Geomorphology
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Lecture – 20
Classification of Mass Wasting - II

So friends, welcome to this lecture series and today, we will going to discuss about this classification of mass wasting part 2, so if you remember in the last class, we are talking something about this classification and we confine ourselves in the hill slope, so we classified the creep, the slowest movement, the solifluction, the gelifluction and we found for the solifluction and gelifluction, there should be a criteria that these base of the system should be water impermeable.

And water should not escape from the system, so that movement can continue now; we will confined our self within the valleys itself. So, in solifluction or gelifluction and in creeps, it is along the slope, a hill slope is there, along the slope the movement is there like spreading somewhere but those classification now, we are going to discuss that will confined within the valley.

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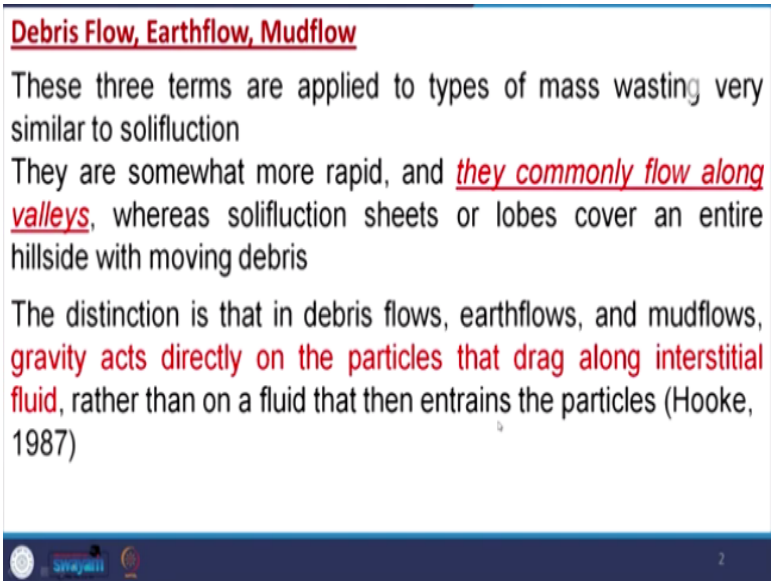

So, this is start with the debris flow, earth flow and mud flow, these 3 terms are applied to the types of mass wasting very similar to solifluction however, they commonly flow along the

valleys itself whereas, sheets on solifluction and gelifluction, they are looking like lobes and spread entire hill side but here, once you say, debris flow, earth flow and mud flow that means, here a valley is associated.

All those flow material, they are flowing along the valley itself, not along the hill slopes or hill slides, very important point here to remember is that the distinction is that the debris flow, earth flow and mud flow, gravity act directly on particles that drag along interstitial fluids rather than on a fluid then entrains the particle. So, here gravity is directly affecting with the associated particles, associated clast.

So, it is dragging down, so that that means, with the help of this gravity, the whole system is flowing along this valley and when this valley is opening up, the system getting slower and slower and it will spread like somewhere, so whenever this confinement within this valley, it will continue, this mass will continue.

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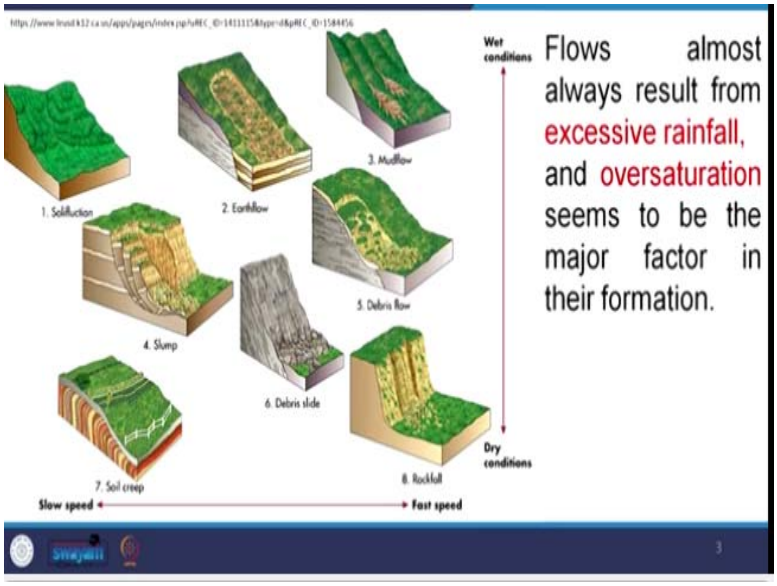

Here, if you see, these figures are indicating here, this side is the wet condition and this is dry condition here, slow speed and here fast speed, we have mud flows, we have debris flows, we have earth flows, here we are confining at top part of the system that means, in the as per as the earth flow is concerned, it is a relatively slower but this wet condition is compare the mud flow and the earth flow, both are; both containing sufficient amount of water.

But in debris flow, the water content is relatively less, flows almost always result from excessive rainfall and over saturation seems to be the major factor of their formation, over saturated materials that means, the water content is more, so that it can flow; to sustain its flow, water should not escape from the system, okay but very important thing that it is differentiated based on the valleys, the confinement within that valley.

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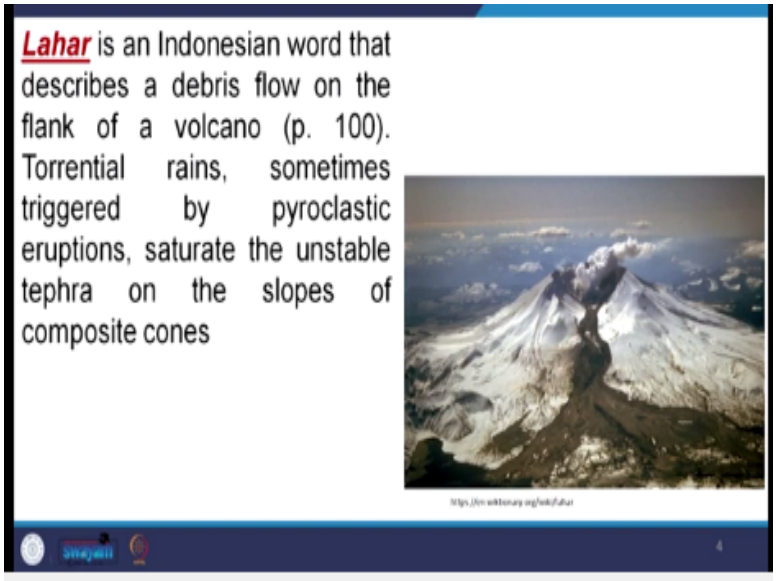

One particular type of flow it is called Lahar, it is a Indonesian term, it is this flow, particularly this terminology it is confined for the volcano material; volcanic material like the tephras, the lapilli, the volcanic ash, along these volcanoes or the side of these volcano, these materials are gather by some means, if water is associated with that, this material flow along this valleys and this is called Lahars. It may be hot and cold, so it is an Indonesian word that describes debris flows at the flank of this volcano.

