Application of Soil Mechanics
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Lecture – 30

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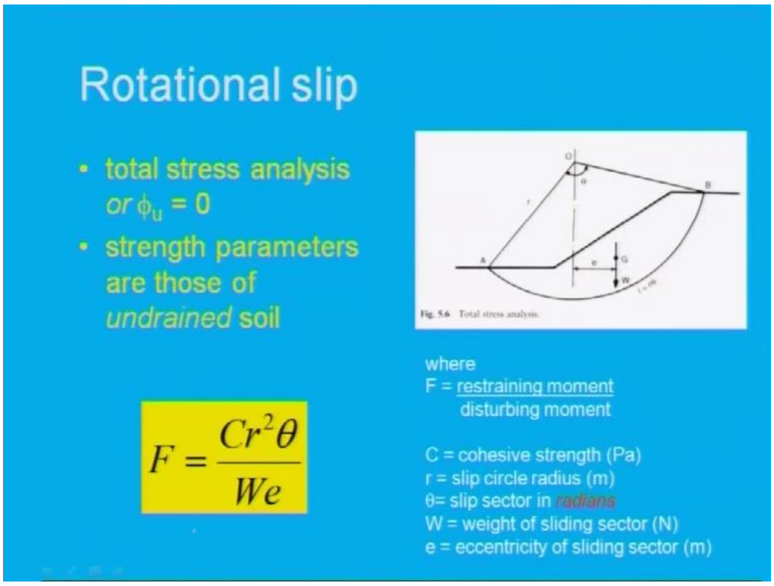

Last lecture we have finished rotational slip a total stress analysis, and for conditions factor for digestive movement as well as disturbing movement.

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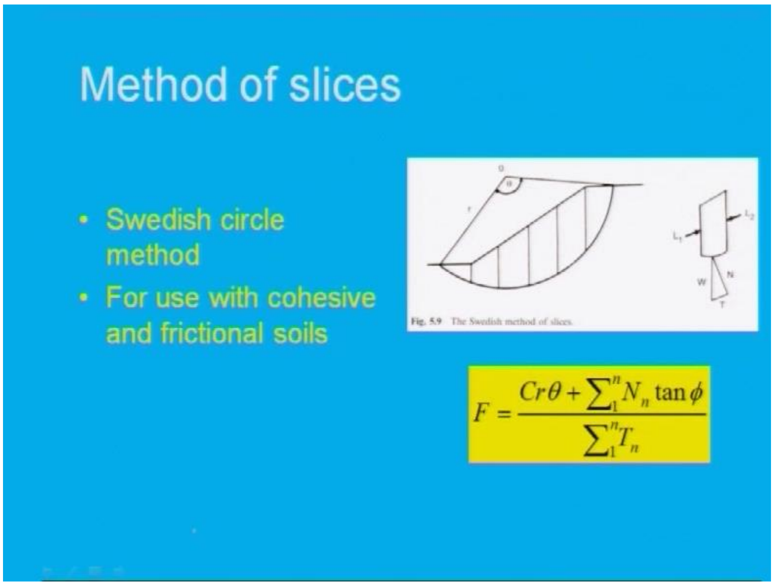

Then method of slices by Swedish slip circle, and cohesive as well as frictional soil.

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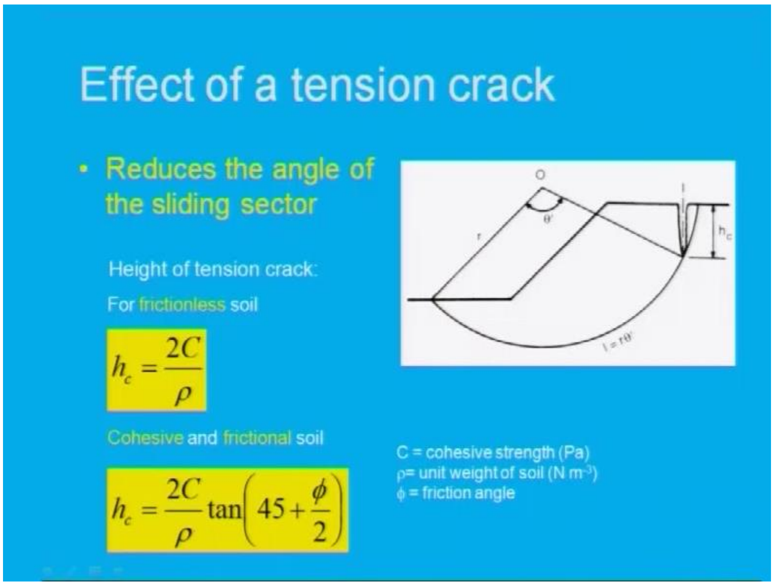

We have also discussed, then effect of tension crack on this loop stability analysis also as we discussed, then how to find it out this location of the slip circle center also you have discussed.

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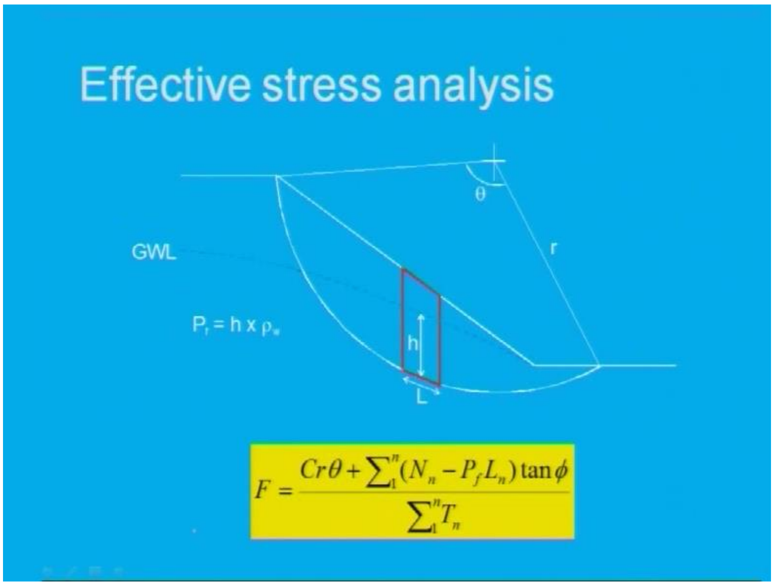

Now, a effective stress analysis also last to last class also you have discussed this effective stress analysis by method of slices also other methods of analysis available is Taylor's stability analysis.

