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

Lecture – 27

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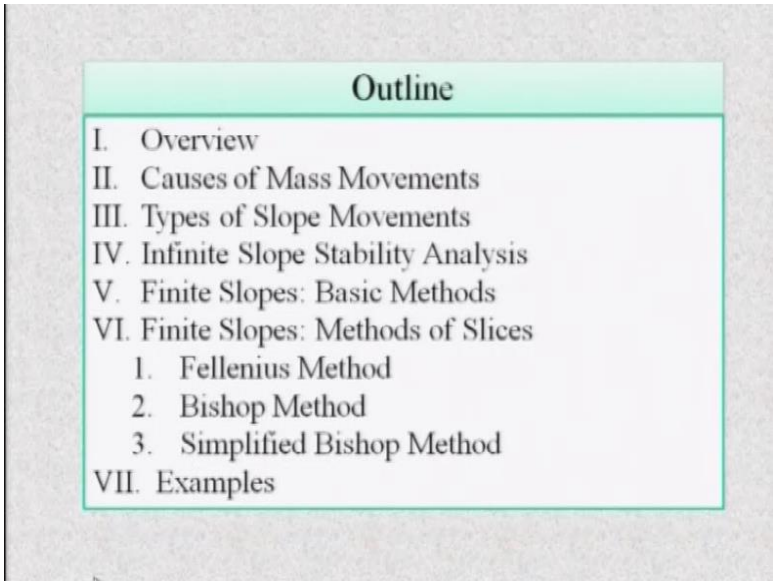

Next part of this lecture we talk the new module that is arc slopes, and embankments, and a dams. So, au let us starts with first basic things spring pools, and basic physics, and basic analysis of arcs slopes affability overview you can see outline one is what is arc slopes affability overview, and what are the different causes of mass movements, and types of slope movements, then in that types of slope movements infinite slope stability analysis, then finite slope stability analysis in case of finite slope stability analysis what are the different basic method. So, will discuss, then particularly finite slopes method of slices by means of method of slices what are the different method available by felonies method bishop methods, and simplified bishop methods, and that the end will try. So, few examples solved example how it has been solved this slope stability analysis.

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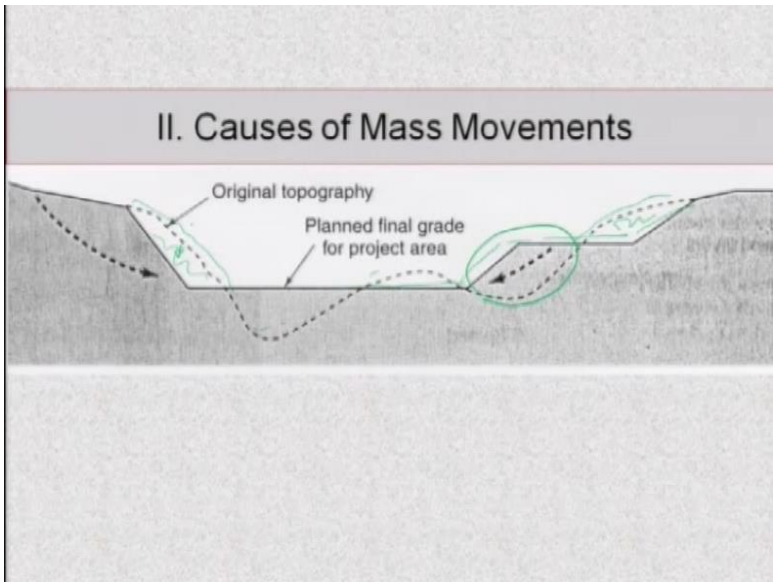

Now, what is the first overview what is the cause of mass movement what is the what is the reason that mass movement, and slope deliver generally occurs it will look at here if you look at here this is my original topography this is the this doted lines are original topography of a reason, then it has been proposed a slope or embankment has to be constructed. So, this embankment construction is this this part of the this embankment construction will look at here this is the embankment has to be this has to be embankment has to be constructed, and this is a planned proposed construction. So, from these original topography what will happen these part has been taken out this part has been taken out, and also this part has been taken out, and this part also filling this part is your filling. So, by means of these if he look at here, once I have taken out, once I will taken out the soil mass from here why constructing this embankment, then what will happen there is a flow flow of the mass this direction has been made also here it is a filing of soil mass the flow of this mass movements.

