Application of Soil Mechanics
Prof. N.R Patra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture – 31

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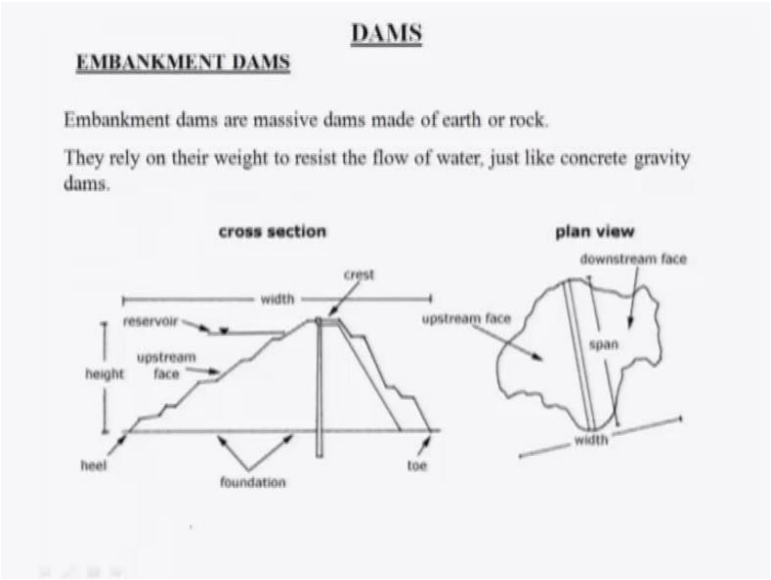

In the last class last class we have to discussed, we are discussing about the dams. So, one part is remaining about the type of dams that is embankment dams embankment dams are massive dams made of earth or rock they rely particularly on their weight on weight to resist the flow of water just like concrete gravity dam. If you look at this embankment dam this is your foundation this is your heel, and toe, and crest of this, and this part is your total from year to year is consider as a width, then there is a reservoir, then there is a reservoir, then upstream face. Then this is your total height, and plan view upstream face, and downstream face as well as span has been zone here.

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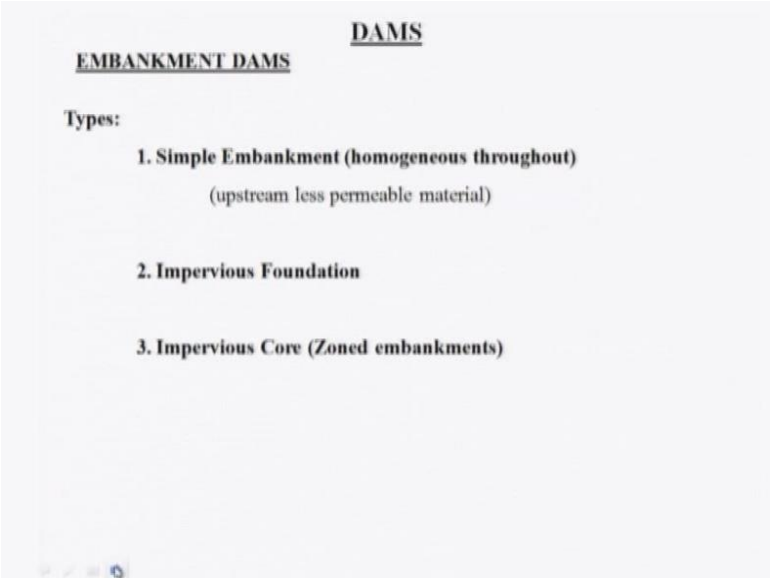

So, embankment dams may be classified has three parts; one is your simple embankment; that means, homogeneous throughout upstream less permeable material, then second is your impervious foundation, and third is your impervious core are zoned embankment.

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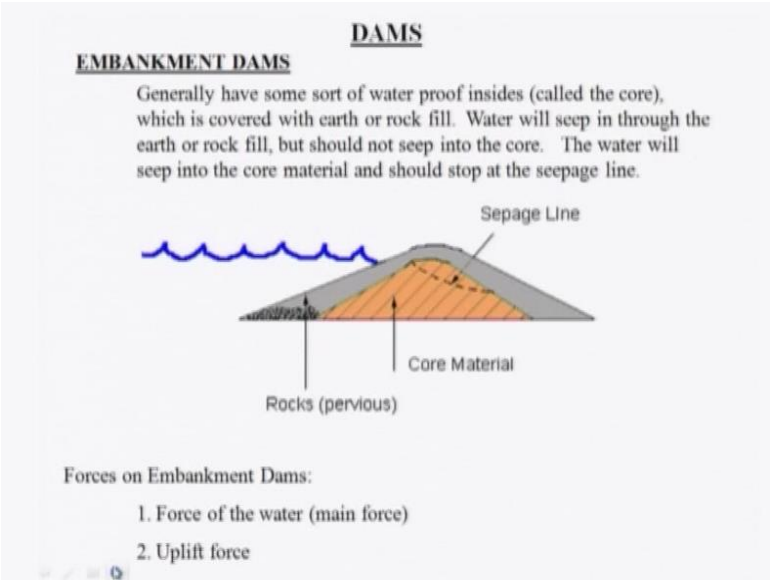

If you look at this embankment dams generally have some sort of water proofing inside called the core. So, this part is this is your core, it is say water proofing, and this part is called core material which is covered, this core is covered with earth or rock fill it has been covered with earth or maybe it is your rock.

Fill water will seep in through this earth or rock fill, but should not seep into the core; that means, water will pass through this earth or rocks fill, and it should not seep through this core they water will seep into the core material, and should stop at the seepage line. If I make into if look at this embankment dam it has been generally consider with this earth or rock fill, and inside this earth, and rock fill there is a there is this is called core, and or it is a core material generally in this core material is called water proofing that mean it is north completely water proofing; that means, this he pays through the core is less has compare to this he face through this rock or per we has material. So, so forces on this embankment dams you can say that main force is, because of your water, then another one is your uplift force; that means, water passes through this, then there will be uplift force.