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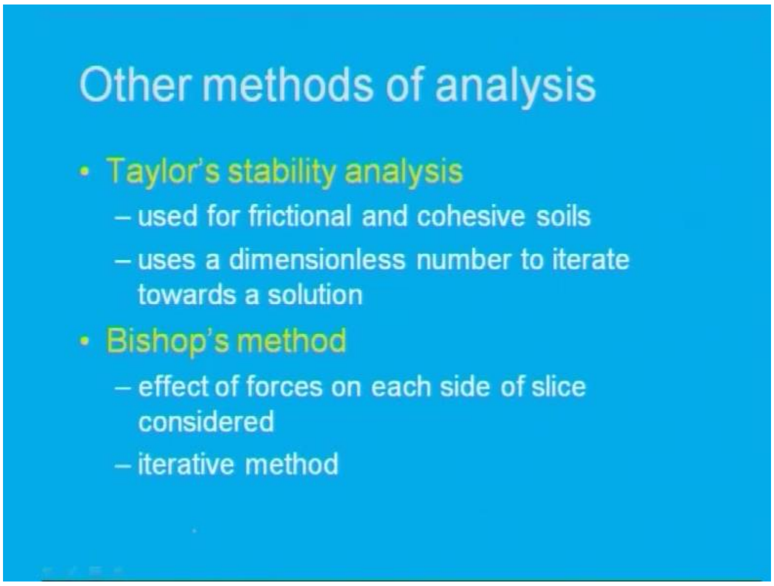

So, this Taylor's stability analysis it is used for frictional, and cohesive soils use as a dimensionless number to iterate towards a solution, then bishops' method also I have discussed also earlier.

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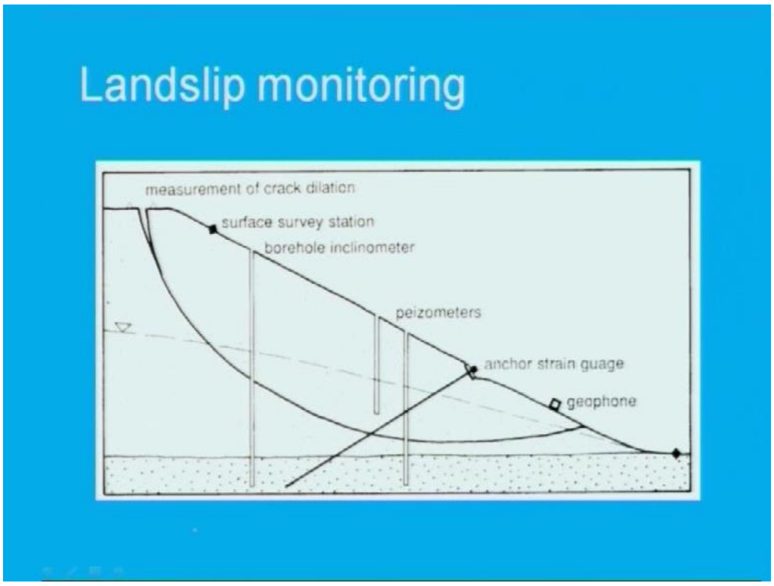

Now, how do you major particularly this landslip monitoring how do you monitor what is the slope failure, and launch slip monitoring by means of mergel instrument of is soon, if you look at here this is a slow for a back matte generally what happen? There are there are if you look at here this is are all you have borehole inclinometer.

So, this borehole inclinometer generally provided. So, to find it out how much it will settle what is that what is that settlement along these along these, and how much this flow will be there, then also there are measurements of crack dilations. If you look at here these are all your one, and two measurement of crack dilations are, if you look at here, then you can find it out how much crack at the top eight it generated, and by means of borehole inclinometer you can also measure this.

What is the how much settle as well as the peizometers are, they are with the help of peizometer, you can find it out water table fluctuation of water table in whether is a raisin water tables in rainy season how much the water table falls down particularly in summer season by means of peizometer, then strain gage has been put it anchor strain gauges anchor strain gauges along the slow it has been put it. So, these anchor strain gauges it has been put it. So, with these anchor strain gauges you can find it out how much strain; that means, what is the displacement of this slow, then geophone also some times will provide to measure this generally you can generate means how what is the what is the travel geophone is their how much your travel time from top to bottom you can measure it by means of sub geophone. So, these are all your land slip monitoring system.

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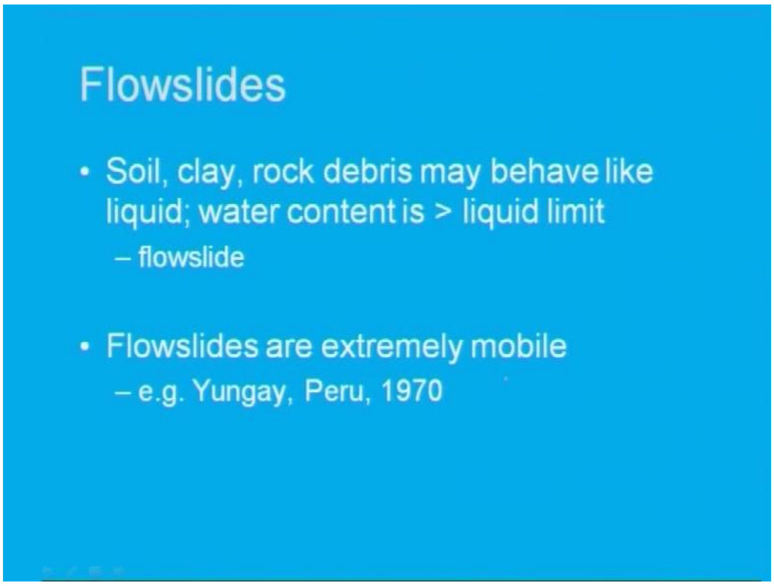

Then flow slides soil clay rock debris may behave like liquid it may behave like liquid water content. So, means behave like liquid, if water content is greater than liquid limit, if you look at here, if the water content of soil of consistent among clay or may be debris if this water content is greater than the liquid limit, it will behave like a liquid, and in that case it is called flow slide it is called flow slide these slide will flow like a liquid flow slides are extremely mobile as given by yungay peru in nineteen seventy is has been a observe.

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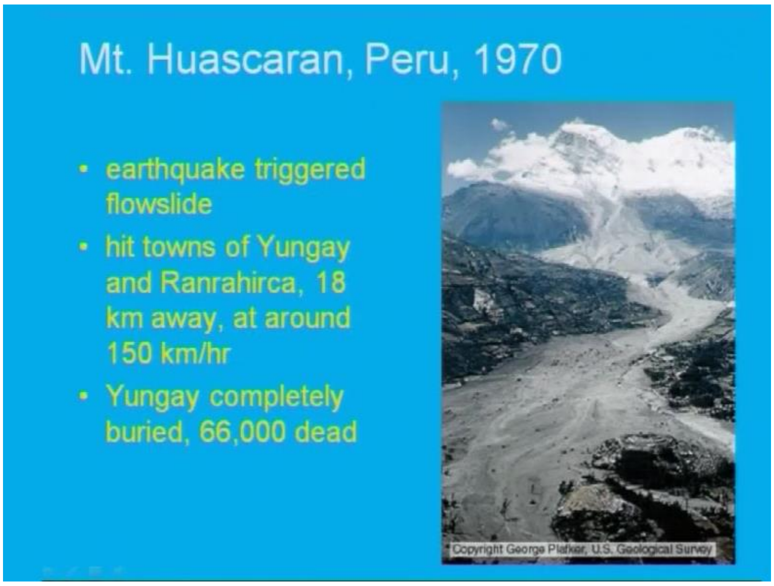

If you look at here peru nineteen seventy earthquake triggers particularly flow slides means what will happen the water, because of earthquake triggered this water content increase this water content is more than water content is more than your liquid limit. So, once is water content is more than liquid limit, if these by means of in peru nineteen seventy by triggering.