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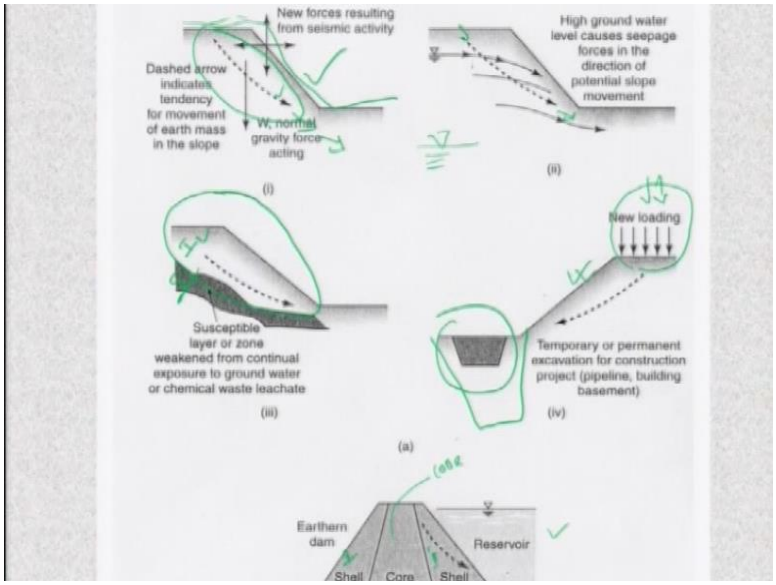

Now, what are the different how how it is possible this mass movement, if you look at here there are there are different cases case one, case two case three case four also dam also au it has been drawn let us start with this case one. So, if we look at here this is your case one in these case what will happen this there will be a if I considered this is my slope, and this is the embankment, this is your embankment in this embankment w g or gravity, and gravitational force acting down ward, and this dashes line particularly this dashes line would be this arrow indicates tendency of soil mass moving towards moving away moving is not away moving towards this embankment sites. So, what are the different forces coming into picture the forces are, because of yourself weight that is your normal gravity forces acting vertically downward, and this dotted or arrow lines is it your tendency how this mass movement occur, and you can consider also.

New process taking into consideration or seismic seismic or earthquake forces this is typical pseudo static cases, then case two high ground water level, if this water level suppose this initially this ground water level or ground water table is at this point, and it has been raised to up to this embankment. So, high ground water level causes a c p s force this is your c p s force c p s force in the direction of potential slope movement how the in case one we saw that direction of potential slope movement this is my direction of potential slope movement how slope movement this is your direction of the potential slope movement. So, once there is a water table from here to here up to be ground surface or up to be embankment level what will happen these sea face force also acting

in the direction of in the direction of your ground movement.

And the direction of your arc mass movements. So, what will happen along with this arc mass movement there is also c p s force movement. So, c p s water along with this it it will arc c p s force will art additional movement or additional arc slope movement, and along with these directions which has been marked now case three if in this embankment if in this embankment may be in this slope particularly this slope if there is a layer layer which is a very weaker which is very weaker in nature; that means, very weak as compare to this if I considered this is layer one, and this is layer two. If I compare with this layer one, and layer two layer two is weaker than your layer one what will happen, because of layer two is weaker. So, it will settle once it will settle. So, these entire mass these entire mass soil movement will occur.

So, another reason is susceptible layer or zone weekend from continuous continual exposure to ground water or chemical waste legates, then forth case is temporary or permanent excavations for construction of a project it will look at here, if this is your existing slope, this is your slope is their existing slope embankment in these case it has been it has been proposed to construct here. That means, some new load will come here construct a structure here at this surface of the embankment at the same time what will happen there is a temporary excavation here this is your temporary excavation has been made ones the temporary excavations has been made what will happen the soil, because here it is new load on new structure has to be constructed.

What will happen? This entire mass will try to move a move towards your excavation this is another cause of your this is another cause of your slope failure, then for particularly added dam or term if you look at the cross section of added dam if I make it this earthen dam there are two sales one, and two in between there is a core in between there is a core. So, what will happen, because of water preserver the sale it will this arc movement will be direction of towards your water reservoir. So, these are all common what is the reason that there is a mass movement or may be a sort of slope stability or slope movement may occur, these are the all few reasons which have been highlighted now types of slope movement. First one we discussed what are the reasons what is the cause for your slope movement, once you know that cause this second one what kind of slope movement may occur.

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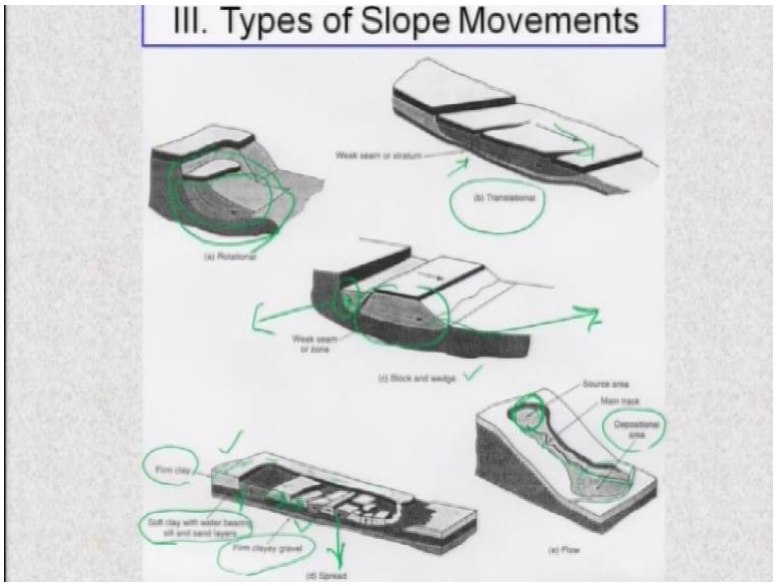