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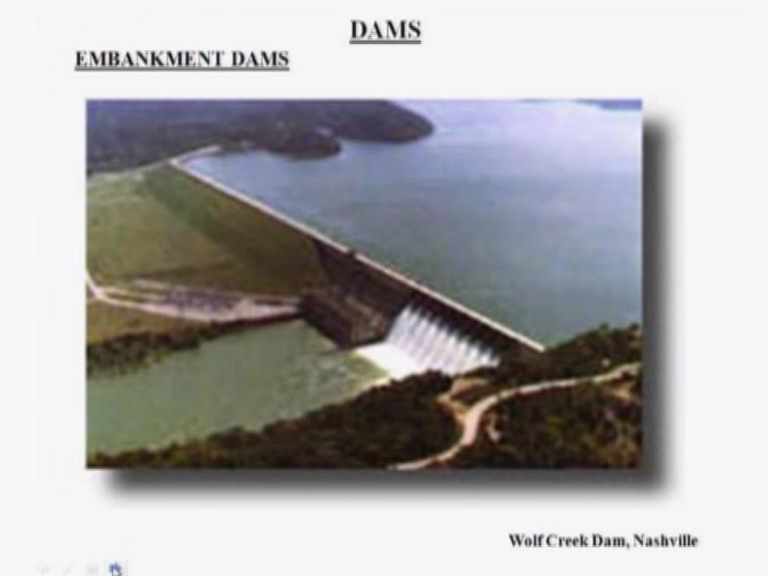

Embankment dam: This figure it is... So, one of the example wolf creek dam in united states this is your built embankment dam.

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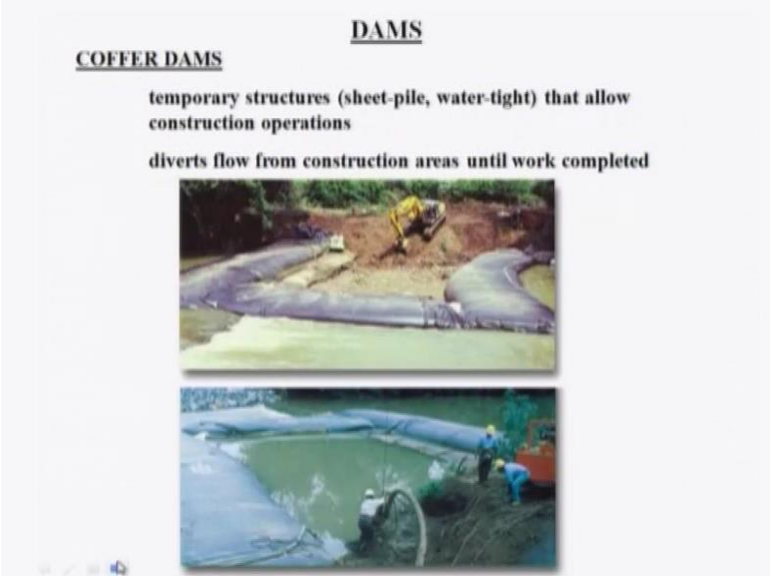

Then coffer dam another part is called coffered dam this are all temporary structures temporary structures made of with sheet pile or water tight that allow construction operation; that means, temporarily it block temporarily it block this water flow. So, that in once side you can do this construction. So, if you look at this, this is your temporary or coffered dam where it can do this construction work; that means, it allow or it diverts flow from construction area; that means, inside construction area. It will not allow water to flow it will diverts this water from this construction area still this work or construction has been completed this is called coffered dam.

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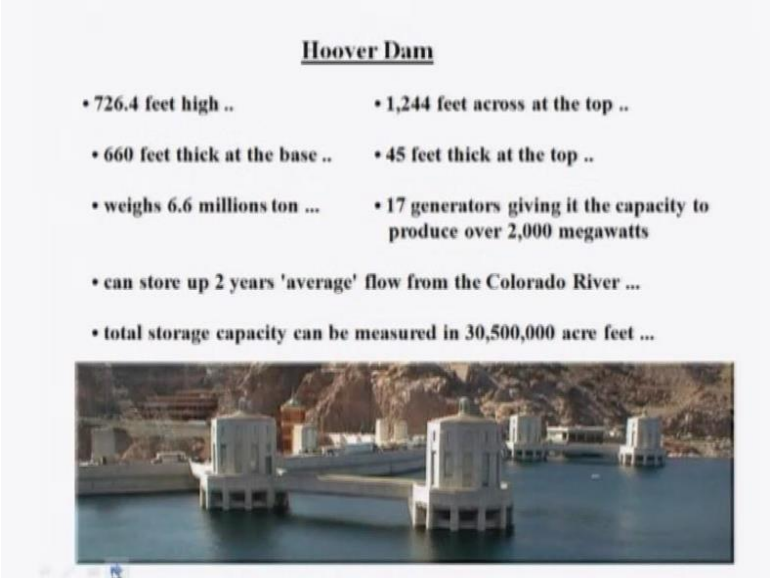

Then hover dam one of the example this is seven hundred twenty six point four feet high, and one thousand two four four feet across at the top, and six hundred sixty feet thick at the base, and forty five feet thick at the top this is a hover dam example has been total storage capacity is about thirty three zero five zero zero thousand acre feet total storage capacity, and can store up to two years average flow from colorado river. One of the example this is hoover dams from colorado river, it can store up to two years of average flow or two years. Water can be stored hoover dam in the top you it has been soon. If you look at this hoover dam it is must if swift that in un united states over the colorado river.