This earthquake it hits towns of yungay eighteen kilometer means away at around, and that fifty kilometer per hour hour. If you look at here it is started from here, then this flow slides it is flowing it is flowing this slope means complete mass of the soil mass along the it is flowing, and it is coming down.

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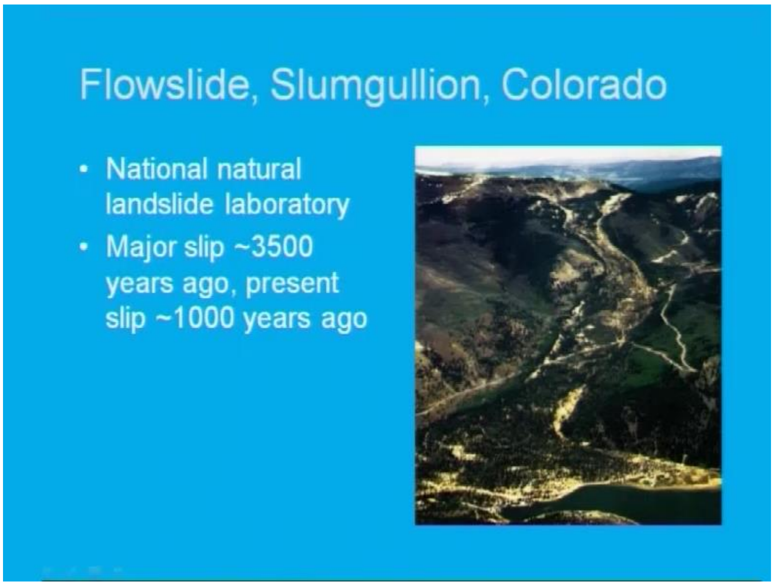

Then next example is soil in a in a case of colorado it is a national natural landslide laboratory if a major slip is a about three thousand five hundred years ago, and present slip is one thousand years ago.

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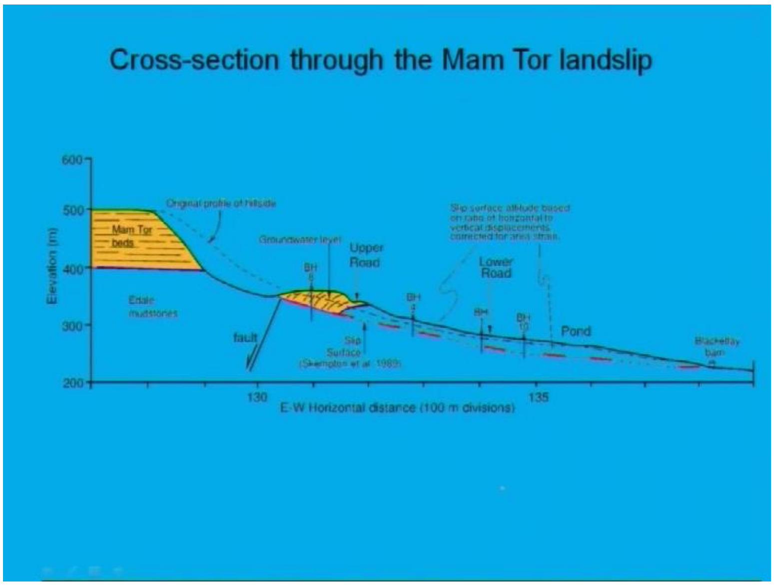

Then the landslip has been means cross section through this mam tor landslip if you look at here mam tor bade here. So, original original profile original profile of this inside, then if you look at this original profile, then it has been this, because of this landslip this part has been gone this part has been slip, and float what is the bottom this a clear picture means these are all your clear examples of k case one, and case two different case studies am showing.

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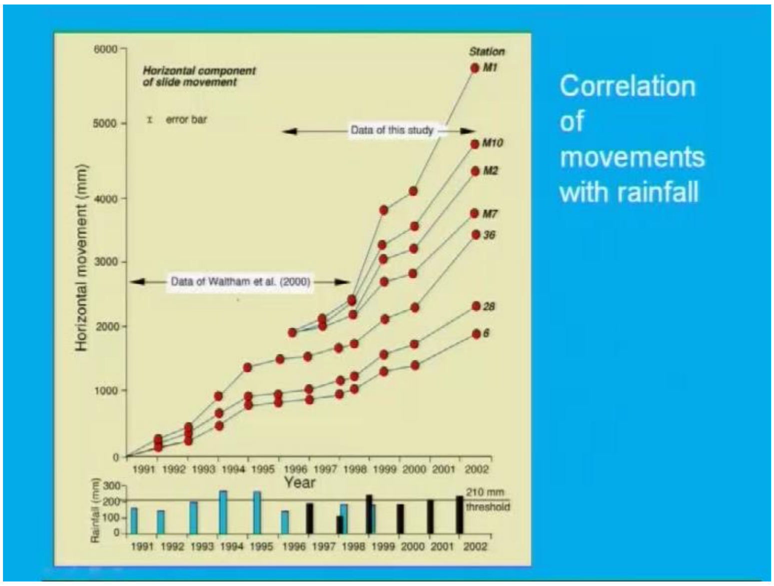

There is there is there is a like correlation of movement with this rain fall they have given. So, that is out of contains those I am showing with the rainfall how much the movement can be possible, let has been some correlation has been given.

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Now, this is all about basically about basically your slope stability analysis, and basic principles of slope stability analysis, how you are going to do this slopes slopes stability analysis, then will start next part of this dam next lecture start with the dam.

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DAMS

Classifications based on type and materials of construction

Criteria for selection of best dam type:

1. Feasibility
   -topography, geology, and climate (& its effect on materials)

2. Cost
   -availability of construction materials near the site; accessibility of transportation facilities

Types	Materials of Construction
A. Gravity	Concrete, rubble masonary
B. Arch	Concrete
C. Buttress	Concrete, also timber & steel
D. Embankment	Earth or rock

Basically if I start with the dam dam has been classified best of type of material of construction. So, classification is what type of material taking in to for construction point of you these dam is classified than criteria from selection of dam is feasibility first one is feasibility; that means, topography geology, and climate what climate your using, and its effect on materials second is cost; that means, availability of construction materials near the site that is accessibility transportation facilities. So, what is the different type of dams available if at look at here different types of dams are gravity dams arch dams buttress, and last one is embankment, and the material construction for gravity dams generally material used concrete rubble machinery for arch type of dam we generally used this concrete, then buttress concrete also timber, and steel embankment it is construction of earth or rock.