These triggered by pyroclastic eruptions, saturated in sustain tephra or the slopes of this composite cones, so these material will move down this terminology, Lahar is used here, other sources of moving of water is bridged craters, melted snow and slide dammed river. Lahar's may be hot and cold, the water content is compatible that of the wet concrete, whenever we go for concrete works for our construction purpose, whatever the water is there, this water content of Lahar can be compared with that.

So, that means, the system is flowing essentially, it is consisting of volcanic material, volcanic ejectas, then another mass wasting term, it is called spread. Spread means, it is spreading, so spreading on lower slope material, lower slopes. So, what is this spread means? Suppose, we have different alternative layers of; suppose, for example, the upper layer is consisting of the sand stone and the lower layer is clay.

By some means, either it is earthquake or by some means, this system is totally shaked, so in the clays, there will be liquefaction, so liquefaction, there will be turbulence within these clay bodies, so once there will be liquefaction, the system turns to flow, the upper layer remain intact, it is coherent, it is cohesive strength is there but once this lower layer wants to flow, there are cracks will developed in the upper surface.

And through this cracks, those materials they will try to break into blocks and it will fall within it lower layer and will be separated out, this type of movement, it is called spread that means, the system is spreading. So, by definition, a spread is defined as the lateral extension of cohesive rock or soil mass combined with general subsidence of the fractured cohesive material in a softer substrate.

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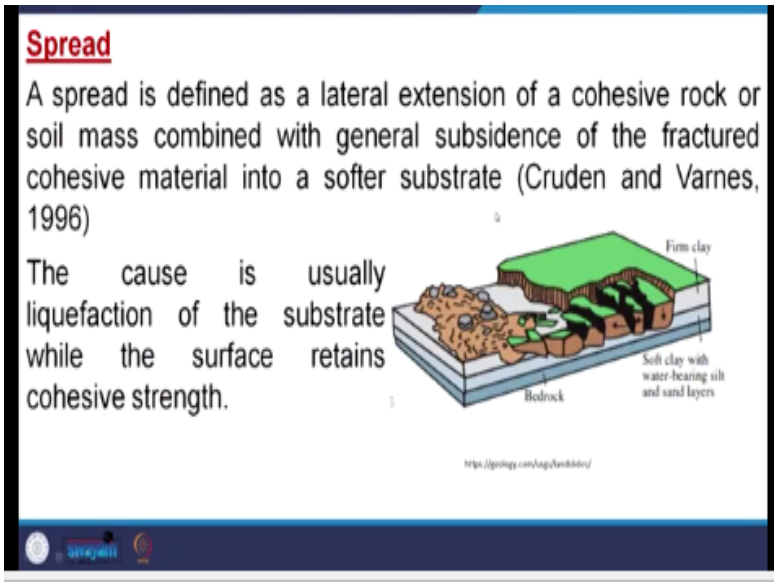

Here, softer substrate, it is the clay as we are discussing and this cohesive material is the sand stone, the cause is usually liquefaction of the substrate while the surface remain cohesive strength, so as we have discussed, the clay it is liquefaction will be there and the sand stone above this clay, it will remain cohesive.

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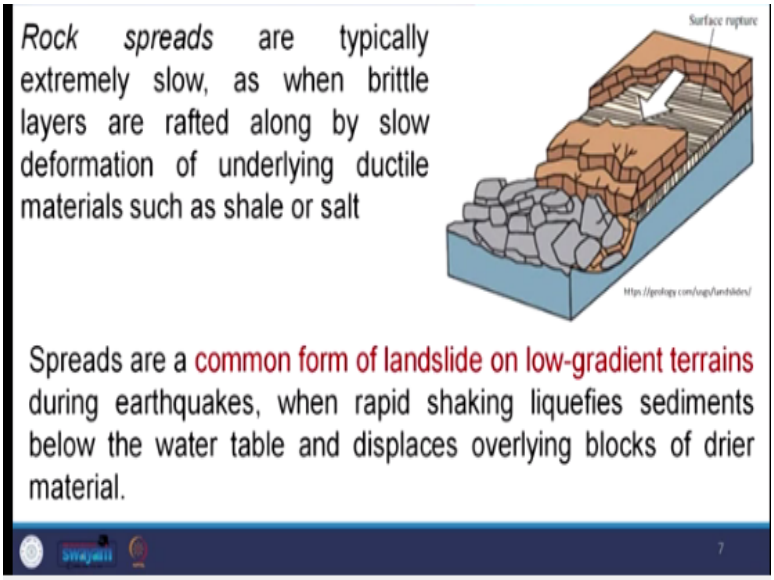

Rock spreads are typically, extremely slow as when brittle layers are rafted along by slow deformation of underlying ductile layers or ductile materials. Spreads are common form of land slide in low gradient slopes, low gradient terrains, during earthquake, when rapid shaking liquefies the sediment below, the water table and displaces overlying rocks in the drier material, so if we have this liquefaction occurs below the water table, the whole material try to move off.

So that, it creates crack on the upper layers, the intact layers and this blocks, they tried to move different directions and that is called the spreads and it is most common in low slope areas like the plains.

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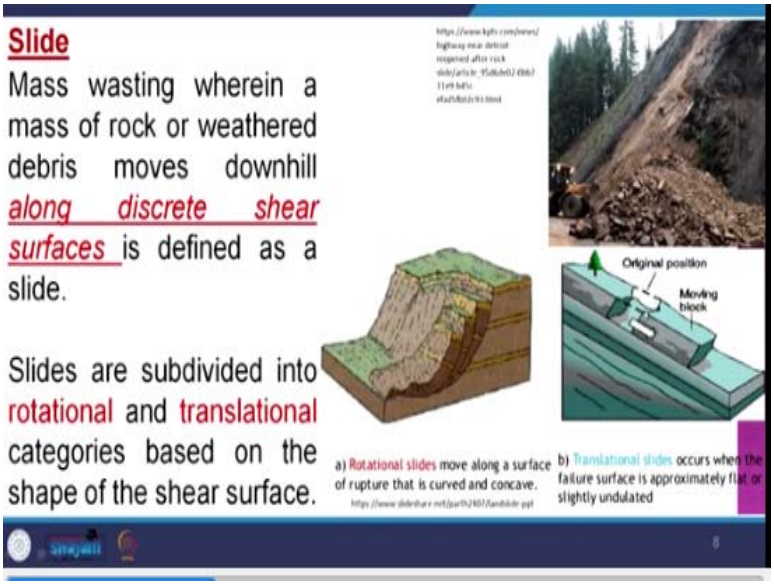

Then, another type of mass wasting, it is called slide, where a mass of rock or weathered debris moves downhill along the discrete shear surface that is a plane, a definite plane is associated, on a definite plane, if rock mass may slide, debris may slide, anything may slide on this surface, so this defined surface is there. So, based on the defined surface that is why it is called slide, it is sliding down.