If you look at here, there are one two three four different cases, if you look at here, case one is your rotational case; rotational case means entire soil mass entire soil mass will rotate entire soil mass rotate. If you look at here in this diagram this entire soil mass will be rotate, this is called rotational slope movement get another case two is your translation translation. If you look at here there is a weak stratum it has been marked, and shown here, then what will happen translation means one of another this will be movement from this. So, this is your translation movement, then third one is your block or block end wedge; that means, what will happen instead of moving case one entire soil mass if you look at here there is a bigger weaker zone below this slope instead of moving entire soil mass like rotational what will happen? It will move like it tool wedge it will move like a tool wedge.

So, here to here this will be one wedge, and here to here this will be other wedge; that means, two wedges are moving. So, that is why this is called block or wedge, why it is called block it will act like a block, and it the movement will be like a sep separate this entire soil mass will be separated into two blocks or two wedges. So, the movement will be called or a soil movement it will be called block block end wedge movement, then another one is yours spread spread movement. If you look at this, this conditions also it has been mentioned this is a farm clay this side be this part is your farm clay; that means, this entire soil here is what ever mark in the white these are all your farm clay below this farm clay there is another soil layer that is the soft clay with water wearing silt, and layer

that is the soft clay with water wearing silt, and layer below this.

Then below this there is a firm gravel clay firm clay gravel or farm gravel; that means, in between two firm soils in between two firm soils there is one soft soil or soft layer of soil is layer; that means, this is your firm soil this is your firm soil in between two firm soil the third one is your soft soil layer is there. So, in this in this case what will happen this soil movement will be like a not rotational not blocked or wedge not like it will be like a spray. So, one by one it will be sprayed about the surface. So, if you look at your one will be one soil movement mass movement will be in this direction other will be in this direction, then other will be in this direction all of certain one layer is moving downward. So, it will sprayed half hazard movement it will sprayed all over it will sprayed all over.

Then last one is called flow type of slope movement, last one is called flow. If you look at here flow this is your source area this is your source of your soil mass source area, and this is marked by your main track how the flow will occur, then this is your deposition area; that means, if there is a hilly region there is a sloppy ground sloppy ground the source area from the top what will happen? This slope will flowed it will it will fell on it will the movement will be in terms of flow; that means, soil are this part it will flow in the main track, and deposited at the bottom in this case it is called flow movement if I classify into basically in broadly broadly what are the different types of slope movement once again number one is a rotational in rotational entire soil mass will movement will movement, move.

That means, entire soil mass will move; that means, this will be a one soil mass it will move, then second case it is a translation the movement will be like in a translational, then third is your block end wage; that means, these soil mass will not move like a independent one soil mass that rather it will move like a block one block other block. So, one is moving like this other is moving like this. So, this is called block movement, then forth one is your movement in this case spread movement if there are two firm layers in between one soft layer is there what will happen, then the soil will spread spread means there will be a vertical movement lateral movement all over it will be a spray, then last one is your flow flow means, if in case of hilly region if there is a there is a sloppy ground what will happen entire soil mass at the top will flow, and deposited at the bottom this is called flow movement.

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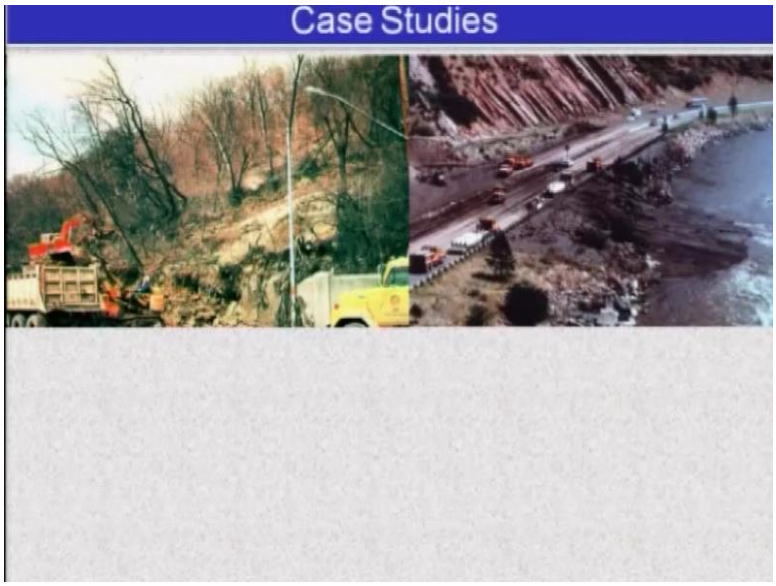