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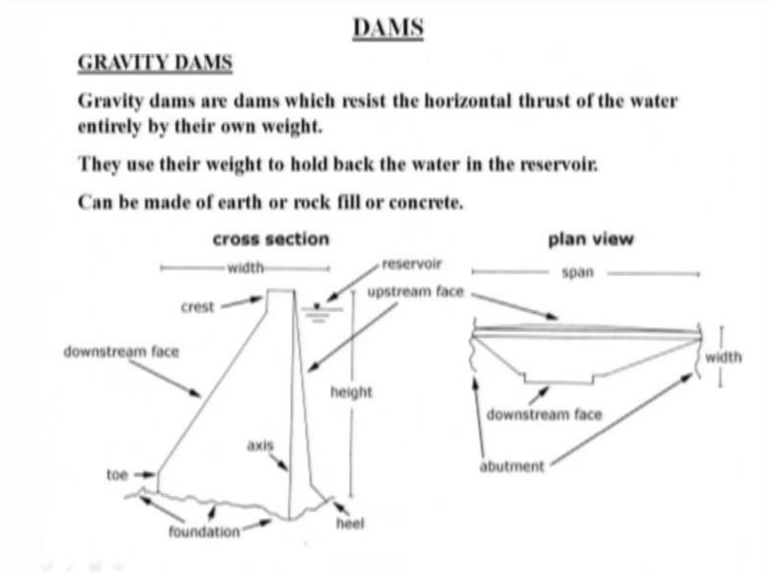

Start with the first one is earth, and gravity dams, if look this gravity dam gravity dams are dams which resist the horizontal thrust of the water entirely by their own weight, if we look at here gravity dam is the dam which resist the horizontal thrust of the water, if this is my water label lying here horizontal thrust of the water by its own width complete by own width; that means, this is the dam gravity dam by its own width whatever the horizontal load is coming it will take or it will completely it resist this is horizontal load by horizontal trust, because of trust, because of here water table. So, by its own weight gravity dams will take stability they use their weight to whole back in the water in the reservoir as I said they use their complete weight.

So, that its start by own complete weight. So, that backside whatever the water label is there that can be whole can be made of earth or rock fill can be made of earth or rock fill. If we look at their this two views; one is your cross section view; other is plain view in this cross section if this is a gravity dam generally says that where this water is reservoir water as to be store here is water as to be store the water as be to store here; that means, this is called upstream face this is called upstream face, then where this water as been store this is called reservoir this is called reservoir, and this bottom part is called heel this bottom part of this where this water reservoir this is called heel, and the opposite side this is called toe it is called toe why it is called toe, because of the water plus at thrust that is charge that the this gravity dam may rotate along this point that is why it is called toe than there is a face this is called downstream face, and this is your crest crest is your top of the dam, and then width width is the starting form base this is total may width of the dam width of the dam, then if I start with the plan view if at look at the plan view this is span upstream face width, and downstream face, and abutment this are all abutments.

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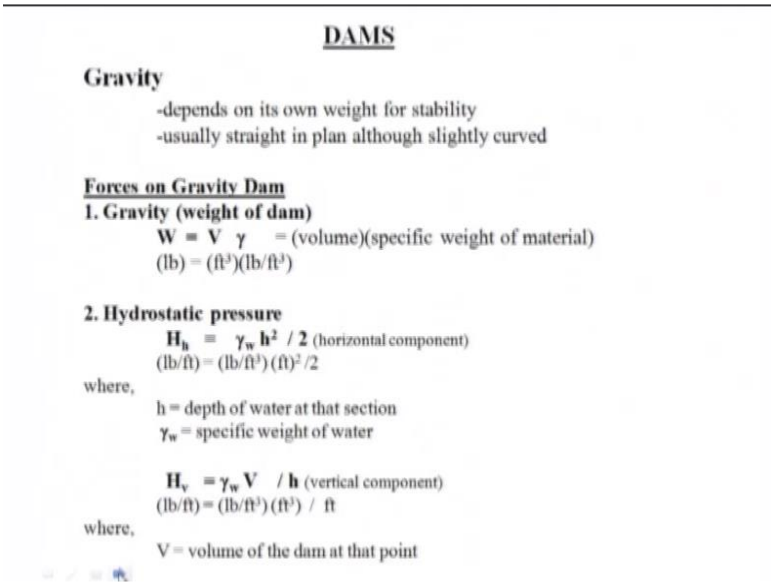

Gravity dam it depends its own weight for stability means particularly this stability analysis of gravity dam as been dam by its own weight, and usually straight in plan although, and slightly curved slightly curved. So, what are the different forces come into gravity dam, if at look at here in gravity dam the forces coming by means of gravity; that means, of by own weight own weight. So, weight can be calculate b into gamma. So, b is equal to volume total volume, and gamma is equal to specific unit weight of material suppose this gravity dam as been constructed over soil, and specific unit weight of the soil or it has been constructed this rock, then it is a unit weight of the rock; that means, volume this unit weight is a units newton is force for meter q or feet q.

If multiply into volume this is your gravity weight of the dam, then second part what is the forces coming into picture hydrostatic pressure hydrostatic pressure means there are two component hydrostatic pressure, because of we are water one is horizontal components other is vertical components. If I start horizontal components this is gamma w unit weight of water into h square of two h is your h your depth of water at that section death of water at that section gamma w is equal to specific weight of water gamma w is equal to specific weight of water. Now h v is equal to h v is equal to means your h h is equal to hydrostatic pressure means horizontal components h v is your vertical components gamma w into b by h by h is your vertical h your vertical component gamma w into b divided by h. So, v is volume of dam at that point. So, this are the forces third forces your discussing what is gravity what are the dams, and classification dam, then we starting one by one first one is gravity dam, and where it has been used how can the stability can be dam for the gravity dam.

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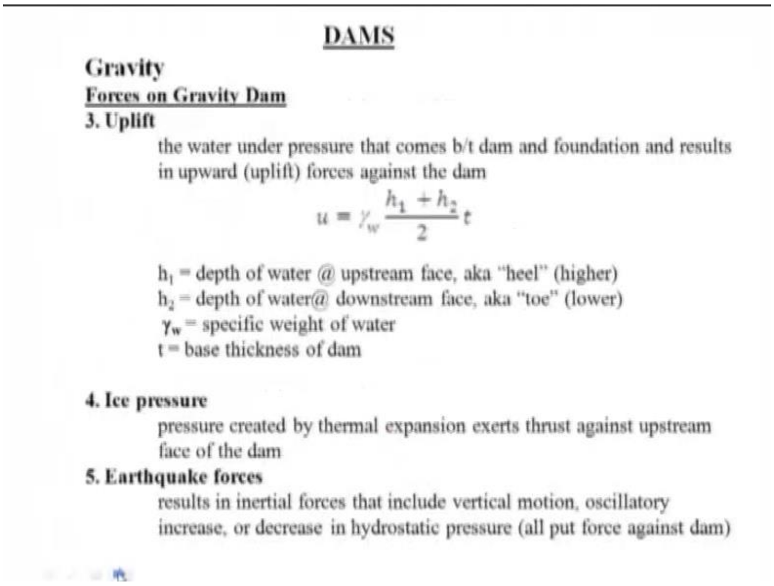