Slide are subdivided into either rotational or it is translational, so rotational slide that means here, this plane, it is a curved plane, the plane of failure, it is a curved plane, so that material rotates or in a translational, if it is a planner surface. Here, if you see in this figure, this plane of failure if you see, it is a curved plane, it is that means, any material which will detached from here that will try to move like this, so this is rotational slide.

Here, in this particular figure, if you see, here this plane of failure, it is straight, it is plane, so this material or this block which detached from the main body, it will slide down here, so this is translational slide, this is rotational slide and in the irrespective of translational or rotational, a definite plane is defined, on this plane, the motion is going on, so that is slide.

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Subcategories of the slide in various classifications are there that is include, slump, rockslide, block glide, mud slide, debris slide and debris avalanches, so here some figures are given, this figure denote to slum; slumping of material here, then debris avalanches; avalanches very rapid movement, avalanches, then debris slide, it is sliding down, then rock glide, this rock; intact rock, if you see here this whole rock as a whole block, it is gliding down, it is block glide.

Then mud slide; mud is sliding down, so depending up on this material involved, depending up on this nature of this plane of failure, this has been classified. First is the slump; is the form of slide most common in thick homogeneous cohesive sediments, this has to be clarified here, it should be homogeneous and cohesive sediments, the surface of failure beneath the slump block is spoon shaped, concave upward or outward.

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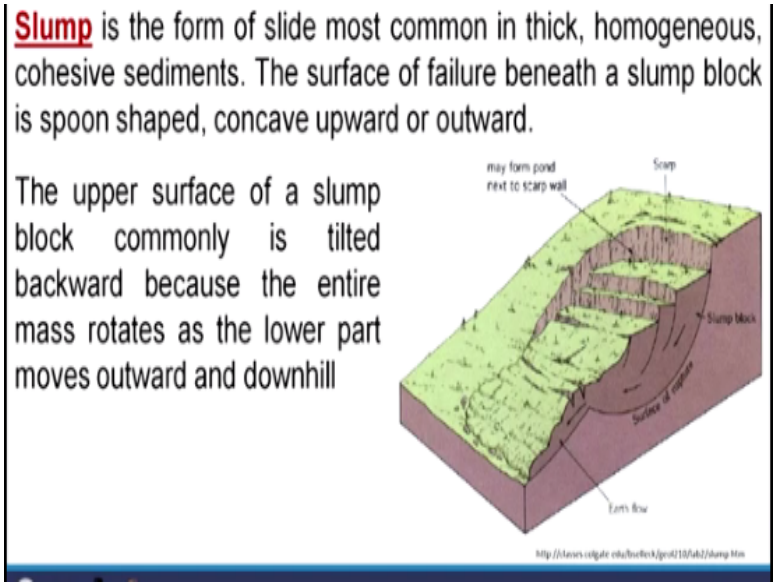

If you see in this figure, this is the plane of failure, it is concave upward, it is like a spoon shaped, so once the material is sliding from here, detached from here, it has to undergo a rotational motion and here it is concave upward and this side if you see here, this is convex upward, so the upper surface of a slump block is commonly is tilted backward because the entire mass rotates at the lower part moves upward in the downhill.

So, here it is rotating, so rotational motion is involved in the slump and this; it is a homogeneous material and cohesive material.

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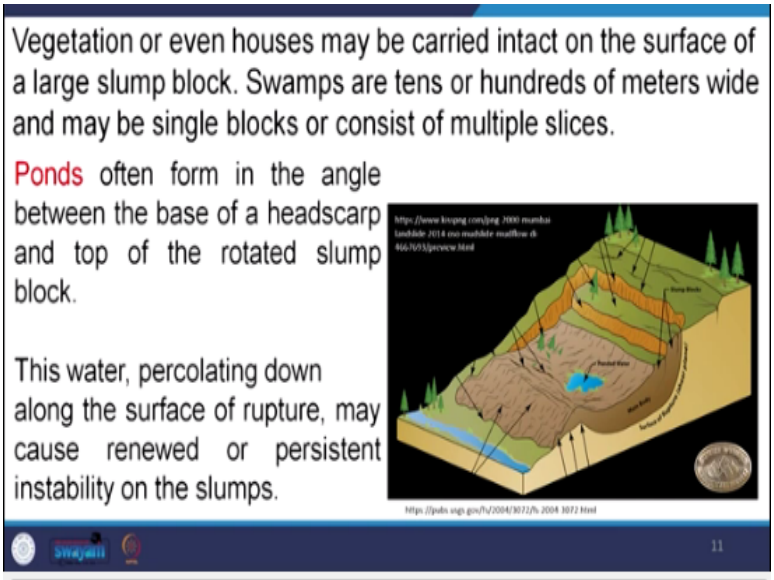

Vegetation or even houses may be carried intact with the surface of failure, the large slump block. Swamps are 10's of 1000's of meter wide and may be single block or consist of multiple slides sometimes, ponds are generated here. For example, if you see in this figure, here these different blocks; this is one block, this is another block; the blocks are detached gradually and are moving rotational motion.

And here if you see, a pond is developed, pond plays a major role in motion or this sustained motion of this slump block, for example suppose, ponds is filled with water and once the system moves that means, there are cracks are develop, weak planes are developed. Through the weak planes, the water will percolate down, once the water percolates down, it behaves as the lubricant, so that this rotational motion, this detachment that will continue for a long time.

If ponds are not there, if water percolation is not there, it may discontinuous motion will be there that means to certain extent, it will move and it will rest but once the water is percolating down, it is increasing the weight of this body, it is also behaving as a lubricant, so that motion will continue for long time. So, water plays major role here.

