Geomorphology
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Lecture – 19
Classification of Mass Wasting

So friends, good morning and welcome to this lecture series of geomorphology, today we will discuss about the classification of mass wasting. If you remember our last class, we are talking something about mass wasting, what does it mean? So, mass wasting; there are 2 criteria has to be fulfilled; one is the rock must be weathered, second thing, gravity plays major role as compared to other geomorphic agents like water and wind and glaciers.

So, that means, I want to say gravitational influence and weathering of material or removal of material from the intact rock body and it is downward movement, it must be sure that it should be downward movement due to gravitational influence that is defined as mass wasting but that does not mean that water is should not be there, water is there but it is playing a different role however, the major role in mass wasting of the gravity.

So, today we will classify the mass wasting, why we should classify it? Because classification as we know, it is for categorisation for easy understanding, once we classify a mass wasting or anything we classify, we categorised it into certain boxes and once we say that is of class this or class 1 or class 2, class 3, that means some perceptions come in our mind.

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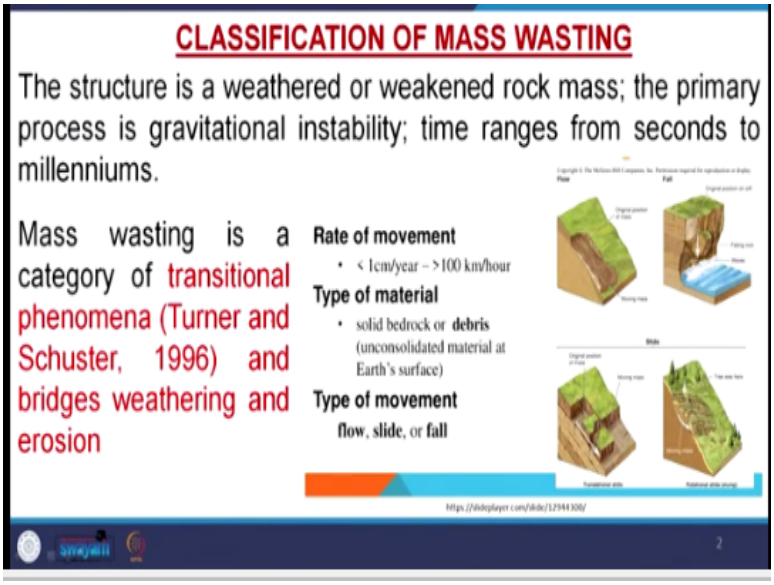

So that means, for example, suppose, we classify it this is of creep, so creep once we say, something comes our mind that it should be slow process, it should be very gentle slope, it should take very long time, so that is why once this classification comes in our mind or a class comes in our mind, we have to plan accordingly because most of this mass wasting, they occur in the hilly terrain but plain areas are there, which are recording this mass wasting but it is of negligible.

But most of this hilly terrains, they are suffering mass wasting in a different rates, in different geological time, at present days we are very eager our development programs and due to this development programs, we are going to modify the hill slopes, we are constructing large dams, reservoirs, we are constructing roads, we are widening the roads, we go for; we are going for tunnelling.

So, those developmental projects on SEZ, so for this we have to modify our existing hill slopes, so once we classify these types of mass wasting which is going on in that particular area that means, it will be easy to understand the nature of this mass wasting, so that the remedial measures we can take in that particular area will be specific, so specific mass wasting scenario is if it is there, we have to plan our developmental program accordingly, so that specific remedial measure has to be taken care.

So that is why, mass wasting classification is must and to before classification, it should be comes in our mind that it is a gravitationally trigger phenomena occurring up to downslope and it is a slow process in certain cases but in a rapid cases, in certain cases. So, the structure it should be weathered and weakened rocks of mass. The primary process is gravitational instability and time ranges from few seconds to few millennium years.

So that means, though we say the mass wasting, it is a slow process but depending upon the process involved, depending upon the type of mass wasting, its time varies, some of this mass wasting, it takes millions of years to move a meter and some of this mass wasting, even if 1 minute or 1 second, whole mountain front will be vanished and mass wasting is a category of a transitional phenomena between these weathering and erosion.

So, weathering; it creates material, erosion it removes in the help of flowing water, with the help of wind, with the help of the glacier but once we say it is mass wasting, that means those removal of the slope material, it is due to the influence of gravity that is mass wasting.