DAMS

Gravity

Forces on Gravity Dam

3. Uplift

the water under pressure that comes b/t dam and foundation and results in upward (uplift) forces against the dam

$$u = \gamma_w \frac{h_1 + h_2}{2} t$$

h_1 = depth of water @ upstream face, aka "heel" (higher)
h_2 = depth of water@ downstream face, aka "toe" (lower)
γ_w = specific weight of water
t = base thickness of dam

4. Ice pressure

pressure created by thermal expansion exerts thrust against upstream face of the dam

5. Earthquake forces

results in inertial forces that include vertical motion, oscillatory increase, or decrease in hydrostatic pressure (all put force against dam)

Then what are the forces update on the gravity dam in this section forces of gravity dam, third is your uplift; uplift means the water pressure that comes below the dam foundation a result in upward means uplift, if I come back to water pressure coming below, and in the foundation, it push up this is called uplift force this uplift force you generally is retain gamma w h one plus h two by two into t h one is equal to death of water at upstream face heel, and h two is equal to h one is equal to death of water at upstream face h two is equal to death of water at downstream face; that means, lower.

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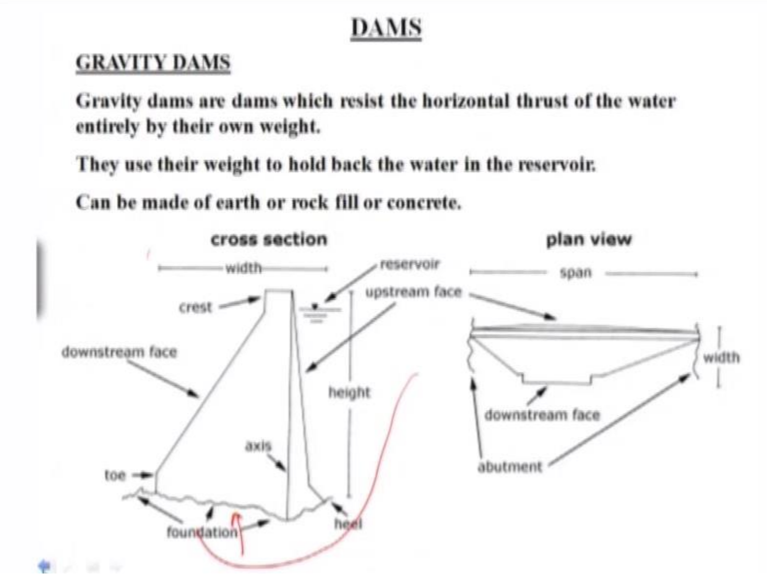

If I say that means, if take it to here this is my death of water at upstream face h one. So, this is the death of water at downstream face h two h one, and h two know gamma w is equal to specific weight of water, and t is equal to base thickness of dam this is your t is equal t is equal to base thickness of dam, then ice pressure fourth one is ice pressure ice pressure is created by thermal expansion exerts thrust against upstream face of the dam what will upon in particularly if there is a dam over the period of a cold means the once the winter season start particularly Europe country what will happen entre liquid entre water will become ice. So, that it will becomes a ice, and soil pressure this pressure will be higher than a water pressure. So, this is one forces suppose to come ice pressure than one we are going for analysis of gravity dam will do it for gravity dam in advance condition this gravity dam particularly in advance condition; that means, what are the different forces as to come in advance condition these ice pressure is not necessary to come particularly summer season.

So, ice will be ice pressure start particularly in winter in European country than last one is fifth one is your earthquake forces. We are check also result in inertial forces that include vertical motion oscillatory increase or decrease in hydrostatic pressure earth quack earth force earth quack load earth quack what will upon. So, gravity dam. So, this earth quack forces also taken in to consideration.

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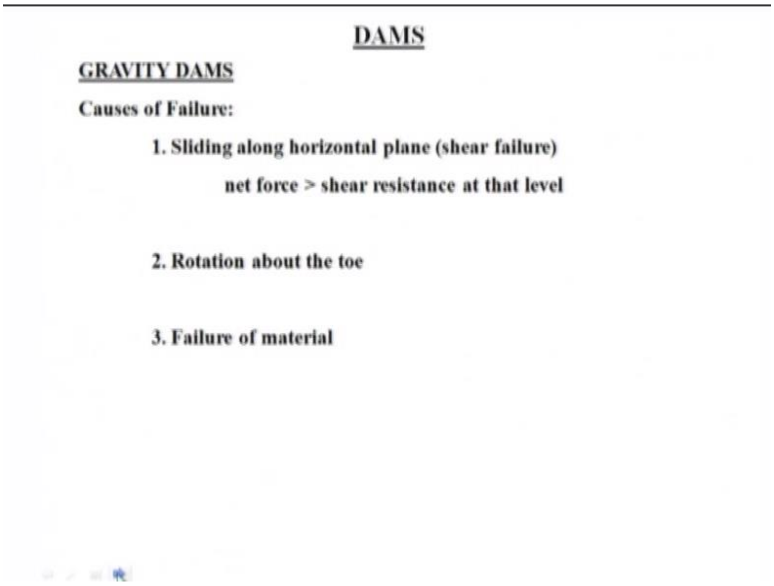

So, gravity dam what are different causes of failure one is your sliding along horizontal plane that is called shear force sliding along the horizontal plane that is called shear force sliding along the horizontal plan; that means, that slide if I take it like this. It is slide along the horizontal plan so; that means, what will upon; that means, what will upon it will it will resist against this your force; that means, sliding along horizontal plan; that means, we are failure.

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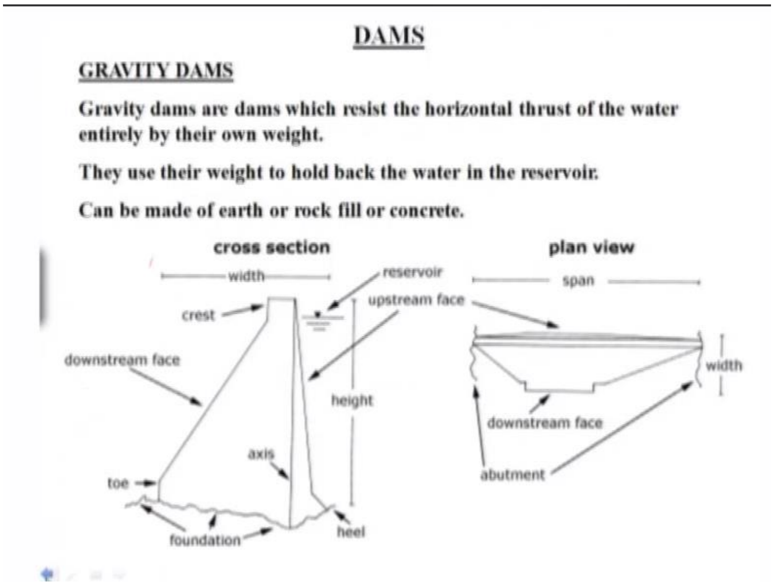

That means, net force net force will greater than shear resistance at that level than second

second cause of failure is equal to, because of all forces ice pressure, water pressure, earth quick pressure earth quick forces, because of this all forces there might be a chance that this particularly this had dam, it may double, it may rotated a type toe a type of the toe. So, this part as taken in to consideration; that means, second type of failure is a rotation about toe third one is that if this construction has not been done properly it may highly possible that this material failure may occur the material may fail material fail may occur.