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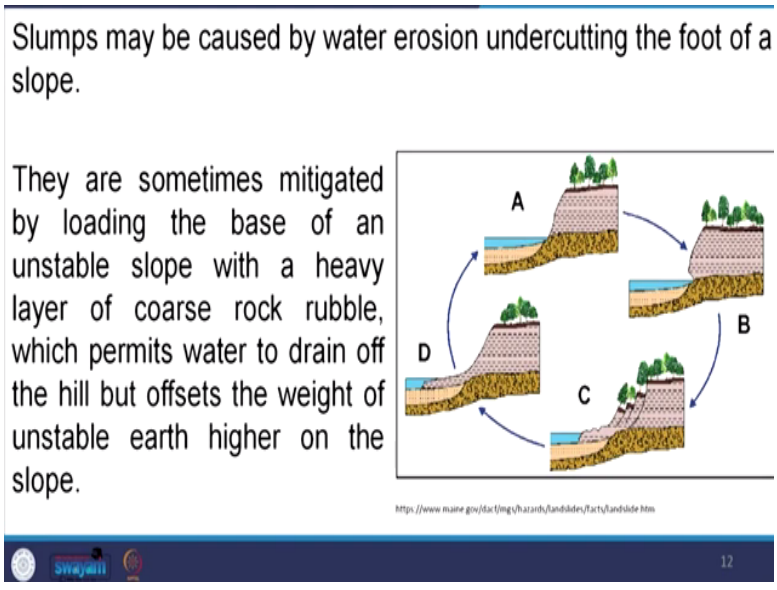

Slumps may be caused by water erosion undercutting the foot of the slope, for example if this figure, if we try to understand here, suppose for example here, this is the cliff surface and this is the water body and with constant erosion; constant heating of this water, here you see there will

be erosion of this rock body and once this erosion takes place, this part of this block, this become unstable.

So that means, due to this instability, these part of this rock gradually sliding down on a curved surface, this is called slump, so that means there sometimes mitigated by loading the base that means, for the engineering remedies, if a loading up; loading the base here, we can mitigate to certain extent, so loading the base with rubbles or the gabion walls, so that this water will only escape but the material will be supported.

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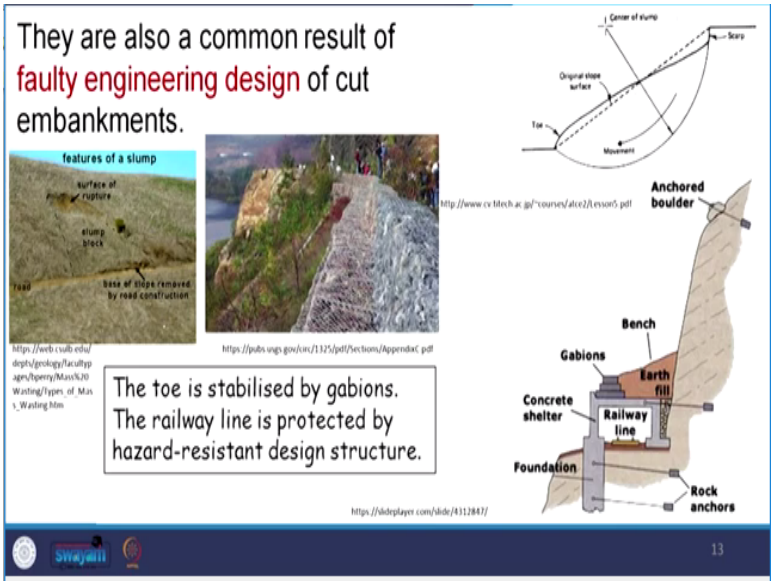

For example, here the faulty engineering structure, suppose here we are removing the material, so that means we are creating a cliff which can free fall here, which can slump down, so in that case, what we generally do; here, we are creating the gabions, the walls composed of boulders, it is tied with nets, with metal nets, if you see here is a metal or plastics or some types of polymer is there, these nets, so that means, we are allowing the water to percolate, water is removed.

But it is supplying a support to the rock mass there, so that is why by loading the toe with suitable material, with suitable design to certain extent, we can prevent this type of slump motion, so there also a common result of faulty engineering design of cut embankment, so whenever you go for road alignment along the hilly terrains, it is tunnel alignment along the hilly

terrains, we must be keep in our mind that once we dress a slope, we redesign a slope, it should be stabilised with proper support.

So that there will be no slumping, there will be no mass wasting from the slope to the road, so due to this faulty engineering design, there are crores of rupees we are spending in the hilly terrains to stabilised the slopes which are naturally got earlier.

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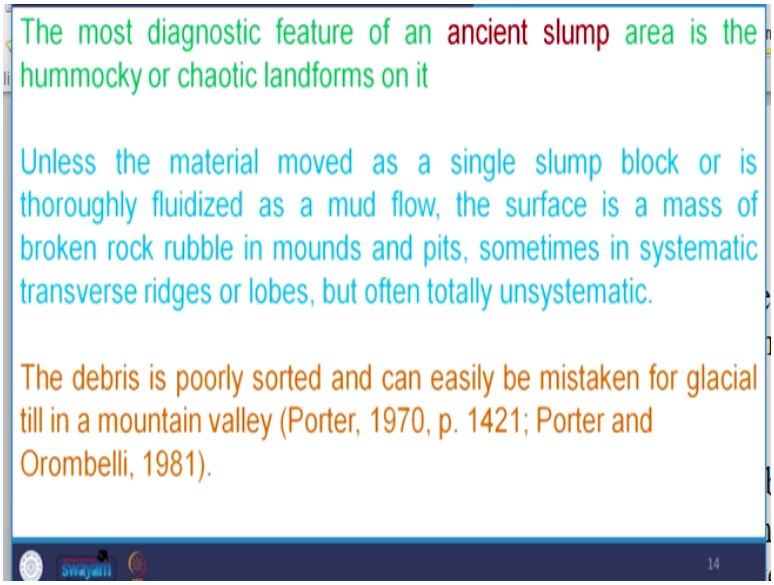

The most diagnostic features of an ancient slump area is the hummocky or chaotic landforms on it, it is very important here, this diagnostic characteristic of ancient slumps, ancient slump has to be understood properly to go for in proper engineering design otherwise, suppose for example, in an area, we are assigned for engineering development or road alignment or so, we do not recognise the ancient slumps.

So, ancient slump may be reactivated with time, so that is why, once we identify this is the ancient slump, so that means we have to go for remedies; proper engineering remedies we have to go, so until, unless, this slump will again reactivated during this time and finally, it will block our developmental program. So, how it will distinguish; so generally, this ancient slumps, they are distinguished by hummocky and chaotic landforms.