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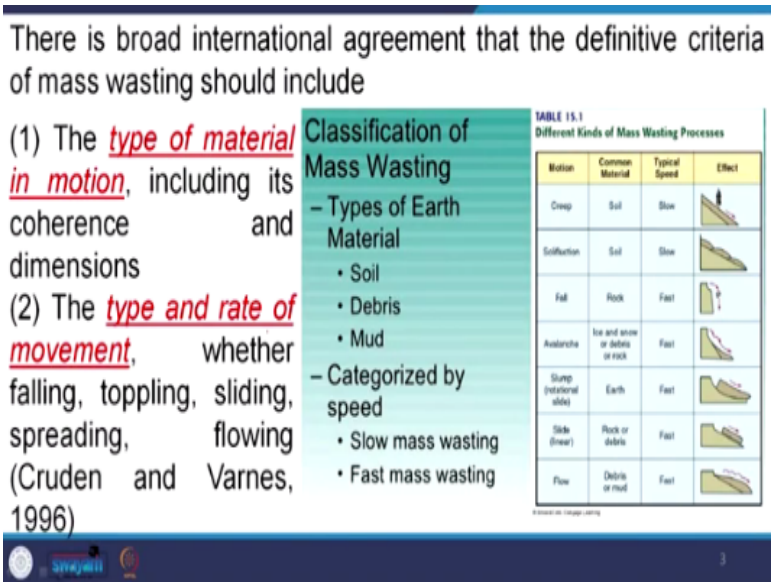

So, mass wasting has been classified according to different parameters, what are these parameters? First the parameter is the type of material involved in motion, type of material that is important, what is type of material? Once weathered material is there, the weathered material is there means, we have boulders, we have cobbles, we have pebbles, we have clays like big, big

blocks of rocks. So, what type of material is in motion; either soil is in motion or soil water mixture is in motion, only soil debris is there, only rock debris is there.

And size of the rock material, if it is block size is there, or it is small particles like pebbles, cobbles, sand particles are there, so the type of material involvement, it also define what should be the name of this mass wasting, then rate of movement; rate of movement at what speed, at what velocity it is moving so, if it is moving very fast, may be it is Avalanches, you might have seen in TV screen somewhere, sometimes there will be avalanches, huge ice, huge snow it detached from the main ice body and is moving with huge speed.

And sometimes, the mass wasting it is very slow so, the rate of movement and the type of material it is involved, so classification of mass wasting, if these type of material is involved either it is soil or debris or mud, similarly categorised by speed that is slow mass wasting and fast mass wasting.

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Type of Movement	Type of Material		
	Bedrock	Engineering Soils	
		Predominantly Coarse	Predominantly Fine
Falls	Rock Fall	Debris fall	Earth fall
Topples	Rock topple	Debris topple	Earth topple
Slides — Rotational / Translational	Rock slide	Debris slide	Earth slide
Lateral Spreads	Rock spread	Debris spread	Earth spread
FLOWS	Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
Complex	Combination of two or more principal types of movement		

Here, the complete table given these classification, you see the type of movement, what type of movement is there; either it is a fall, fall means, it is a slope face, from the slope face a particular boulder is or particular clast is falling down freely, so only air resistance will be there, free fall only air resistance, nothing else, no sliding friction, no frictional flows with the body, so that is called fall. Topple; topple means like this which is toppling down, it is also free fall.

But one end, it is attach to this main body, it is toppling down, then slide; slide means sliding, it is sliding down, it is the main intact body, main rock body, another the detached part is sliding down, so slide there are 2 types; one is called rotational slide, another is called translational slide. Rotational slide; when you see the rotational slide, that means the detached part it is performing a rotational motion.

So, rotation means, there should be a centre around which it to rotate, so in that case, this motion is on a curved path, for example, suppose we have a hill slope and hill slope is curved like this and this is the detached block, so once this detached block has to move, it here to move this path, this way, so that is rotational slide that means, it is rotating here, it is rotating on this curved path, so this is rotational slide.

Another is called translational slide, translation simply it is sliding friction is there, simply this detached path or this detached plain it is a simply planar body and it is sliding down, translational slide, then it is called lateral spread that means, the material which is detached from this main body, it is laterally spreading; spreading means, once the spreading is used that means, it is water is associated, it is spreading down.

Then, flow; flow means, it is flowing, the detached material it is flowing, flowing water again associated, then it is complex; complex means a huge body of detached mass, some part it is flowing down, some part it is sliding, some part it is in turbulence motion, so like this submarine landslides, so this is a complex one okay. So, mixture of all those things, once we cannot define particularly, so we say it a complex one.

Similarly, either it is rock is involved or soil is involved, if it is rock is involved or it is called bedrock in engineering science, it is called bedrock. If rock is involved, so depending upon the material associated that can be classified into rock fall that means, rock is falling down from a slope face rock is falling down directly, it is called rock fall. Similarly, rock topple, rock body is toppling, rotational motion, it is toppling down, it is rock topple, then rockslide similarly, rock is sliding down.