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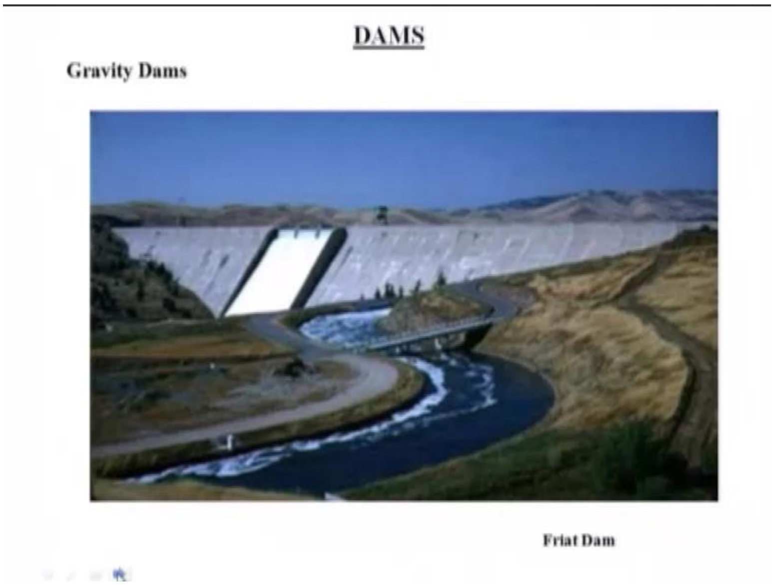

So, examples this all means there two three case example put it graphic dam if look at this gravity dam, then second one is your it is in west virginia also in india graphic dam west Virginia, there it is look at here, one this is your upstream.

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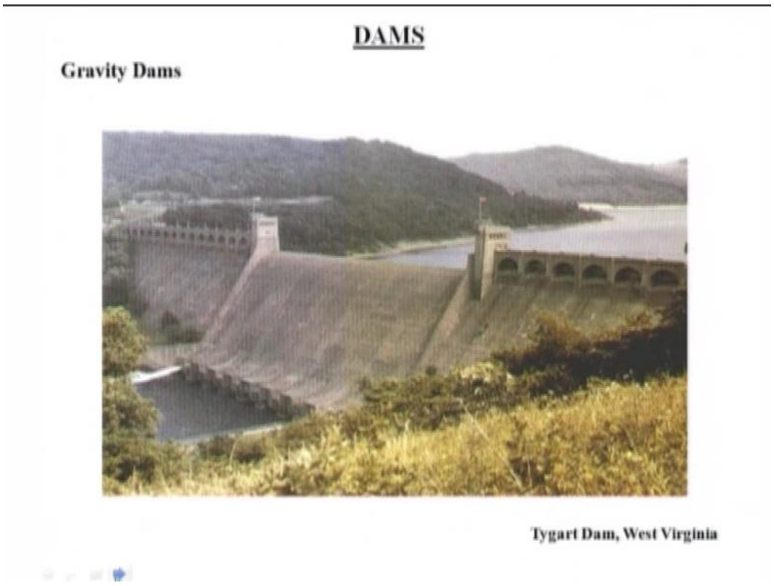

This is your upstream side this is your downstream side, if I draw the cross section simple cross section of the gravity dam look at here this is the water, if I am looking like this. So, this side water river is there water has to be the remains stored.

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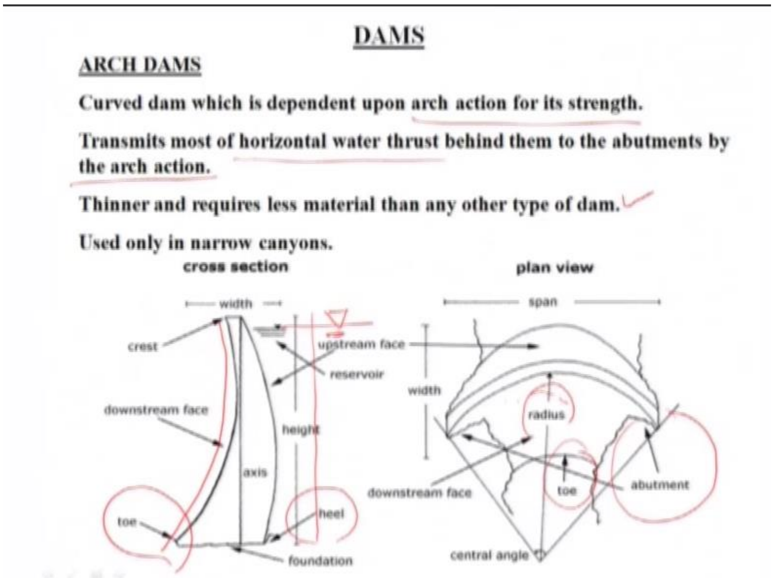

And this size downstream side second case is arch dam is are all come down curve dam, which is dependent upon arch action for its strength, which is dependent upon arch action for in strength transmits most of the horizontal water thrust thrust means most of the horizontal water thrust arch dams these are particular crop dam, which is depending upon arch action for its strength, and transmits most of the horizontal water thrust behind them to the abutments by the arch action means whatever the horizontal water thrust horizontal water force is coming. It will transmit by means of arch action by the arch action means whatever the water pressure is coming it will transmits to abutment by means of arch action advantage of that it is a thinner, and requires less material any other type of dam means it is a very thin, and requires less material than any other type of dam used only, and it is also limitation used only in narrow canyons. If we look at this cross sectional view this is my width, and this is your upstream side, and this is your height this is your total height of water, and this your complete reservoir, this is we are complete reservoir, and this is your toe, and this is heel, and this is downstream face, and this has been updated by this is your arch action, then this is axis complete axis this is your arch action, if I take the plan view.

How we look the plan view this is the complete span, and this is your abutment, and this is your toe, and this is your downstream face, and there is are radius, and central angle.