Now, there are different case study, if you look at there at different case studies

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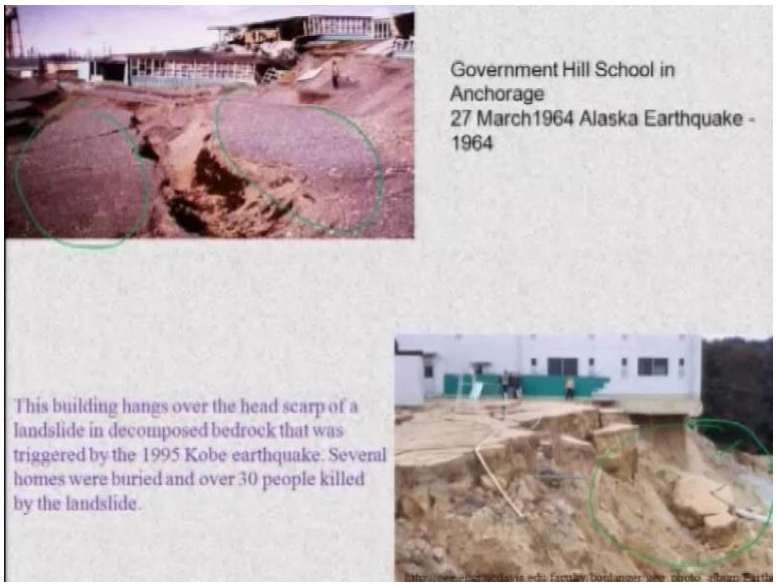

Now, I come back to here ground means, if you look at this there are different case studies has been taken one is a case one it is nineteen sixty four Alaska earth quake, if you look at these Alaska earth quakes how the soil movement will be there from the top, and it has been deposited, because of earth quake entire mass of the soil mass, and be sloped has been movement means. If you look at this is one block this is another block this are all separated out this soil will be separated out, then second one is your if you

look at here ninety ninety five kobe earth quake this is a case of kobe earthquake. This building hand over the aids craft of a land slide in decomposed bed raw, that was regard by the ninety ninety five kobe earthquake. If you look at here kobe earthquake what will happen this building just simply hanged below this entire soil mass entire soil mass it has movement soil movement is there. So, the building is simply hanged.

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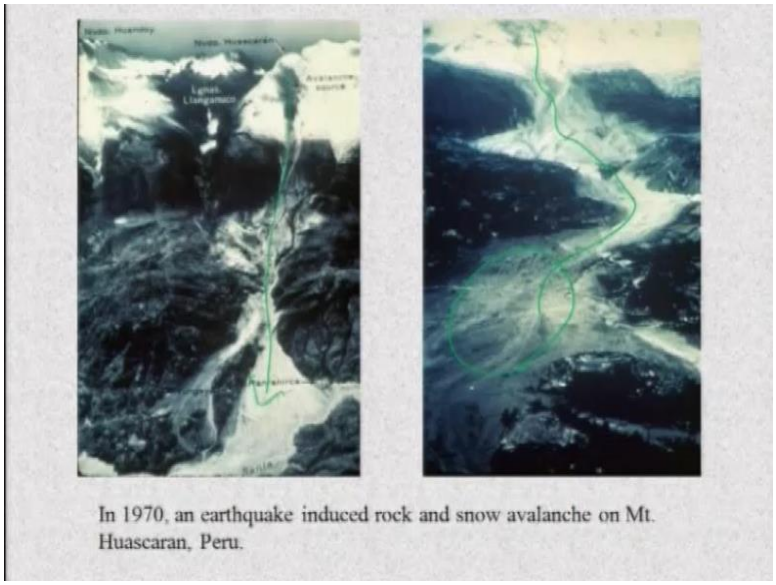

In 1970, an earthquake induced rock and snow avalanche on Mt. Huascaran, Peru.

Now, come back to second in au third example in ninety seventy, and earthquake in used rock, and snow a valence on huascaran peru, it is particularly a peru earthquake. If you look at here peru earthquake how this flow from here to here, how it has been movement of this soil mass movement will be there from here to here, how this flow a occur a deposited a this soil mass here this is the third example in ninety seventy peru earthquake.

