluence best part is the confluence of two rivers. Normally, it is recommended that the dam should be made at the confluence of two rivers, because here you will get a narrow passage where you can built a wall or some rock fill there are different type of dams also.

For example Tehri dam is a rock fill dam and then a reservoir can be made, geological I mean report is also important the nature of the soil and nature of the rock. The rock should be a I mean season dimension or be a sort of rocks which is not able to sustain the pressure of the water. So, such type of analysis has to be done, because if something happens in a hydro power plant the down side planes will be completely flooded right. So, in order to avoid that first of all these three survey is has to done.

So, an adequate water supply it is important, adequate water supply to the hydro power plant is important and how by silt is coming into the water because if the siltation is there in the hydro plant, then it will fill the reservoir and the capacity will automatically get reduced ok. And the available of the water available of the water had would decide how much power can be generated and which sort of turbine can be use in a hydroelectric power plant.

Second thing is accessibility to the site, site should not be in a far of place where accessibility is different difficult right. Accessibility to the machines, accessibility to the human being because labor has to be transported and machine has to transported to the site. So, site accessibility of site is also very important right load power generation and load send this distance is also important because transmission loses are always there right. So, in order to reduce the transmission losses this power generation point should not be far off from the location of the load right.

So, we have to make a compromise, I mean we cannot go absolutely close to the load because or the load you will you will not find other things. So, it could compromise of all these factor is necessary for a hydroelectric power plant. The land as I said geological survey has to be done geological survey of the land has also to be done to at the site, everything has to be in order only then we can go for a hydroelectric station at the particular site.

And there are environmental and sociological aspects also, so because when a reservoir will be made at the site and when reservoir will filled the some part of the land will be summer. Suppose there is a there is a valley right and we have made a dam here, so the part of the I mean this land will be submerge and normally if you go to the hilly area the population lives in the valley only right. So, they have to be rehabilitated, there is the sociological aspects of making a dam.

So, rehabilitation is a big problem rehabilitation is a big problem because people love the place they are where they are born and brought up and when we try to rehabilitated them there many aspects which I mean prevent them from moving from that place right. So, this is about the site selection. Now, we will discuss a little about the hydrology.

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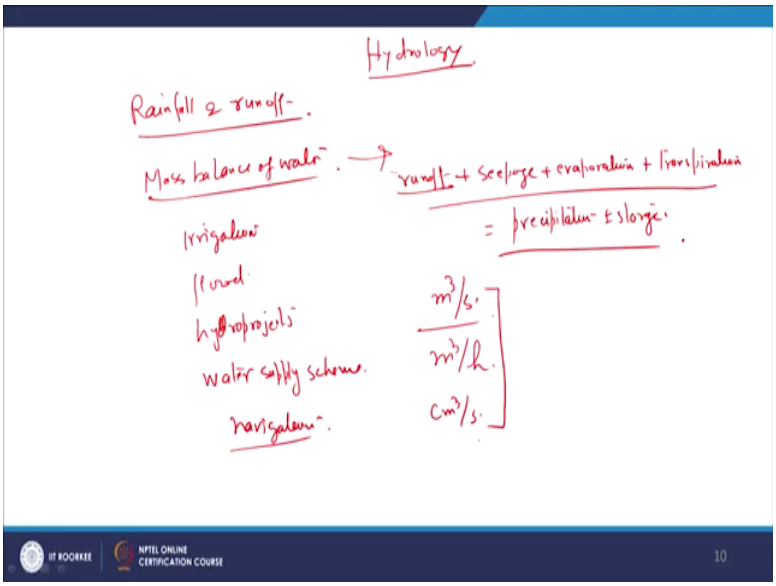

So, hydrology is the science which deals with the rain fall and runoff. Suppose in a river the water is flowing during that course the water also gets evaporated right and sometimes the seepage is also there right. So, there is a mass balance of water has to be done, first of all mass balance of water. Now, before the mass balance what exactly happens, when the water flows in the river it goes to the sea where it gets evaporated right, forms the clouds are formed and the cloud clouds they come back to the main land where precipitation takes place and this cycle keeps on going.

So, in hydrology we take into the account of environmental aspects also right and hydrology is used for irrigation flood control hydro project, water supply and navigation right. Now if you do the mass balance, if you do the mass balance then first is runoff water is flowing in the river plus seepage plus evaporation plus transpiration.

Transpiration means the water is served by the plants and subsequently it is evaporated to the atmosphere that is known as transpiration is equal to precipitation plus minus storage. The runoff there several units to express the runoff, if you use the FI unit SI unit is meter cube per second, it is also expressed meter cube per hour or centimeter cube per second it dependence I mean upon the I mean the person who is representing the data right.