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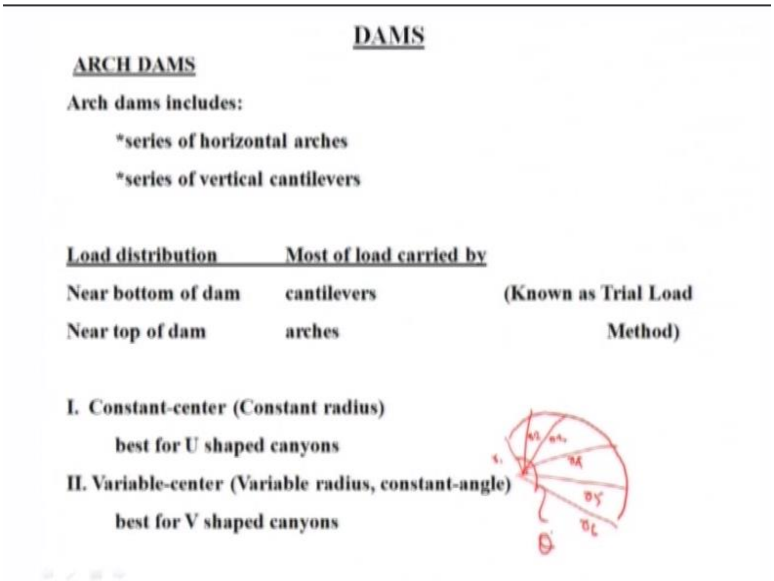

Particularly arch dams it includes series of horizontal arches, and series of vertical cantilevers load distribution most load distribution near bottom of dam near top of the dam, and most load carried by cantilevers arches known as trial load method. So, constant center; that means, constant radius. If I look at the types of the earth one is constant center; that means, this is a constant center this radius is the radius is constant.

Means throughout the radius is constant this is one shape of arch type, and another one is variable center variable center means variable radius. If at look at here, if at look at here, the radius at each point the radius is each point is vary; that means, r one r two r three r four r five r six, but the angle is constant angle is constant. So, there is two cases first case is your radius constant angle is vary, and second case is angle is constant, but radius is vary. So, first one is called constant center second one is called variable center. So, generally, it is used for u shaped canyons, and best for v shaped canyons will see these will see these photographic.

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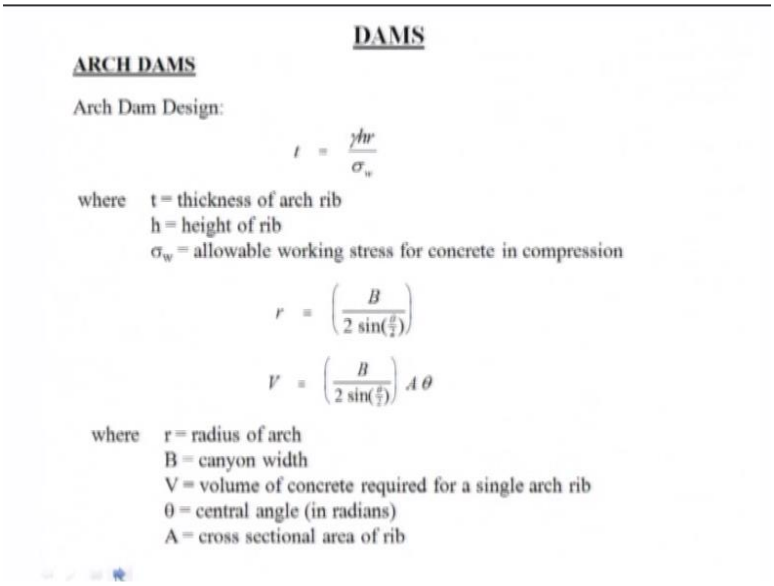

Graphical picture of these arch dam design generally thickness of arch rib is as to be calculated from t is equal to gamma h r by sigma w t is equal to thickness of arch rib t is equal to thickness of arch rib h is equal to height of rib gamma w is equal to allowable working stress for concrete in compression, and r we can we can get it b by two sin theta by two, and v is equal to b by two sin theta by two into a theta r is equal to radius of arch r is equal to radius of arch B is equal to canyon width v is equal to volume of concrete required for a single arch rib, and theta is equal to central angle in radians a is equal to cross sectional area of rib a is equal to cross sectional area of rib.

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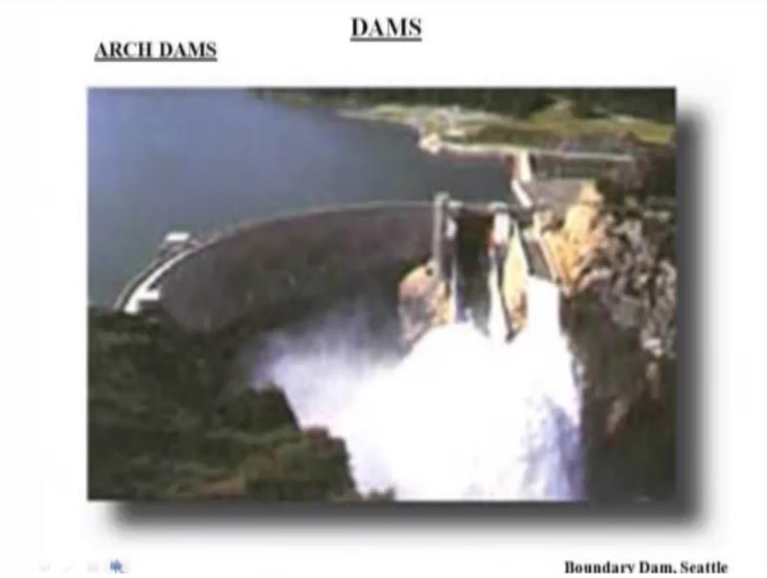

And if we look at this in u s it is boundary dam see at in u s, if we look at here arch dam how this arch safe photographic picture may not be clear look at this arch rib, and look this thickness a material used is a very small quantity is compare to other the dams again is a not visible. Let me see if you look at this look at this, this a arch safe this part your. This part your upstream side this part your upstream side this is your downstream side juct one picture may be next class show that clear picture can be one picture slid can be make it. So, that more clarification more it may be clear all of you.

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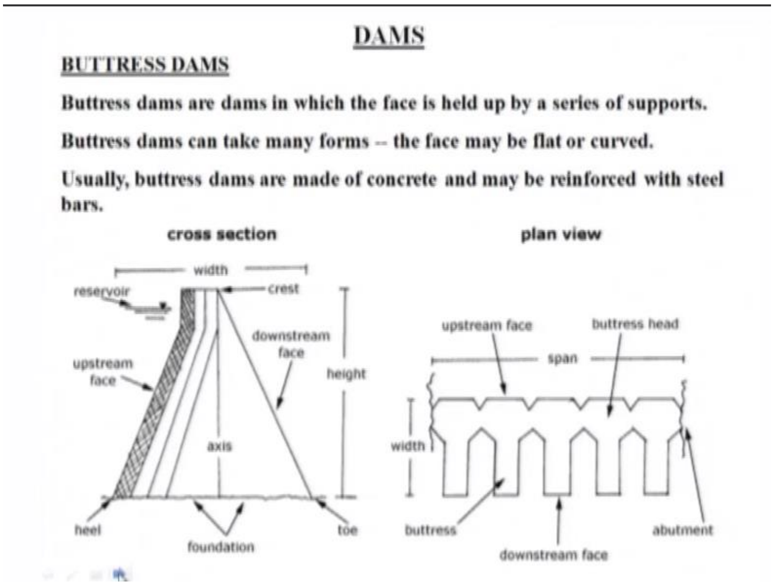

Third part where starting with this that is your buttress dam buttress dams are a dam in which the face is held up by series of support of face is held up by series of, support if this is my space this is the upstream face this is the downstream face face is suppose by series of support held by series of supports buttress dam can take many forms the face my be flat or curved usually buttress dams are made of concrete, and may be reinforced with steel bars. Usually buttress dams are made of concrete, and may be reinforced with steel bars may be reinforced with steel bars. So, if we look is cross section this is the width, and this is the crest, and this is your downstream face downstream face this is your height, and this is your toe, and this is your axis, and this is your foundation of upstream face with is series of support in the upstream face is there.