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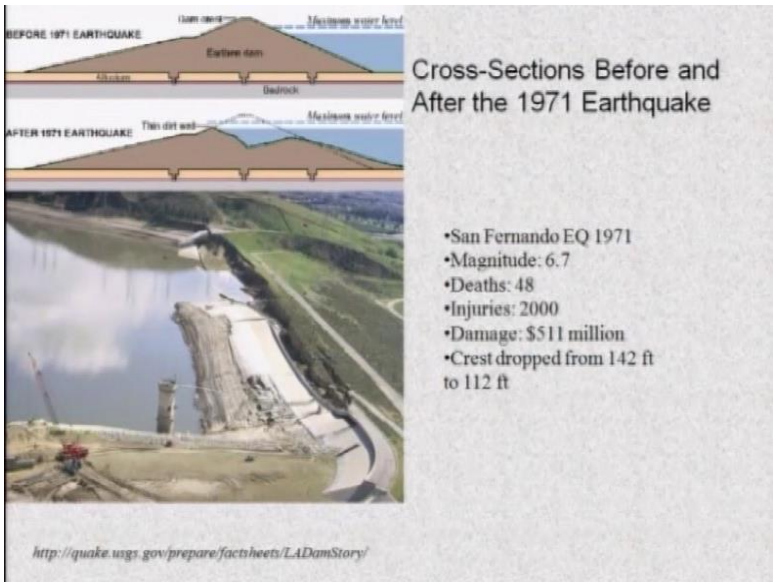

Now, typical one one cross section arc dam had been in this own in ninety seventy one earthquake. If you look at here before earthquake ninety seventy one, there is see an arc dam look at here this is an arc dam this is your maximum water level, and this is your dam au top of the dam, and this is your earthen dam one this earthquake has happened the soil mass. If you look at here it has been marked by dot at the soil mass entire soil mass has been moved the movement of the soil mass has been occurred or you get he say that this embankment failure, because of earthquake, because of the soil movement from here to here if move towards your downstream side means ma particularly toward your water level or reservoir side I have sown earlier also if you look at here this diagram I have sown in this case.

This particularly, if you look at here there is a flow, and one case I have sown here this case typical case I have sown if this is an arc dam, and there is a if there is some earthquake some forces are coming. So, this part of the soil will movement move towards your reservoir; that means, this soil will move towards your reservoir. So, this is a earthquake in nineteen seventy one occurred in san Fernando, and magnitude from about six point seven six point seven, and total from forty eight death occurred in the two thousand injuries, and damage is about us dollar five hundred eleven million dollar has been damage has been marked, and graced if this is my dam graced this is the dam graced dropped from hundred forty two feet to one one two feet.

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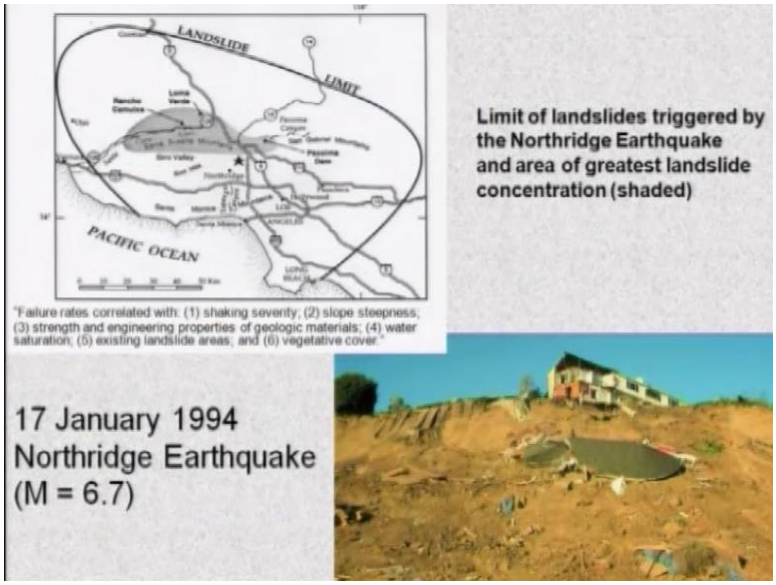

This grace has been dropped from hundred forty two feet to one one feet, another one is nineteen ninety four seventeen January earthquake its magnitude is six point seven six point seven into look at here limit of landslides regard by the Northridge earthquake, and area of greatest landslide concentration said that particularly greatest landslide concentration. If you look at here how the land slide has been occurred entire soil mass has been eroded eroded means it has been, because of your slope failure entire soil mass has been flow two your downstream side, and this has been shown in graphically means particular pictural point of view top view.