Rock spread; rock is along with water it is spreading, then rock flow again, more water is associated, so this type of classification is based on the rock involved, similar if soil is involved in terms of rock, it is rock fall, in terms of soil is involved, suppose it is predominantly of coarse material, so it is called debris. Debris means it is the weathered material irrespective of its size to debris.

Debris; it is consist of boulders, to pebbles, cobalts, salt, sand, silt, clay, every material, it is called debris, so debris fall, the whole material is falling down, then debris topple, same thing, then debris slide; sliding of debris, debris spread, debris flow, all these case debris, the weathered rock material is involved. Then, if it is fine material then it is called earth fall, mostly soil, fine material, silt, clay, sand, these are associated, this is called earth fall.

Then, earth topple, earth slide, earth spread, earth flow, so these are this classification based on this material involved and the type of movement that is associated but combination of 2 or more is also possible, so that means that does not mean only one type of material or one type of; one type of material is associated with one type of a flow. If you analyse larger flow, even if smaller if you vividly analysing it, minutely observing it, then you can say many types of this classification is associated with one type of mass wasting too.

So, that means the dominance part which is dominating, we name it like that so, rock fall that means, major part of the rock is falling down but within that rock fall, there may be some grains that toppling, what measure is looking at that is takes the classification scheme. So, let us discuss it one by one the first and foremost thing is creep and it is the most simple one to understand.

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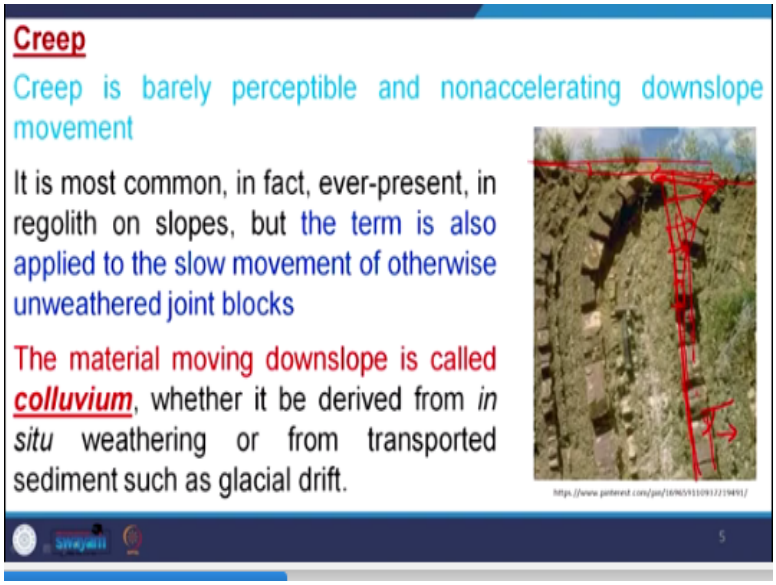

Creep is barely perceptible and non-accelerating downslope movement, if you see here in this photograph, here slope is downward and slope is very gentle like 1 degree or so but if you see this rocks associated or exposed here, if you see here, concentrate here this dip of this rock is towards this direction but a dip is near about 80 degree or more than that but once you are coming to the surface here you see, it is here this was the dip.

And here, this much it is deviating, here the deviation is relatively less, here the relatively less, again less, again less and finally, this is the original dip of this rock body or the rock bed. So, once you see this rock from bottom to top, you are looking that the rock bed is bending; bending towards the slope and this type of movement of this rock bodies of these mass, whatever the slope mass, it is called creep.

It is a very slow process, if I project this rock bed, it should exposed somewhere here but now you see this is shifted from here to here, this much distance has been shifted, so this is called creep, it is the most common in fact, ever present in regolith on slope but the term is also applied to the slow movement otherwise un-weathered joint rocks also. So, whenever you say about creep, we always think, that it should be associated with the weathered material with it.

But not necessarily sometimes, it has been observed that these joint intact rock mass, which is un-weathered, simply it is jointed but not weathered that is also performing very slow motion

downslope that is also categorised on the creep. The material moving downslope which is called colluvium, the whole material, it is moving downward, suppose for example, we define this, beyond there will be no movement.

But once the weathering system goes down, once more time is involved, this movement may takes from here again, with more and more time, the movement will take from here, so that means, depending upon the degree of weathering, depending upon the slope, what is the angle of slope; more angle the slope, less depth it is effected, if it is less slope, the effect will be up to more depth.

So that means, this material moving, the whole total material which is involved in the motion that is called colluvium, whether it is derived, either it is derived from in situ weathering or it is derived earlier weathered rock which is transported and deposited on the slope, irrespective of its origin, the whole material which is associated with the motion this is called colluvium.