Hummocky landforms, hummocky structure you might be knowing, hummocky that means, it is concave and convex type of material which is hummocky structure, then chaotic landforms, there is no arrangement of landform arrangement, some lobes is here, some lobes are there, some are like this. So, this chaotic arrangement of landforms and this hummocky structure in the ancient slumps can be distinguished.

Unless the material removed as a single slump block or it is thoroughly fluidised as a mud flow, the surface mass is broken rock rubbles in mounds and pits, sometimes the systematic transverse ridges or lobes but often totally unsystematic, so this type of; these are the signature how you will identify this ancient slopes or ancient slumps. The debris is poorly sorted and can easily be mistaken for glacial tills also, this is important.

In hilly terrains, in geological past, we have many glaciation and deglaciation events, so these are suppose in the hilly terrain, it is lying there, so if were not able to properly identify this slope material, we can easily mistaken it for the earlier moraines, so that means, proper understanding, proper identification is must for proper engineering remedies.

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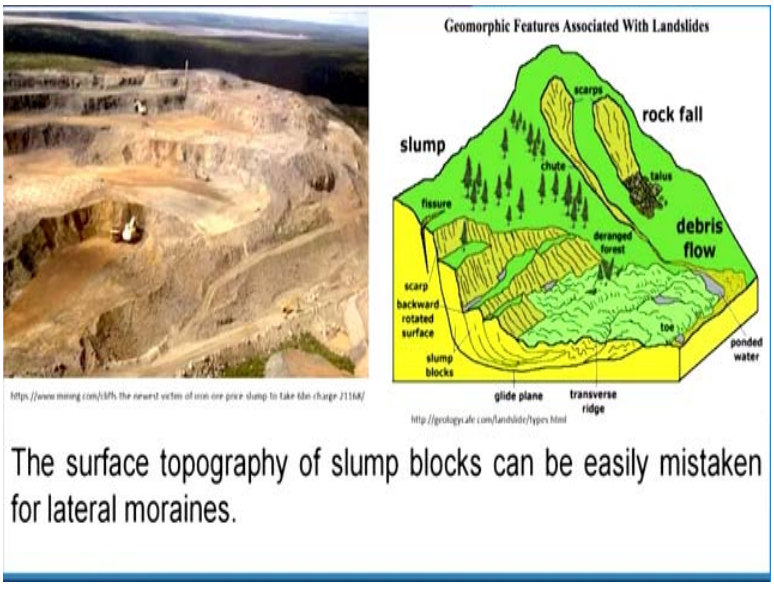

Here the surface topography of slump blocks can be easily mistaken with lateral moraines, for example, if you see here, these are this debris material is mined here and this is nothing, it is the slump material ancient slump material but it should not be mistaken for ancient moraines, okay

but their characteristics will be same moraines it is totally unsorted material will be there similarly, slump rocks, it is totally unsorted material will be there.

But there should be a geologist should properly distinguish what he is dealing with, okay so, if ancient slump material is there, it is mistaken by moraine, so it will, he will not take proper engineering remedy, so that that means, your again engineering design will be faulty, so that is why proper identification is must.

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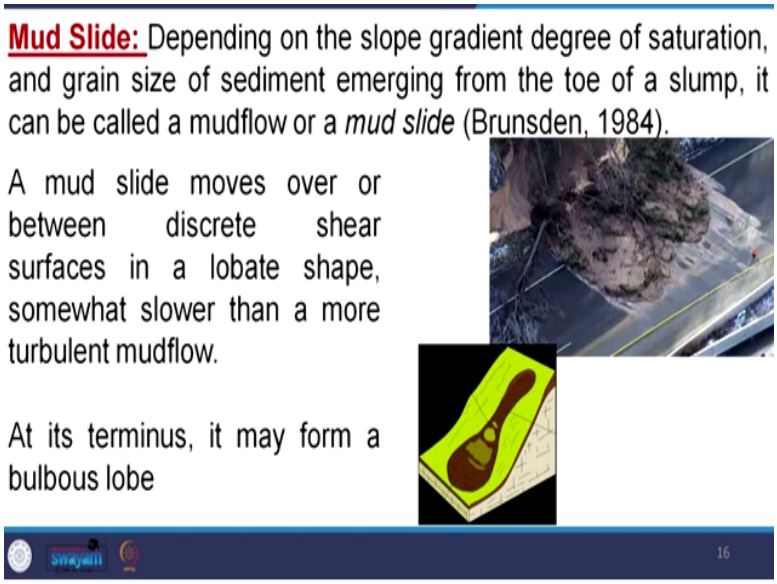

Then another classification of slide is called mud slide, depending up on the slope gradient, degree of saturation and grain size of sediment emerging from the toe of a slump, it can be called mud flow or mud slide. A mud slide moves over or between discrete shear surfaces in a lobate shape, somewhat slower than the; than a more turbulent mud flow, at its terminus, it may form a bulbous lobe.

For example, if you see this, these are the lobes, they are the mud flows or mud slides, so mud slide that means there will be turbulence motion will be there, discrete planes will be there, within that planes, there will be motion, so those planes they are the sliding planes. Then, rock slide or block glide; the simplest form of translational motion is the rock slide or block glide. The moment which relatively rapid and the most common occur were steeply dipping strata or

sheeting's nearly parallel to this surface slope, that is very important region, this is the fastest motion.

Suppose, a plans is there, discrete plane is there and the rock mass are fractured into different independent blocks, on this block, on this plane, these rocks can move violently, suddenly this rock can transfer downward, so this is called rock slide or block glide that means, the whole block, intact block is gliding down, this is glider, this is gliding plane, okay.