So, this is your entire area how this land slide has been occurred from here to here this landslide failure rated co related with sucking severity sucking severity, then slope stiffness, then strength, and engineering property job geologic materials, then is your, then existing landslides areas. If you look at here; first one is your number one number one is coming out to be somewhere else one two three four five six this your five ten somewhere else number one here, this is slope stiffness slope stiffness, then geology matter, then landslide area. If you look at here this is your existing landslide area, this is the number, if this if this is your number clip; that means, in these area this your area of landslides landslides means entire soil movement entire soil or entire soil movement or slope failure.

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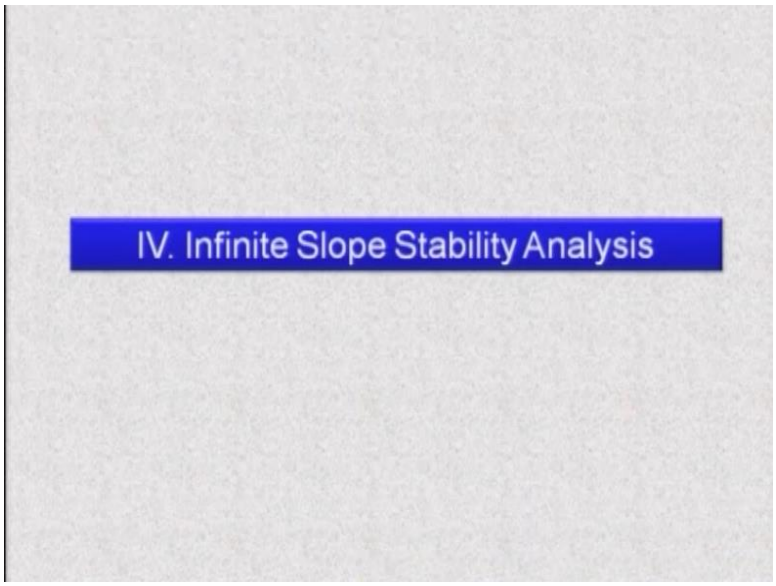

There are two kinds of slopes one is your infinite slopes. So, this slope is in infinite in nature, then another is your finite slope

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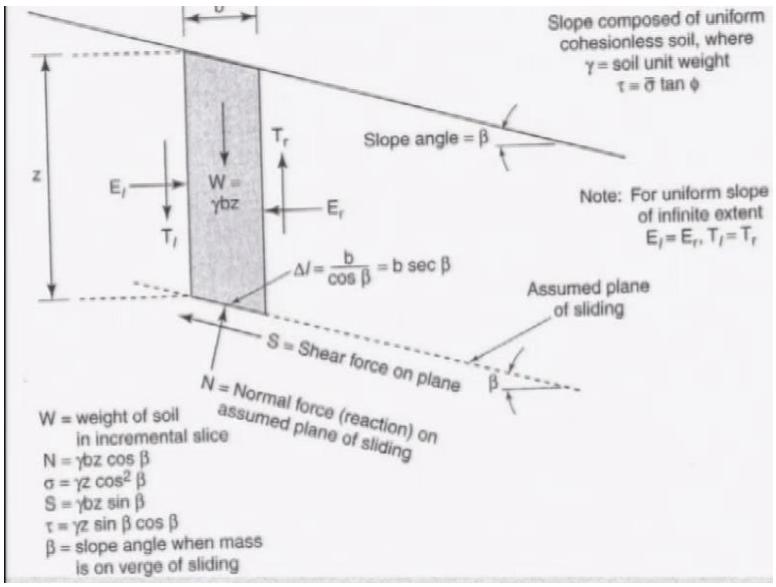

Now, if you come were this infinite slope analysis before I go to the infinite slope analysis let me come to the finite Guesses.

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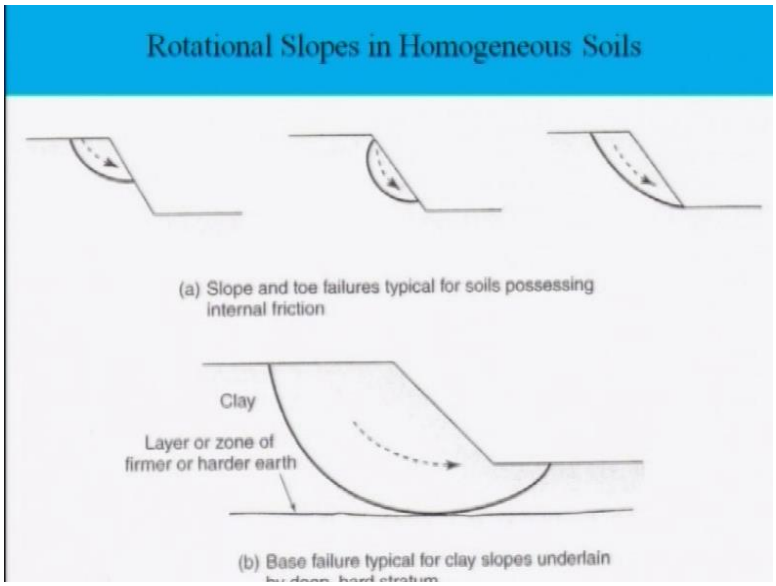