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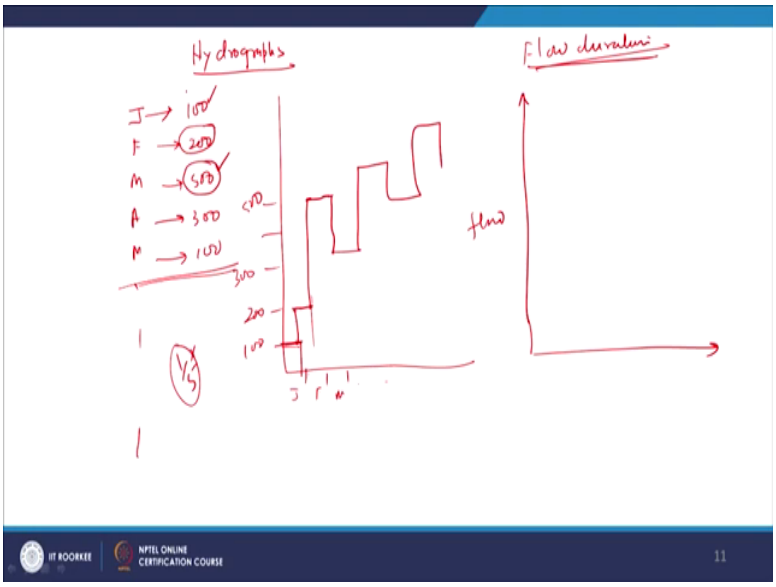

So, hydro graphs are made hydro graphs, now how the hydro graphs are made for every month let us start from January, February, March, April, May and so on, there is certain flow rate. January flow rate is so let us say 100 units for February it is let us say 200 then 500 then 300 then100 and something like that right. So, we will make hydro graph this is January Feb March and so on and this is the flow rate.

So, 100 Jan it is 100 Feb it is 200 this is 200 this is 100 this is 300 500 200 and then it is 500 then it is 300 January Feb, Feb it is 200 and then March 300 and then March April sorry January 100 Feb 200 March 500 April 300 and so on, we can have a graph which is known as hydro graph. There is another curve which is known as Flow duration curve and the third curve is mass curve.

Now flow duration curve is it is a cumulative curve, for example we will say that 100 percent flow rate for 100 percent time let us take these 5 months, 100 percent time the flow rate is 100, 100 is 100 percent time. Then we will find for how much time duration the flow is 200, continuously for how much time flow rate is 500 it is minimum I think that is a only one by fie 1 by 5 into 1 by 5 into 100 20 percent time, 20 percent time we are getting flow rate 500 100 percent time we are getting flow rate 100 percent right.

So, this is known as flow duration curve for how much duration a particular minimum flow is ensured right. And the third one is mass curve mass curve is a cumulative curve first month 100 second is 200 so first 2 month is 300. Now third month is 500. So, first 3 month is cumulative value 5 to 7 and 800 like this right ok, so this is known as mass curve of any flow.

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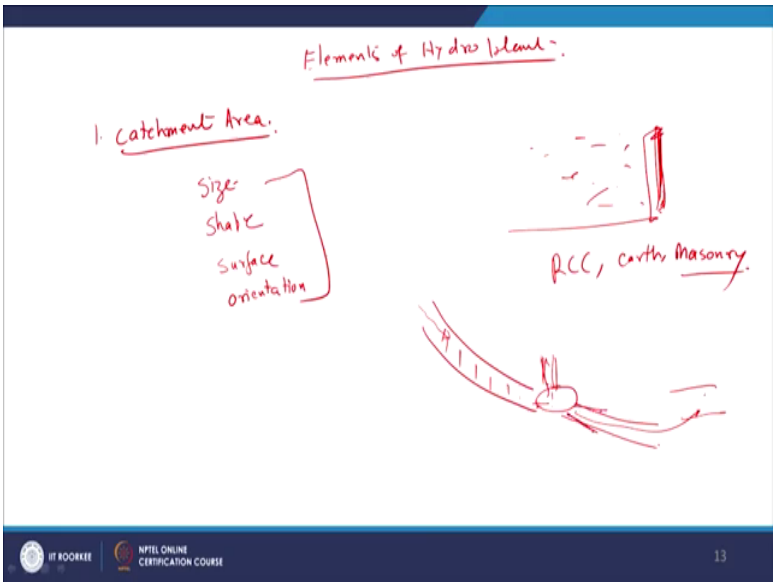

After this now we will come to the main elements of hydro plant, main elements of the hydroelectric power plants. First is Catchment area, it is the upstream area suppose a dam is made here it is the upstream area which is across which the dam is constructed. So, that area the waterfall in that area along with a upstream flow of the river will be stored in the dam.

So, that area is known as catchment area, it is characterized by the size. What is the size of the catchment area, what is the shape of the catchment area, how is the surface of catchment area, what is the orientation of catchment area, this is how it is characterized. Another thing is reservoir in hydroelectric power plant the reservoir is the main body of any hydroelectric power plant, where water storage of water takes place.

So, if the runoff is something like this, if only a particular months the runoff I mean high flow rate is there otherwise flow rate is less or there is seasonal rain fall, huge reservoir will be required. If throughout the year there is a constant flow almost constant flow of water less capacity of the reservoir will be required, but this reservoir is the main part of any hydro power plant and there is a dam, dam is used for holding the water in reservoir ok.

And they are there is it is a thick wall it may made of RCC, it may be earth or masonry dam, it can be masonry dam right and after the dam there is a headrace through which water goes to the turbine here is a turbine. So, there is headrace from headrace water flows to the turbine, here transmission of energy from fast flowing water to the shaft of the turbine takes place and there is a tailrace. And tailrace from tailrace the water joins the mainstream right.

A draft tube is also provided in some of the turbines draft tube is also provided to extract more energy from the flowing water ok. There is a spillway also suppose there is a over flooding of there is a over flooding of reservoir right. So, there is a spillway also to bypass the water right. So, that a particular level in the reservoir is maintained that is all for today.

Thank you very much.