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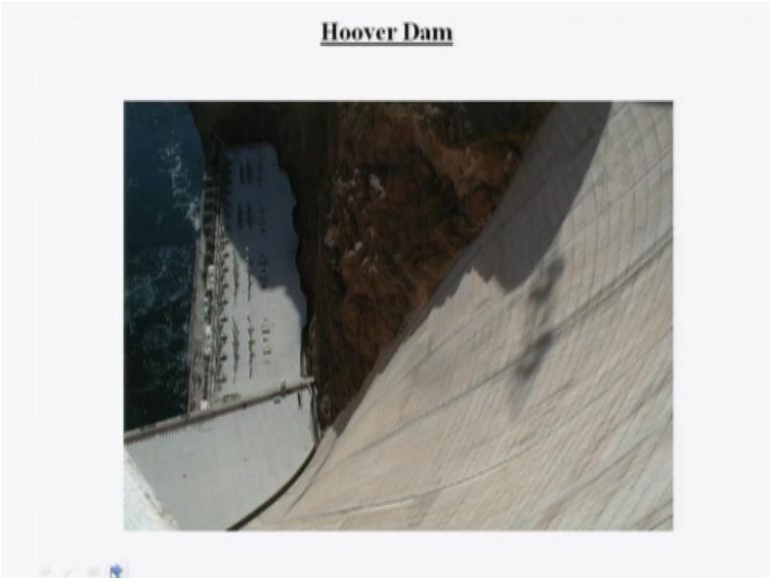

This is your top view of this hoover dam, if I this is the all about your classification, and what are the different types of dams, then you will start this next part is your reservoir, and dams in this dams. Now you will need to half this let me start with this different types of dams once again.

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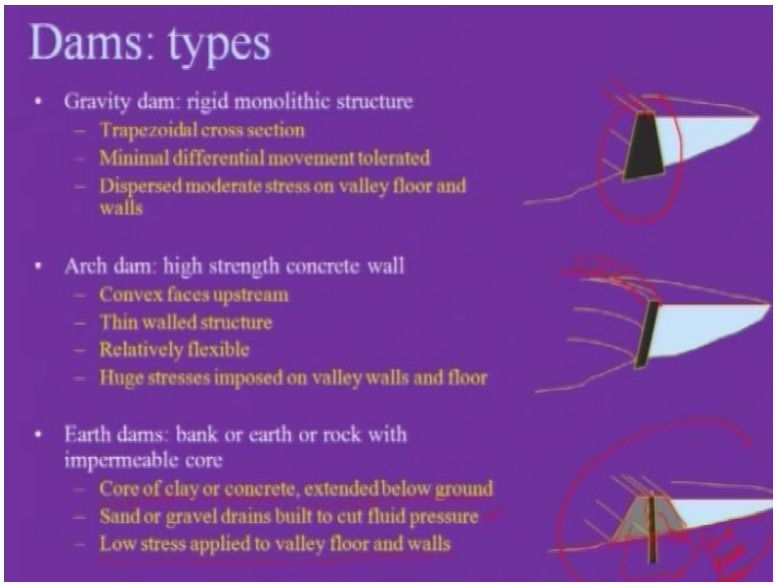

Once again if I summarize different types of dam, it can be classified into three parts a their said a layer. One is your gravity dam second is your arch dam third is your earth dam in gravity dam they cross section may be it say rigid monolithic structure rigid monolithic structure this is your gravity dam this is a rigid monolithic structure this is this part is your cross section, and this is towards your length direction, and an minimal deferential movement tolerated, and dispersed moderate street on valley floor or walls arch dam arch dam is kind of high strength one concrete wall, and it a convex faces upstream.

If you look at this, this arch dam is a in arch safe with convex this is your convex faces upstream, then wall structures all the way of discussed a layer it is a very, then wall structures, and relatively flexible it is relatively flexible huge stresses imposed on valley walls, and floor used huge stresses imposed this wall, and as well as this floor, then third part is your a dam it is say earth or rock with impermeable core right. Now we have discussed this; that means, a impermeable core is in between, and surrounded by earth or rock fill, and core of clay generally.

If you look at here core clay or concrete extended bellow the ground, then sand or gravel drains built to cut fluid fluid pressure sand or gravel drains has been put it. So, that it will reduce or allow the permeability allow this seeps. So, that it will reduce this fluid pressure, then low stress applied to the valley floor, and walls low stress applied to the valley floor, and walls, if you look at this a dam this is the a dam this core. If I take this is a cross section,

this is your cross section this core it, this is your core this core is made up of by clay or concrete it extended been beyond the ground surface if this is my ground surface it extend beyond the ground surface, and the side by this are sides the side by it is a y means of sand rock or gravel. So, that it reduce this pressure fluid pressure on this core, and low stress applied to valley floor on the wall; that means, low stress applied to the valley floor or the walls.

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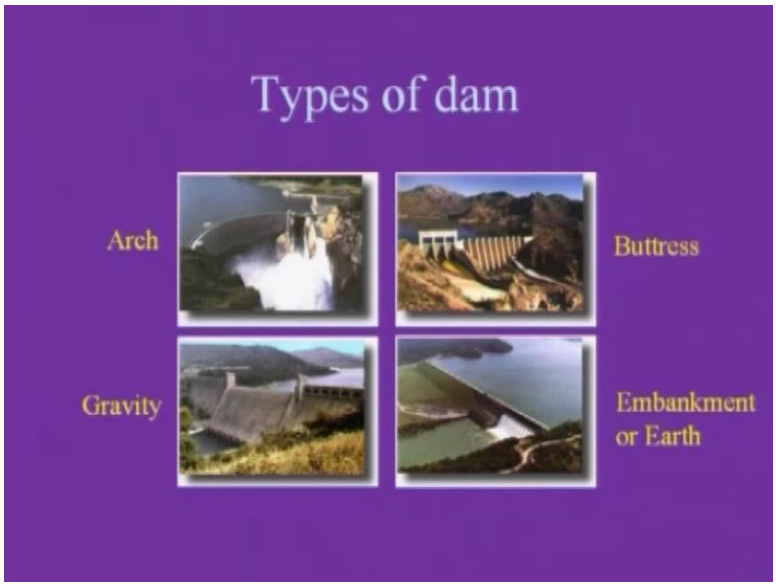

Once again this example arch dam, if you will look at this a clear picture here arch dam this is in arch safe with a very, then thickness thickness is very, then is your gravity dam by means of own gravity resist this whatever the forces coming on to this, then this is your m a embankment or earthed dam earthen dam this is typical example of earthed dam, then buttress dam all this dams previous we will have discussed.