In case of finite what are the different types of slope failure occurs, finite means it is a distinguished particularly it is a finite finite means, there is a long infinite long slopes. So, in these case particularly there are three category; one is your slope failure another is toe failure other is your base failure, if you look at here this is a slope toe failure typical for soil internal friction. Now this is your slope failure now in; that means, the failure will be generated from this side, and it will be somewhere else along the slope this is my slope this is my slope say this slope may be one is to one or one is to two it depending upon this, but generally one is to one two one is to two or one is to three has been this slope has been provided.

So, why this is called as slope failure the failure surface the failure surface extend here from the embankment at generate, and it ends at the point of slope that is why it is called slope failure same cases it is also extend here, and ends at the point of the slope, then third one is your, if this is my toe second one is a this is my toe, if this is my toe. If you look at here both this case one, and case two these are called slope failures, because the failures starts form this embankment at the top, and it continue, and were along this slope failure first two examples is your slope failure, because this failure starts from the embankment top, and the failure it will it will terminate somewhere else along this slope here, it is if I draw a draw a embankment like this, if this is my slope; one is to two or one is to one.

So, this failures this failures I can say failures of a one two three are slope failure, because the failure surface ends at the point of anywhere else along this slope that is why it is called slope failure the movement I say that this is a toe failure; that means, particularly in case of finite slope; that means, the failure surface starts from some from at the top at in at, and it propagate at, and it end its just at the point of toe if this is my point of toe, and this is my top of the top of the embankment top of the embankment. So, here its starts the failure from the top at it ends at the point of toe this is called toe failure; that means, there are two one is your slope failure other you have toe failure.

Third one is your base failure base failure generally occurs if there is a kind of if you look at here this is a clearly this, this, this is your embankment constructed, and this is your particularly clay soil it is retain here, then layer or zone of hard it is a hardest atom is there, then what will happen, then the base failure means the entire failures of mean this failures surface will start from the embankment if you will progress progress, and it will passed through below the toe it will passed through below the toe if this is my toe if this is the toe. So, it will pass through below the toe. So, that is why this is called this is called base failure.

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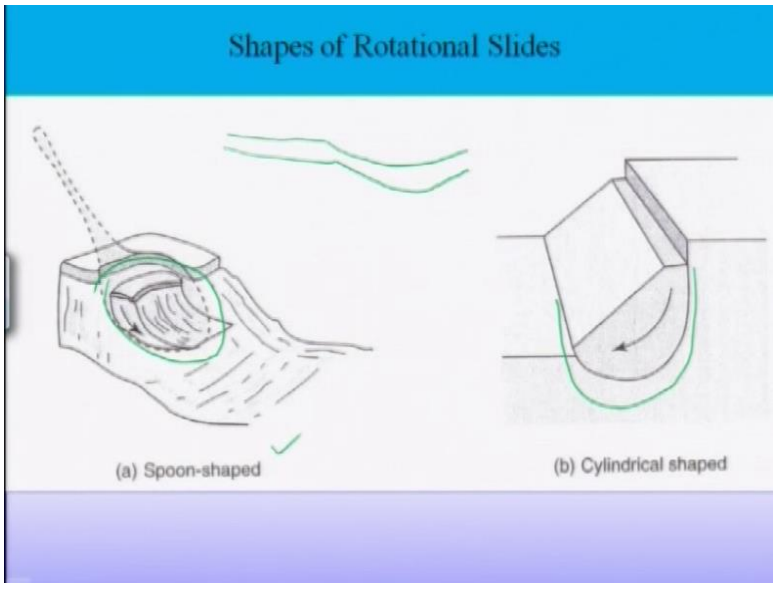

Now, same up this rotational slides shape of the rotational slides. So, if you look at this rotational as I said earlier now come back to this kind of second slides as I have explained earlier rotational failure in types of slope movement rotational movement

movement block, and wage movement, then your spread movement, then third is your flow, if you come back to a the rotational movement in rotational movement made made what should be a safe how this rotational movement were how it looks like one is your spoon shaped one is your spoon shaped are this spoon is a kind of this. So, this is a kind of a spoon shaped. So, the failure is a kind of spoon shape failure. So, that is why it is called spoon shaped rotational slides other is cylindrical shape; that means, it will go in these. So, that it will take a cylindrical shape that is why it is called a cylindrical shaped rotational slides. Now if we look at this finite, and infinite slopes I am discussing about right now this equations what are the driving course there is what are the different courses, and how this finite, and infinite slope particularly analysis has been done now go back to classifications. So, there are two types of or slope failure.