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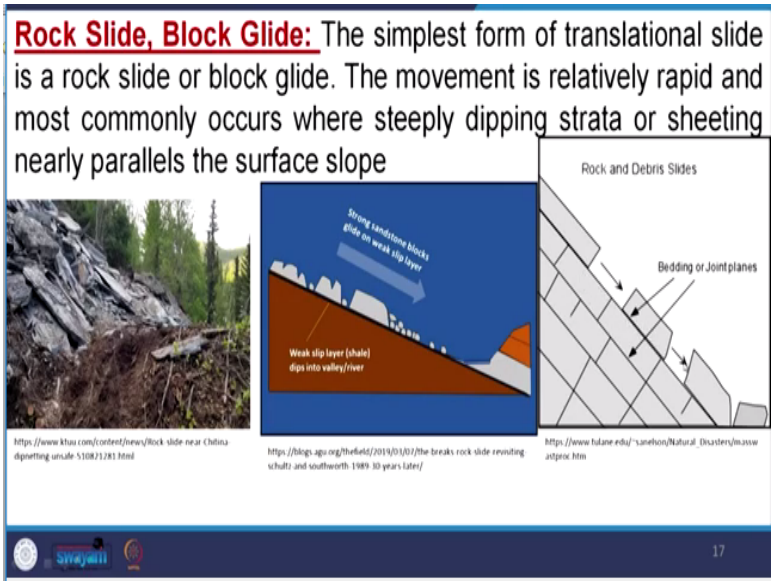

So, in this figure if you see, these are this rock slides and here the rock sliding is there, this is the block glide, the block glides are there, so along this plane these rock material is going down.

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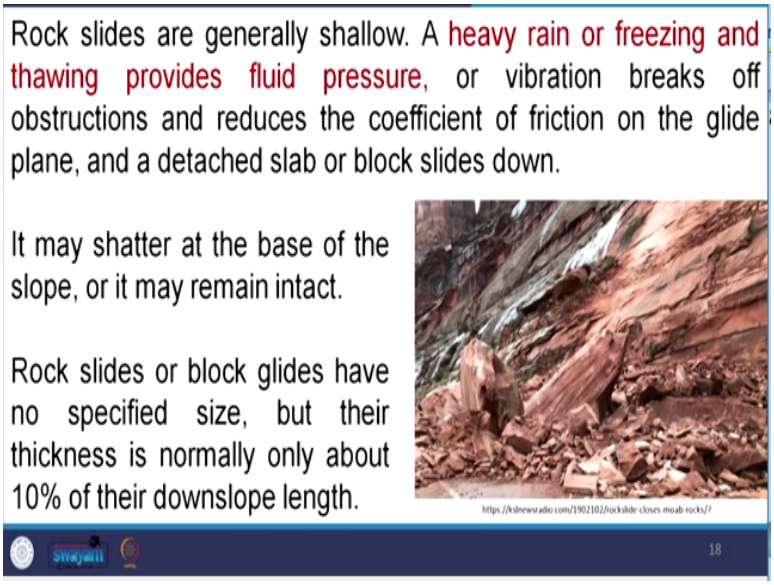

Rock slides are generally, shallow, a heavy rain or freezing and thawing provides fluid pressure or vibrate breaks of; vibration breaks of obstructions and reduces the coefficient of the friction of this glide plane and detached material comes down, so these are this few regions either vibration will be there, saturation will be there, heavy freezing and thawing will be there, so that this rock try to move along this discrete plane.

It may be shatter at this downslope suppose, it is heavily it is coming down and it is heating to these layers of material, so it may be shatter there or depending upon this hardness, depending upon the physical property, it will be shatter or will be remain intact, it will depend on that. Rock slide or block glides have no specific size, so block may be of this much size, of may be this much size or is may be of this much size.

So, there is no specific size is there but thickness is normally only about 10% of their downslope length, that is important to note it there but the thickness is here, it is less than 10% or about 10% of their downslope length, this is rock slide.

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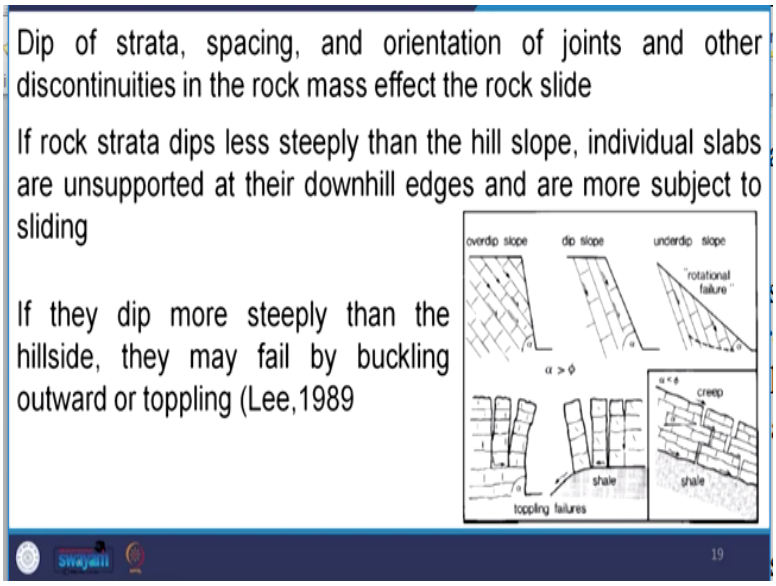

Dip of strata, spacing and orientation of joints and other discontinuities in the rock mass that effect the rock slide, if rock strata dips less than that of the hill slope, so individual slabs are unsupported at the downhill edges and are more subjects to slides. If the dip is more than the or the dip is more, it is steeply dipping than the hill slide, it may fail and looking outward the toppling.

So now, if you see in this figure, here this is the over dip slopes and is the dip slopes and it is under dip slope, here the slope face is there and dip is there, here rotational failure because the failure will be like this, it is rotational failure will be there. Here, simple sliding will be there, here simply sliding will be there but if this joints are vertical, then toppling; topples are there. Similarly, here it is shale and sand stone.

Now, you see the system it is toppling that means, rotational motion will be there, so depending upon the dip and slope, dip and slope; dip is in the rock bodies, slope in the rock surface. So, slope and dip relationship that describes or they defines what type of motion will be there. Rock slides can be deadly if large mass slide down along the sloping joints from bedding surface.

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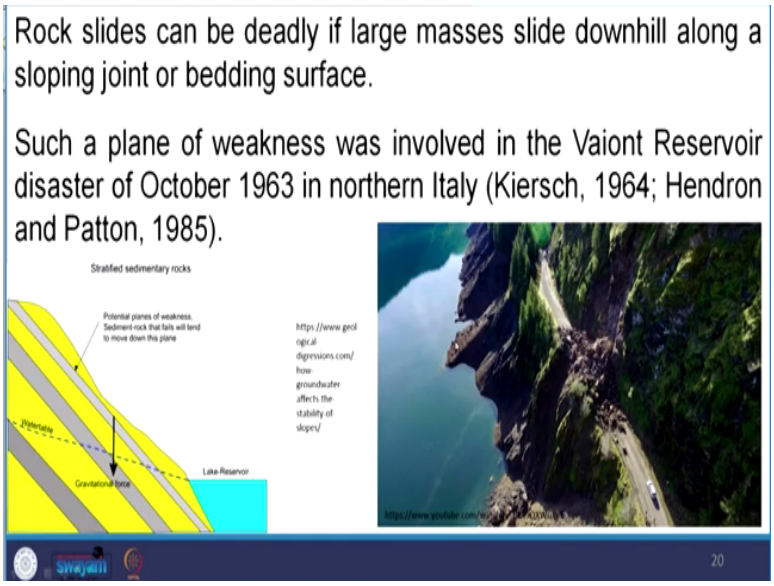

Such a plane of weakness was involved in the Vaiont reservoir disaster in the October 1963 in north Italy, where rock slide suppose, for example if you see in this figure, here suppose, this is the lake and reservoir and this is the plane of weakness, so if this material is sliding down to the reservoir, it is creating huge waves and the energy of that wave maybe sufficient to breach the dam, to breach the dam axis.