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Now, some of the examples in clear bigger pictures, some of the examples Switzerland.

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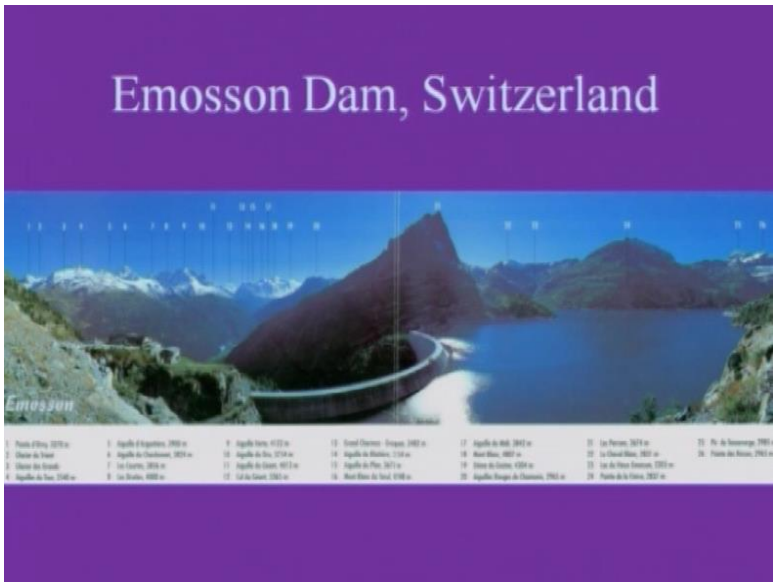

One of the arch in the switzerland whether it is if you look at this, this is the arch safe arch dam in the Switzerland.

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Then vaiont dam today.

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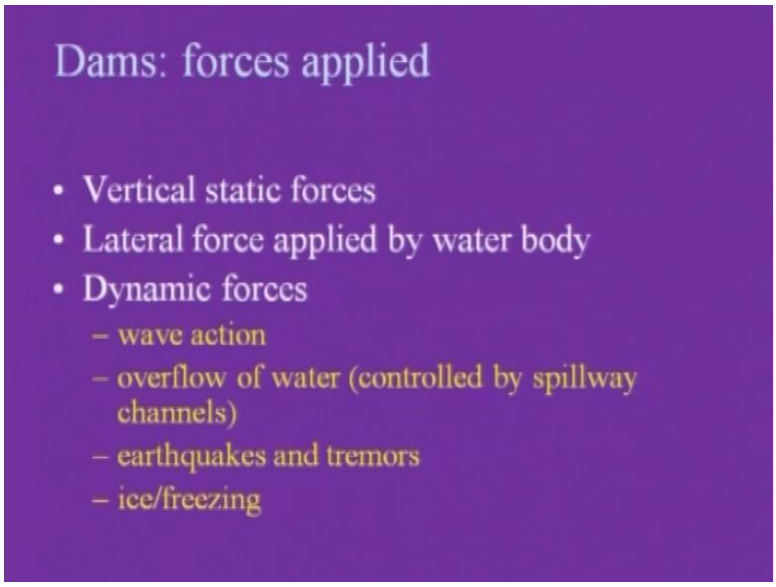

This is the is I can when what are the forces applied in dams, as you have discussed vertical static forces lateral forces applied by water body. One is the vertical static force or there is your lateral forces by means of water body, then different dynamic forces is you can into consideration in the form of water wave action over flow of water, then earthquake, and tremors by means of there is earthquake earthquake force has to take into consideration ice or freezing generally in Western country particularly European country. What will happen?

In the water reservoir where the movement in during winter this water become ice by means of freezing once it become ice by means of freezing, it will impact ice will become a solid, it will impact a force, this are all your dynamic forces to be taken into consideration in case of dam.

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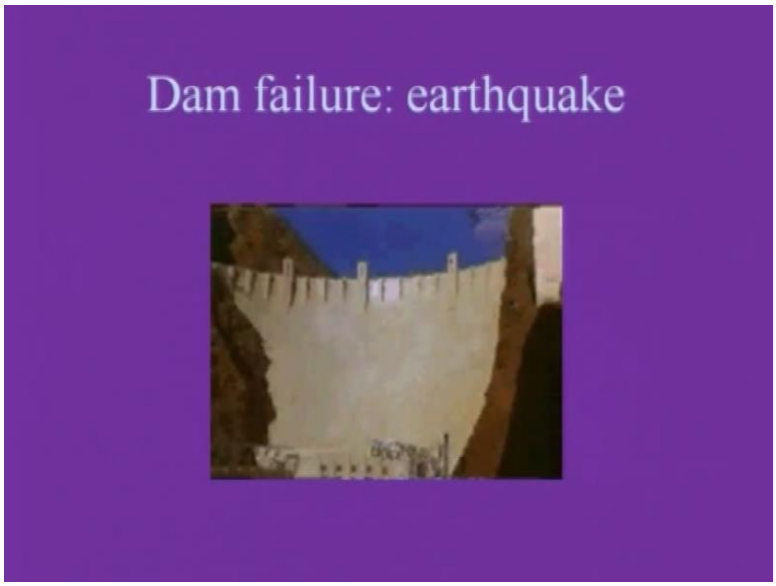

So, typical cases of dam failure by means of earthquake.