One is your infinite nature, second is your finites slope. In case of finite slope are you have discussed in case of finite slopes there are three kinds of slope failures one is your slope failure other is a toe failure third is your base failure now if you comeback infinite, and finite now in these case we have to identify what are the different forces acting what is the resisting courses what is your driving courses, then you can find it out these factors of…

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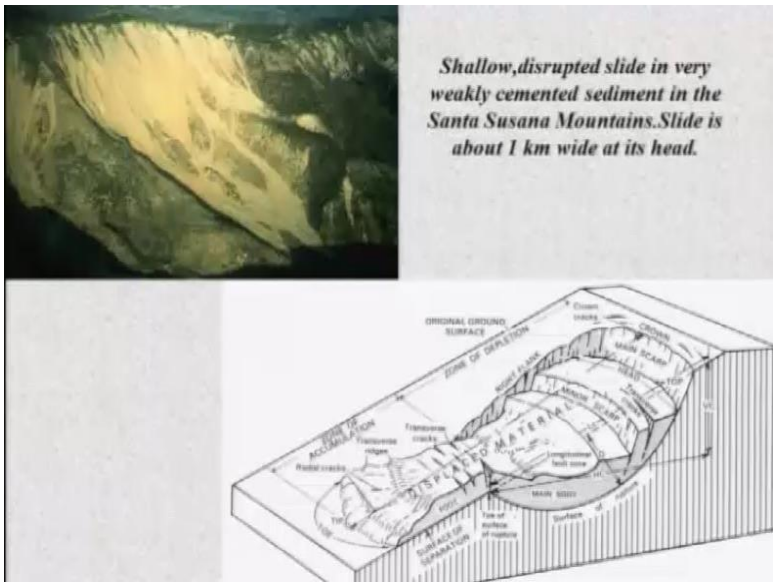

Now, if we look at these a typical figures sallow disrupted slides in very weakly cemented sediment in the santa mountain slide is about one kilometer wide at the head

the slide is if we look at this it is a mount, and the slide has been sown this is this slide is about one kilometer wide can you imagine this slope.

This mass movement one kilometer wide this entire soil mass slide this width is about one kilometer one kilometer long stretch. So, this width is about one kilometer now if I look at this a typical disease at au a photography view. Now if I analyze these if you look at here this is my original ground surface this is the original ground surface this is the original ground surface, and this is your crown this part is called crown now now if you look at here this is the original ground surface, and this is your crown now in these case if you look at here displacement material is starts from here to here now this is a main scraped main how is scraped. So, this part is generally main scraped, then head, then there are also at this same time what will happen?

At the same time what will happen there are cracks developed there are cracks developed over the period over the side by side. So, here it we look at here this cracks may be vertical or may be transfers. So, this crack crack is here it is own this is a transfers crack this is a transfers crack transfers crack, then there are two scraped means how it moves one is your main scraped main scraped will be at the top main scrap, then another one is your minus scrap once in movement what will happen these slope is very stiff at the top, then it becomes slightly stabilize. So, there will be a kind of there will be a kind of minus scrap now this is a main body, if you look at here how this slope failure if I take it how this slope failure.

This is your main body it has been sown here main body now in these main point body, this is has been marked toe toe toe is if I say this is means if I say this is heal this is your toe this slope. So, this has been scraped about one kilometer what has been said wide, and his how this surface of rapture occurred, this is a surface of this is a kind of rotational rotational said, then this part is your separation this month's there are again cracks develops. So, this source how this soil movements starts particularly in the case of slopes slopes, and what are the major parts how this rapture surface develops now, next step we are going to go we are going to derive this basic equation for infinite, as well as finite slopes, now if you come back to infinite slope.

Now I take a take a slope of infinite length, and take a very small elementary part small elementary part of the soil in case of infinite slope. Now what are the component will

have to see what is your driving courses what is your resisting courses? Now one is your one is yourself weight of this self weight, if I take a very small element of this soil in by infinite slope the slope angle is beta. Now this is yourself weight w is equal to gamma into b e into z b is equal to width z is equal to depth this depth is your z, but and this is your width self width, and what are the courses acting both the sides, if you look at here one is your one is your infinite x extend, this is a lateral forces e r e l e r.

If I take I take is your left hand side, and right hand side this your left hand side force, this is right hand side force as well as t is your particularly fictional force t is your fictional force. So, it will be one is your vertical down other is your vertical up now on the plane. So, because this is a infinite slope equal to this, and this is your normal force now if I take as a this length is called as a delta l delta l width is b this length is delta l. So, this delta l is your b by cause beta beta is your angle. So, this is your b said beta will discuss all this things. Next class complete derivation of your infinite as well as finite slope I can stop it here.