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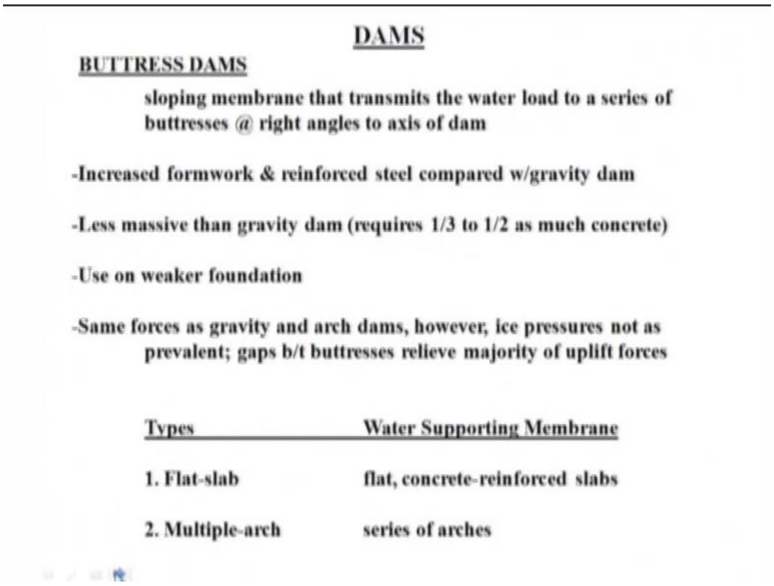

So, in case of buttress dam sloping membrane that transmits the water load to a series of buttress at right angle to axis of dam at right angle to axis of dam, if you look at here. Sloping member sloping member that transmits the water load to a series of buttress sloping member this are sloping member the transmits the water load to a series of buttress transmits the water load to a series of buttress increased formwork, and reinforces steel compared gravity dam if we look at this increased formwork, and reinforces steel as compared gravity dam they reinforcement they reinforces steel provided is more less massive than gravity dam here what we will upon axis bars generally provided, if come back to gravity dam it is a less massive means the area, and mass stature is coming it is less massive required.

One third to one half as much concrete it requires one third to one half as much concrete, then use on a weaker foundation use on a weaker foundation, if I make it into buttress dam where it has been used what is the purpose, and how are it is advance t gravity dam, and particularly where specifically where it has been used use on a weaker foundation. So, some. So, forces means particularly same forces as gravity, and as dam is same forces as acted like we ice pressure not as a prevalent. So, grasp of a buttress relieve majority of uplift forces. So, same forces the way of discuses this way of gravity dam what are forces as gravity it is the same forces along the arch, then types of buttress dam.

But one is flat slab; that means, flat concrete reinforced slabs flat concrete reinforced slabs second is your multiple arch multiple arch; that means, series of arches there this is the two type of buttress dam.

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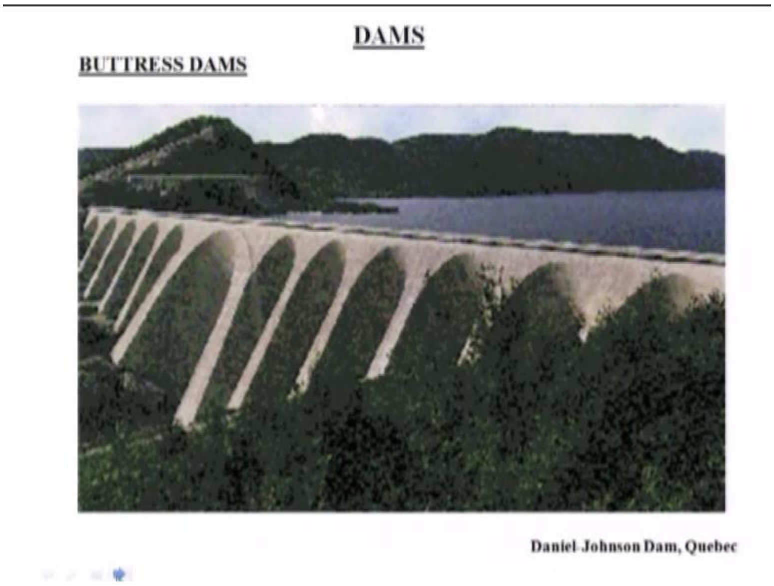

Now, look at this examples buttress dam first one buttress dam, if you look at their buttress dam upstream side buttress dam, if you look at here in quebec one cases of buttress dam.

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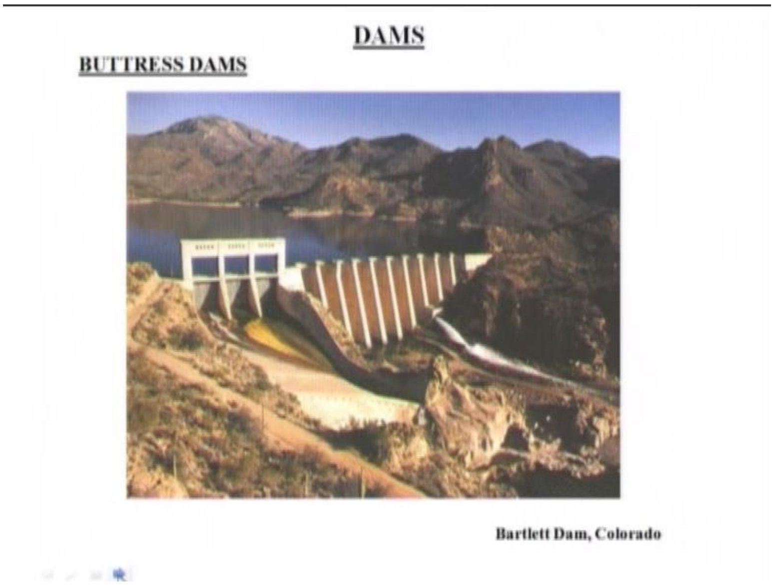

Second, now it is clear. Now if you look at here colorado also buttress dam as been use this side is upstream side; these is your particularly downstream side. May be we can shop it here. So, start with a other embankment type of dam next class.