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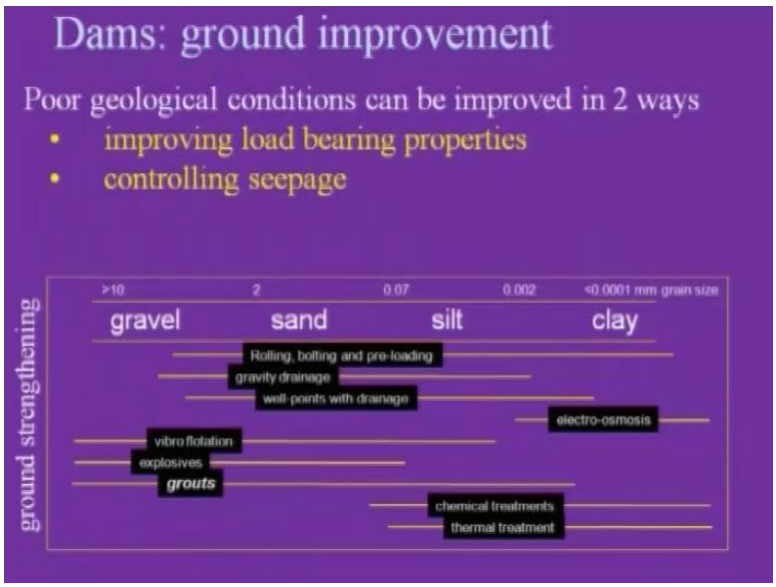

Now, how this once it dam has been constructed; one another aspect is your how this ground improvement technique has been den has been done for dams; that means, poor

geological conditions can be improved in two ways; that means, improving load bearing properties one is your by wind ground improvement, if an improve they load bearing properties other is your you can control this seepages by means of ground improvement control this seepage. So, ground strengthening if I put it, if I make this all into particularly core parts one is your gravel sand silt, and clay gravel is more than ten sand is two silt is a about bitten to two two zero point zero zero two, and clay less than about zero point zero zero one mm grain size generally per sand, and silt rolling bolting, and preloading has been done to strengthening this bearing properties, and gravity drainage, and well point with drainage well point different well point with drainage has been apply, if there are gravels generally you can go for vibro flotation, and explosives as well as you can go for gravity you can go for gravity ground improvement are; that means, improve been load bearing properties within silt, and clay. If there is a mixture silt of as well as clay you can go for chemical treatment or thermal treatment chemical as well as thermal treatment, if it is clearly clay. Then electro osmosis is as well applied for particularly clays soils. So, this all this ground improvement technique or ground improvement methods to improved your load bearing properties.

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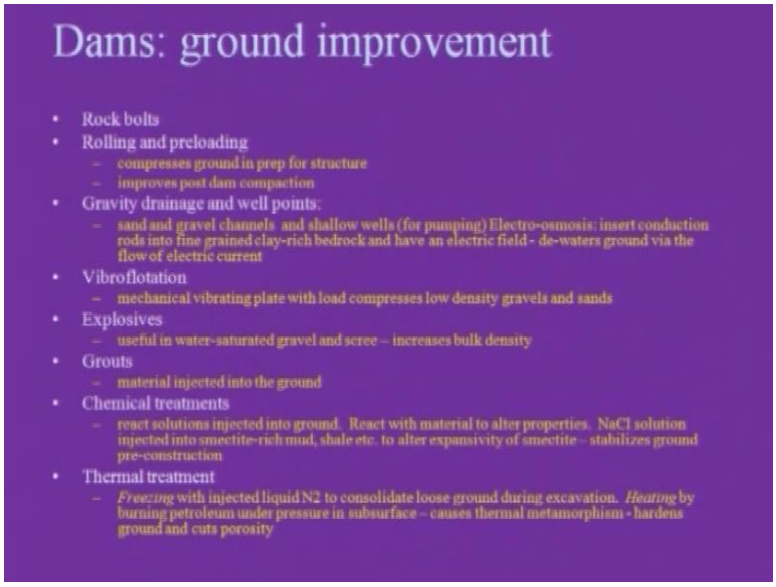

Now, if I say come back to in details rock bolts rolling, and preloading rolling, and preloading particularly compresses ground in prep for structures it, it completely compress the ground compress the ground improves this post dam compaction improve by your post dam compaction gravity drainage, and well points what is the meaning of this gravity

drainage, and well point; that means, sand, and gravels channels, and shallow wells shallow wells generally you put it near by the dam electro osmosis is; that means, insert conduction rods into time grained clay or rich bedrock have, and electric field. So, de waters ground via the flow of electric current by means of flow of electric current you can the de water the water, then you are vibrate protest; that means, it is a mechanical method mechanically vibrating plates with load compresses low density gravels, and sands if there is a gravel sand of low density by means bri vibro flotation's; that means, it is a mechanical vibration by means of vibrating plates. If can improved this bearing capacity exclusives sometimes.

We used this exclusive particularly exclusives; that means, it is usefully no water structures gravel, if there is a water structure if there water saturated gravel water saturated gravel in that case once you used this exclusives what will happened water will come out from this saturated gravel; that means, it is wall density will increase, and hence this strength will increase, then grave material particularly in case of grave materials you inject inside the ground surface. So, by means material injecting it will mixed with ah soil. So, it will increase it is bearing capacity's so; that means, material injected inside the ground or inside this dam, then chemical treatment what are the chemical treatment may chemical treatment meaning means it react solution injected into the dam; that means, there some solutions it has been injected inside the ground. So, that it will react with material to alter the properties that for example, sodium chloride solution injected into. So, smectite rich mud if there is a mud smectite reach more, if I inject sodium chloride what will happened it will react with this mud, then it will improve; that means, it will stabilize this your ground. So, chemical treatment means this are all over view what is the meaning of this rolling, and preloading dam gravity drainage, and well points vibro flotation explosives grouts chemical treatments.