So, here if you see this rock material if it is sliding down, huge rock material is sliding down to the reservoir, that may this dam may over flow and the over flowing of dam, it will cause damage to the dam itself along the downhill sides or down dam sides.

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Then avalanches and debris slide; any large catastrophic landslide maybe called avalanches, that may be ice, the rock material that may be mixture of that, anything the large and catastrophic landslide that is called avalanches, then include; they can include the broken rock that may include the ice, snow and easily usually, the mixture of all these material that is called avalanches.

And suddenly it is coming down, the obvious general cause for humid climate debris avalanches is saturation by heavy rain, it is very important, in humid climate generally, there are heavy rain occurs, so in heavy rains, once the system is saturated, so in saturated condition, the whole material is coming down, so this is called avalanches, within a time, within a very fraction of time, summer storms are known to fluctuate many folds intensely.

Even over the time span of hours or less during the brief interval of these heaviest precipitation, water alone may be ultimate cause of this failure, so if it is heavy rain is there, some fracture planes are there in the rocks and these rocks through the fracture plane once this water percolates down, it behaves as a lubricant, so its accelerate the motion.

So, the whole hill slide it is coming down with whole with whatever this structures are there, with trees and everything, it is total system is coming down that is called avalanche. Lightening striking trees in vibrating thunders and the tree fall down, so this is called also avalanches so, that means there are different mechanisms either it is lightening, it is vibration, it is heavy rain, it is earthquake, in everything.

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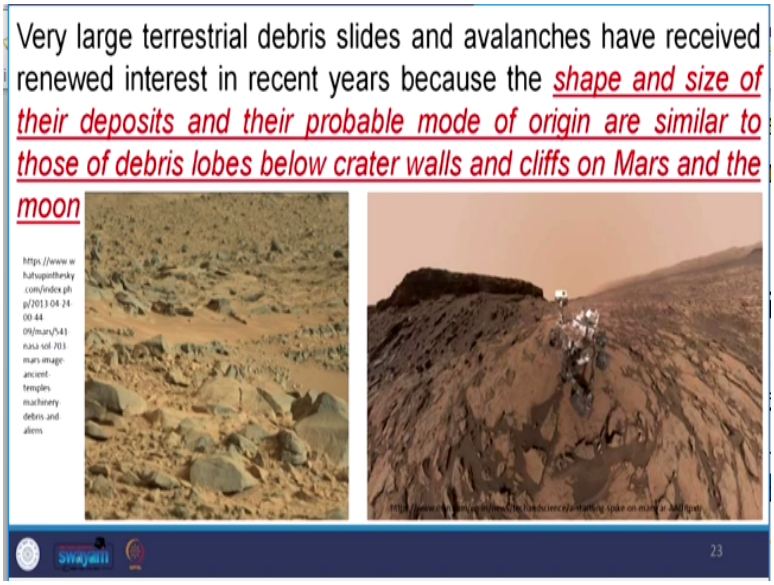

In the whole system is coming down suddenly, it is defined as the avalanches, so very large terrestrial debris slide and avalanches have received renewed interest in recent years because shape and size of their deposits and their probable mode of origin are similar to those of debris slopes below the crater walls, cliffs on mars and moon that is very important to see. In mars, whatever; in moons, whatever the photographs have coming, we are looking this similar type of mass flow at the avalanches; debris avalanches as we are looking at the earth.

So, it is believed that this systems which is working on the earth surface probably, this same system was working in this mars and moon surface in geological past, so this that is why, interesting is; interest is being grown on this to understand what is exact mechanism behind this debris avalanches, so that we can understand the lunar and the martian processes.

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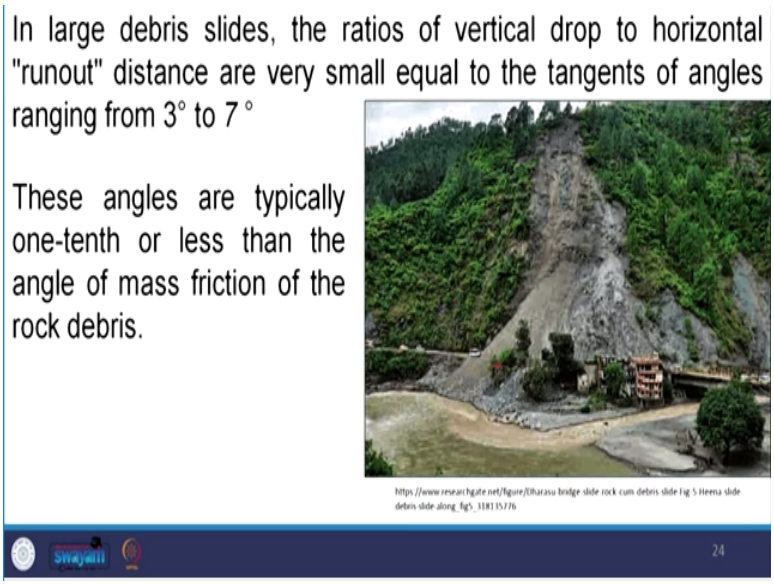

In large debris slide, the ratio of vertical drop to horizontal run out distance is very small equal to tangents of angle ranging from 3 to 7 degree; these angles are typically, one tenth or less than the angle of mass friction of the rock debris. So, if you remember our earlier class, when we started about this mass wasting, we are talking something about the strength, this angle of repose or so. So, here the large debris slide, the ratio of vertical drop to horizontal or not.

The distance are very small equal to the tangents of the angle to 3 to 7 degree and these 3 to 7 degree a typically, one tenth or less than the angle of mass friction of this rock debris, so that means, the angle of repose is more than the angle of repose, so that is why the system is going down and its horizontal distance is less, it is restricted.