Then come back to your thermal treatment thermal treatment means freezing or heating thermally; that means, freezing with injected liquid nitrous oxide proved consolidate lose ground during excavation to consolidate it lose ground during excavation; that means, if I freeze by means of nitrous oxide; that means, what will happened it become hard; that means, if there an excavation it becomes hard. So, it will allow, it will allow their lose ground to consolidate, then heating by bounding petroleum under pressure how the heating has been done heating generally done by burning petroleum under pressure in the

surface by petroleum material has been taken under pressure, the bounding has been applied in the surface. So, cause it causes thermal meta metamorphism it causes thermal metamorphism; that means, what will happened by means of bounding it hardens your ground, and causes the porosity causes the porosity means it hardens the ground cut the porosity means the it want allow the flow; that means, it completely hard. So, this are the deferent techniques this are the different techniques such may used to improves this bearing capacity of ground this is called by on ground improvement techniques. So, this different techniques once again I am repeating once is your rock bolt rolling, and preloading gravity drainage well points the n your vibro flotation explosive grouts chemical treatments, and thermal treatments these are the treatment has been generally applied. So, that bearing capacity has to be improved it will look at a very simple example.

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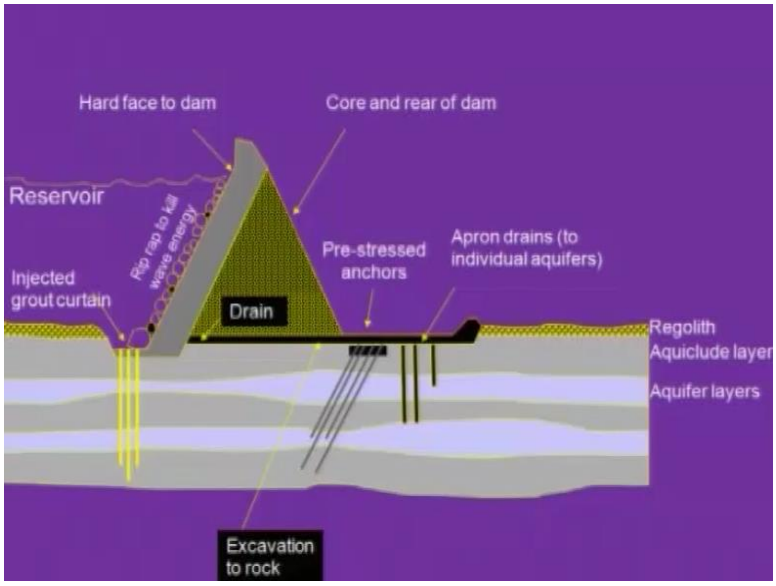

There is a dam hard face of the dam this is your hard face of your dam hard face of your dam; that means, sometimes what happened a rip rap to kill the wave energy, what will happened you put some stones along the hard space or rip rap, he can applies some stones or breaks. So, that this wave energy again, and again the wave water will trouble this reservoir this way again, and again it will impact a cyclic loan it will impact is cyclic cyclic; that means, this wave energy has to be reduce. If the hard face of the dam has been rip rap more by means of killing hard face has been done by means of rock or stones, then core, and rear of the dam if this is the core this is the core rear of the dam, then another face of their if there is a reservoir one there is a wave form at what will happened at the bottom by

means of water it will come, and it will stored here. So, injected grout curtain injected grout curtain by means of grouting, if you come back here material injected inside the ground. So, that it become hard.

So, what will happened this seepage here or may be error zone, because here wave, because of your wave wave what will happened there is a chance of at the bottom at the bottom hard face of that dam erosion may be possible true to make or to reduce this erosion what will happened injected grout grout has been injected inside, and it become harder. If you look at here this are the grout materials injected inside means of way long distance. So, that what will happened it will make harder. So, that it will reduce this erosion or erosion may be completely reduce, now if you come back to this excavation to this rock if you come back here.

Now if you look at here there cases there are cases what will happened water flows from here to here or may be it passes through this dam what will happened may be possible that it may uplift force may earth; that means, pressure are the bottom of the dam will be more. So, what will happened once their uplift force it will take out completely your dam to prevent this what will happened anchors pre stress anchors if you look at this point to point to pre stress anchor at this at this exist point has been provided what will happened by pre stress anchors by means of pre stress anchor along with this grouting along with this grouting. So, that it will become hard, and this is your pre stress anchor what will happened this anchor will resist this anchor resist against your uplift. So, if you will look at here this, this blacks safe this block safe which IO have mark in the red color this is a pre stress anchor the moment there is uplift force the movement there is a uplift force it is trying to take out or maybe uplift by means of water pressure, this anchor will prevent this anchor will prevent to go true to this anchoring again pre stress anchor are this same time also at this same time this why, because water is passing through this this soil are to be become most strata means hard strata.

So, what will happened again your grouting has been done these are all your grouting has been done. So, that this starter become harder. So, you can prevent it, then drains you can are this same time you can are the same time apron drains this are the drains has been provided. So, that what will happened, once there is a seepage, once there is a seepage bellow their dam below the dam what will happened water passes, and passes through this or may be water passes through body incoming, if it is happened dam what will happened

there are some point there are some point drains should be given. So, that after will be accumulated. So, water will be accumulated had this point. So, you can take out or may be pumping out may be procedure may be taken out. So, this flow by this means of by this ground improvement technique what will happened will completely change the flow pattern inside the your dam.

So that means, flow pattern has completely change it has been resisted means particularly uplift force has been registered by means of your pre stress anchor at the same time in the downstream in the downstream face you have to provide also drainage. So, that water can may accumulated this are all your typical cases typical cases example how this ground improvement technique has been done from the beginning from the upstream face to downstream face. So, that this dam will be stubble or may be this hearing capacity of this dam or the low carrying capacity can be increased now next what of this dam where going to start with this different construction, and monitoring of what dam how it has been constructed how this monitoring process how day to day basis it has been monitored.

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That we are going to discuss reasons for construction, and monitoring; that means, what are the different reasons for construction monitoring this; that means, during construction you need to have monitored discus process ensured proper material are used, because this is a huge structure you will have to ensure proper material has been used, then ensure proper construction, and design is followed; that means, whatever they design has been

made according to that design proper construction has been made that is should ensure, then quickly modify designed, and construction practice based on encountered site conditions this is most important.

What will happened? These are all your based on designs you can go for construction, suppose if the movement you go to this site there some of that else you find it out or encounter during condition or made be site condition immediately what will happened? You should modify the designs well as your construction practice is based on your site conditions. So, it is imperative you have full time site inspection while this particularly dam construction is going on full time site inspection is mandatory.

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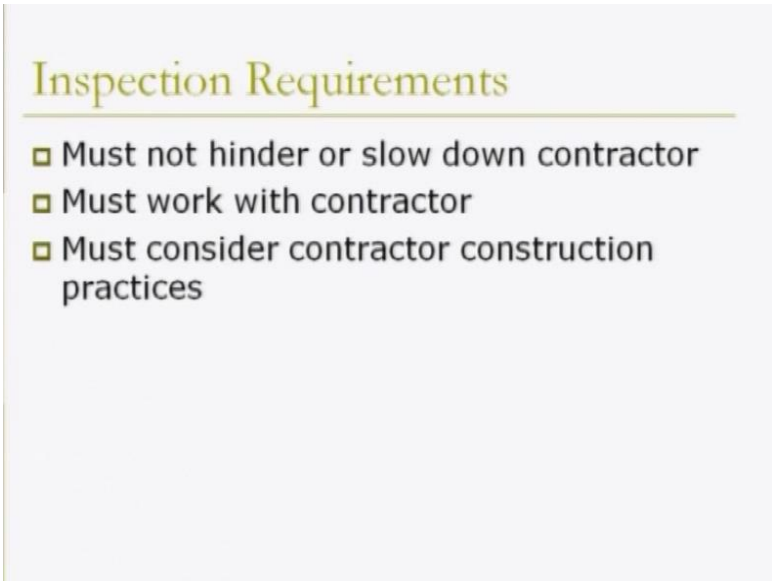

Inspection, it requirement must not induct or slow down contactor, second is your must work with contactor must considered contractor construction practices means it should consider also construction practices, what are the construction practices made?

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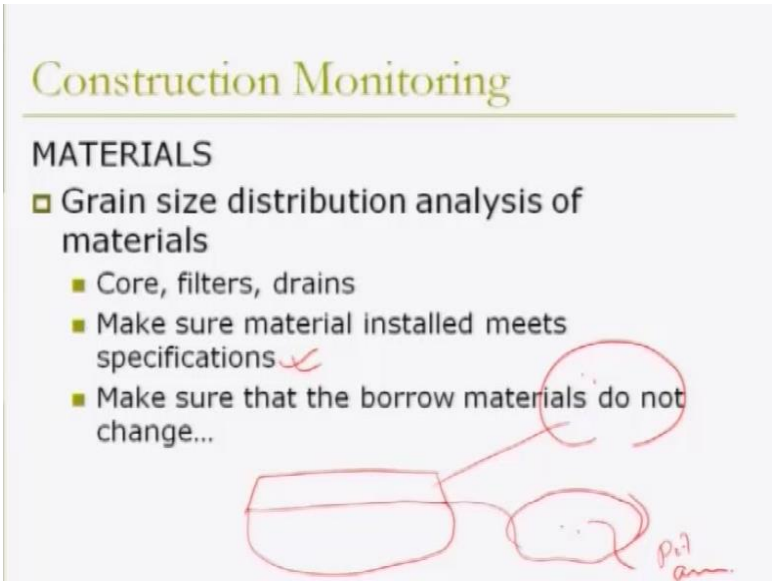

Now, construction monitoring materials, let the start in to this materials grain size distributions analysis of materials grain size distributions analysis materials look at here, what are the different materials, and this there is first ones is the core core is a impermeable than filters than drains than seconds is the make of materials installed meets specification it not be arbitrarily than makes your that the borrow materials do not change the borrow materials this construction, whatever your taking. Suppose this is the dam to be to be constructed, and this side particular this side then what happened form the earth materials.

You are going to take it you will take it near somewhere else this is called pit area; that means, during consents very time you cannot change suppose your taking materials form this are one fage of this construction all i s t form hear next time you cannot change the it areas side then what will happen ones this materials will change the property will change materials also the grains size distribution will change accordingly this strengths also will change; that means, make sure borrow materials; that means, form one borrow the material should be change taken for the construction point of view called pit area; that means, during every time you cannot change suppose your taking materials form this areas one face of this construction all i s t form hear next time you cannot change the it areas side than what will happened ones this materials will change the property will materials also the grains size distribution accordingly this strengths. Now you will change; that means, make sure borrow materials; that means, form one borrow the material should be change taken for the construction point of view.