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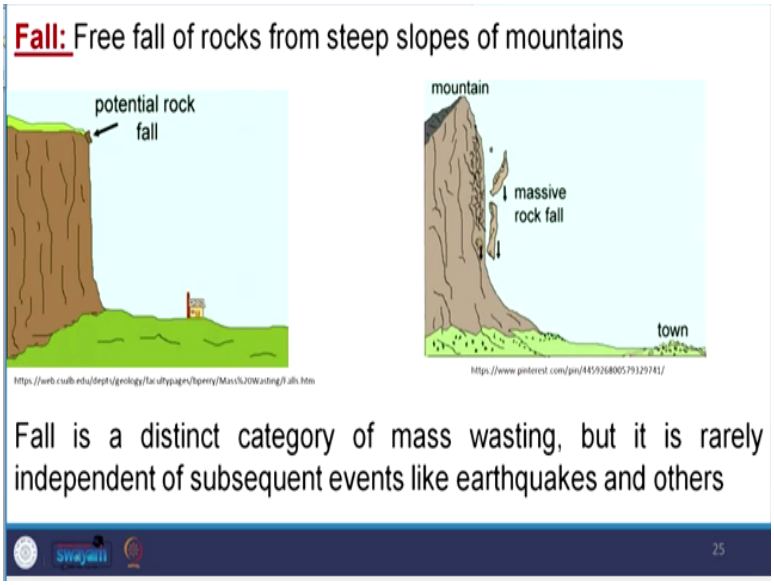

Then, another type of mass wasting, it is called fall, it is free fall, that means, only the air resistance will be there, so to prerequisite this for the fall, this, there should be a steep slope and there should be weathered rock material, there should be jointed rock material, so that this material which is detaching from this rock body, it is freely falling on the surface; freely falling to this valley and air resistance is the only resistance nothing else.

So, fall is a distinct category of mass wasting but it is rarely independent of subsequent events like earthquakes and others, so that means we need a triggering event, a triggering mechanism, so that the whole system should shake and the block should be detached from this main body and if you see this 2 figures, here due to; these are the joints or the exfoliation joints or the pressure release joints to this free part of this valley.

And this is the potential rock that can fall and in this figure if you see, the system totally is falling down so, here the massive rock is falling down, only the air resistance, you see it is not in contact with the main body, then it is falling down, it is not contact with the main body, it is free fall, only air resistance is there.

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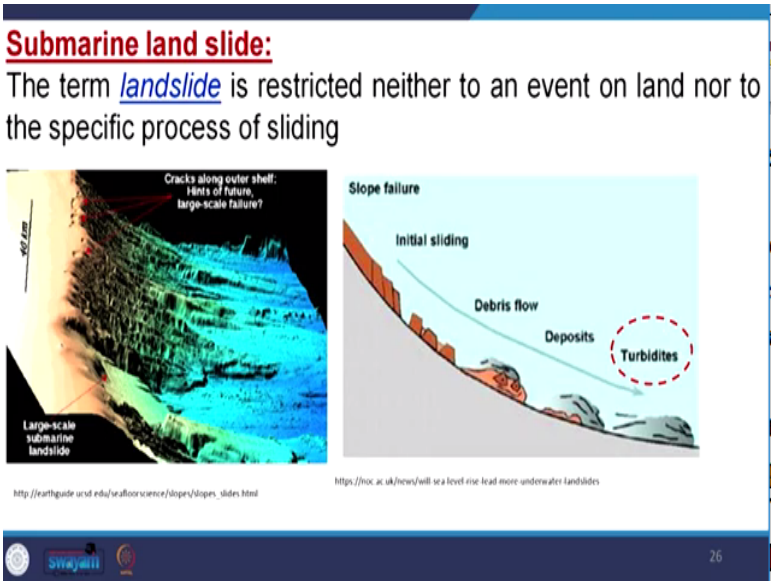

Then, whenever we are talking something inclined, we should keep in our mind that landslide does not occur on this subaerial system only, there are landslides that has been reported in the submarine system also, submarine landslides. Nowadays, in the present day also, we experience submarine landslides, in the past oceans, in geological past, when there are ocean was existing in certain parts, there also some submarine landslides have been reported.

And those submarine landslides or the past submarine landslides, they are now recorded within our rock stratigraphic, within the stratigraphic record, so by identifying those submarine landslides, we have to precisely identify those rock structures which are nowadays, occurring with the present day landslide, so that we can correlate, yes, those rock structure which are preserved in the stratigraphic section, it is indicating a particular submarine landslide.

So, the term landslide is restricted neither to this event of land nor to the specific process of sliding, so anywhere either being the submarine or in the land surface, if the sliding is going down, if the rock mass is going down, so that is called landslide; a submarine landslide, you might have heard about this turbidity current; turbidity current Bouma sequence like that. For turbidity current, they are these characteristic features or characteristics events of the submarine landslides.

And this turbidity current if you see here, there are debris flow and there will be turbidity current and finally, this will turbidite deposit will be there, here we will get these Bouma sequence like that whatever been studied in the; you will be taught in sedimentology, so these type of deposits if we are finding in our present day rock record, that means we can say these are the deposition or these are the outcome of this ancient submarine landslides. So, here is some of these photographs I have taken for you, it is the submarine landslide recorded in a stratigraphic record in Proterozoic sea.

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It is from this Pranhita-Godavari Valley, it is of Proterozoic, as if you see here, these are the autoclastic limestone flows, here these are the limestone clasts, these are the limestone clasts and the matrix is also limestone, it is autoclastic; autoclastic means, same clast, same matrix, it was subsiding that the same place where it was deposited, so those mass flows in this inside Pranhita-Godavari valley, they are indicating the landslides, the submarine landslide in the geological past.

So, this is the end of the story, so landslides we can summarise here, it is should not, this terminology should not confined within the land itself, so there are marine events, there are some events occurs in the marine, there is a failure of material which is also termed as landslides and landslides depending up on this material involved, depending up on this site, depending upon the

velocity or the speed of movement, so depending up on the slope, they are classified into different categories.

So, 2 main thing is that that material has to flow with the influence of a gravity, either it is on the hill slope or it is confined in the valley, so depending up on those circumstances, depending up on those parameters, the landslides are named and different landslide has to be classified or classified into different categories for our proper understanding and if we categorise it, so that means we can design our engineering structures depending upon that.

We can take some engineering remedies, depending up on the probability of what type of landslide is going; is expected in particular area, so this much is for today, we will meet in the next class, thank you.