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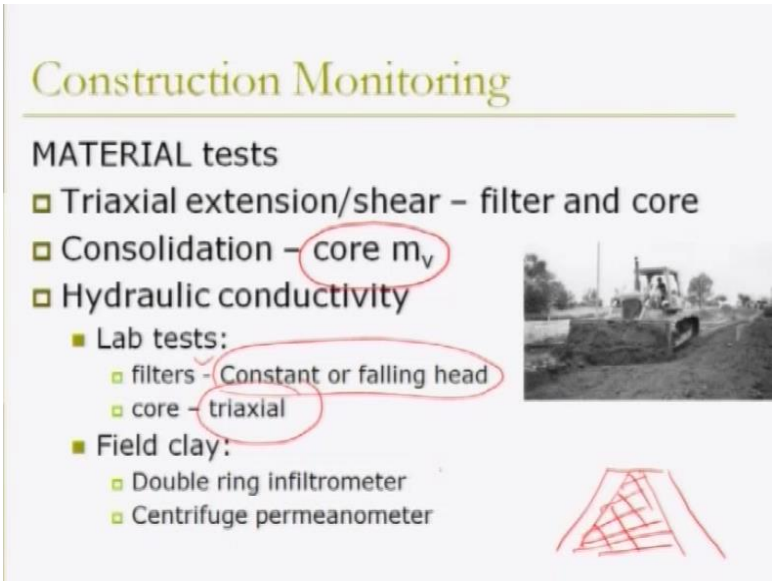

Then material test once for these including construction has been decided core core materials, and filters you will have to do in the laboratory as well as for core material, because core material what it says if this is my core that is means core material is less formable core material is less formable; that means, it is formable for this you need to have your consolidation test. So, that you can find it out co efficient of consolidation co efficient of consolidation you need to have; that means, consolidation for core material you need to have these are all means once this material you are taking for construction. What are the routing test required these are I am discussing, then hydraulic conductivity hydraulic conductivity means how much his particularly k value permeability what is your permeability value for laboratory test; that means, for filters for filters either you go for constant or falling head method either you go for constant or falling head method for core you need to have your triaxial test, then field clay; that means or field clay, if there is the in double ring double ring in infli infiltrometer, then centrifuge permeanometer these test is required for field.

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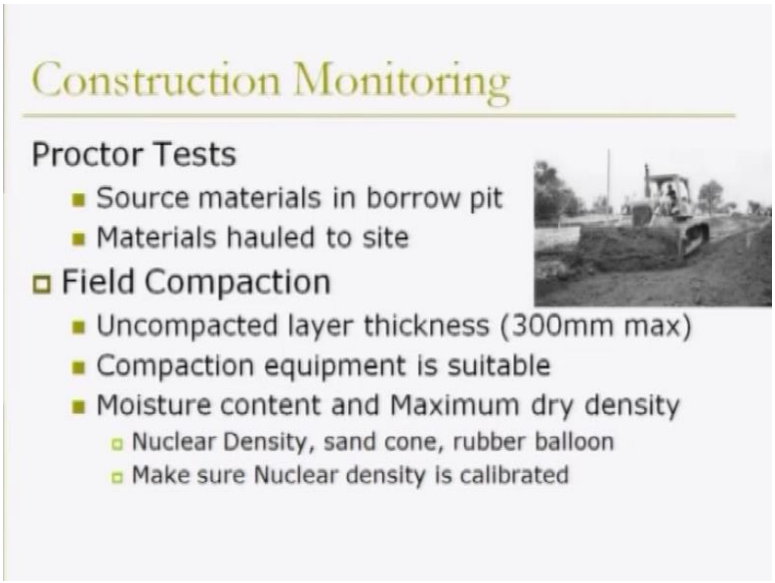

Then proctor tests basic compaction test you need to have the source material in borrow pit the source material from why are you are going to take the material for that you need to have your proctor tests, and material hold hold to the site, then what are the field compaction; that means, un compacted layer thickness uncompacted layer thickness field compaction tests you need to have that is your three hundred mm maximum, then compaction equipment is suitable, then compaction equipment is suitable different compaction equipment is required. Then moisture content, and maximum dry density moisture content, and maximum dry density; that means, nuclear density sand cone, and rubber bell on for moisture content, and maximum dry density make sure nuclear density is calibrated; that means once you are going to find it out for moisture conte particular, and moisture content particular, and maximum dry density of your material, then makes sure that whatever the instrument your using it should be calibrated at like a slight error in your laboratory test it will make lot of difference during these construction goal of compaction why were doing this compaction.

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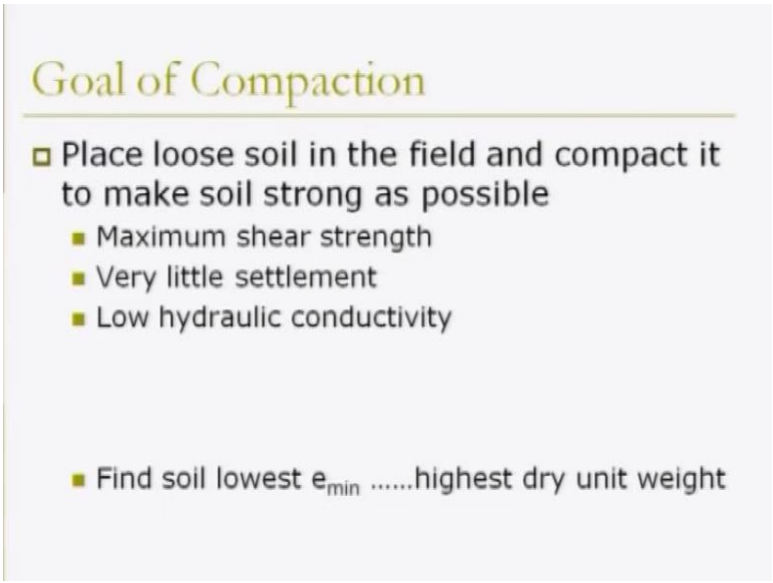

Place loose soil in the field, and compact it to make soil strong as possible; that means, strong as possible means in still, if I say strong as possible; that means, it will be have maximum shear your strength very little settlement settlement will be less maximum shear strength as well as low hydraulic conductivity low hydraulic conductivity means less formable. Then find soil in lowest e minimum e minimum is your soil ratio minimum lowest e minimum density will be more highest dry unit weight; that means, you need to have find soil of lowest e minimum e minimum lowest soil ratio; that means, lowest soil ratio means pouts very less; that means, what will happen its density will be more will discuss all other parts may be in the next class. So, I will stop it here.