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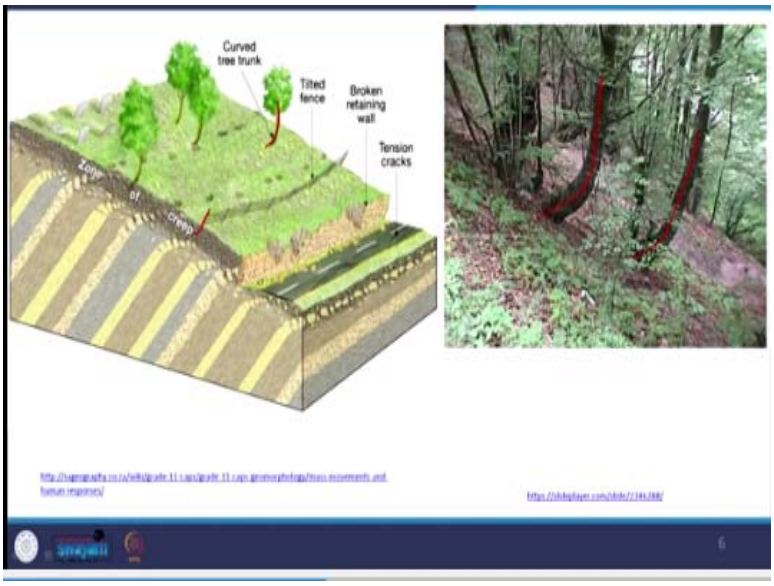

If you see this 2 photographs here, the first one you see these trees, they are bending, all these trees they have bending roots, similarly here is the fence, it is bending, its root, it is the bending, so these type of signatures on the hill slope that indicates the slope is under motion and it is slow motion, perceptible motion, some millimetre to centimetre per year, so this is due to creep action.

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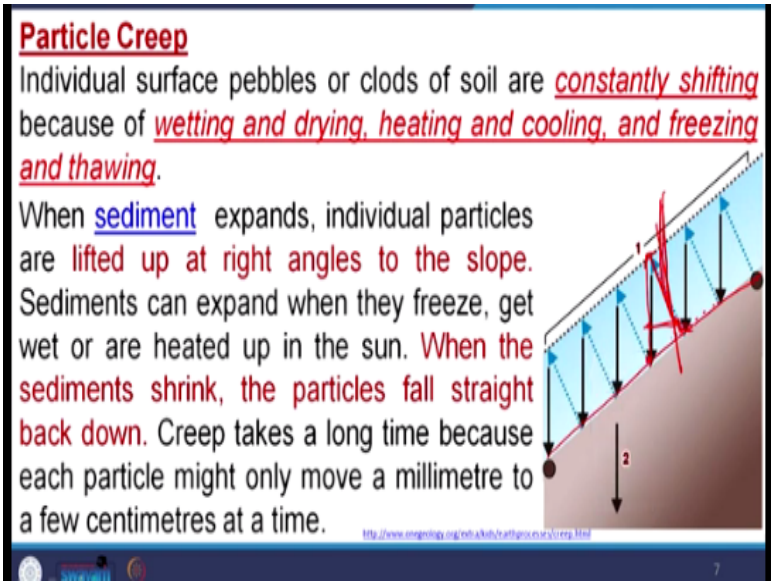

So this is divided into 2 parts; one is particle creep, another is soil creep. Particle creep why it occurs; individual surface pebbles or clods of soils are constantly shifting because of wetting, drying, heating, cooling, freezing and thawing, how it happen so? Now, you see, suppose, this is the slope we are measuring the creep motion, here all these particles, A, B, C, D, any particles, when it is expand either the expansion is due to heating or due to freezing or due to absorb of water, anything.

So, once it expand, its expanding perpendicular to the slope but during thawing process, during squeezing process, the particle is moving vertically downward, so for a season or for a completion of 1 cycle, this particle once it was here now, it is shifting to here, so this much is the horizontal distance, the particle has moved. So, when the sediment expands, individual particles are lifted up at right angle to the slope.

Sediments can expand when they are freezing, gets wet or they heated up in the sun, when the sediments are shrinking, the particles falls straight back to down, creeps take a long time because each particle might only move a millimetre to centimetre per year, so that is why from here to here motion, it will take some times, even if years or so, so that is why, each and every particle, it is moving very slow process and finally, this always nature wants to be intact.

So, suppose we have tree here, we have a tree here and this part is moving but this part will try to remain intact at this valley that is why this tree will bend like this, so this is due to creep motion.

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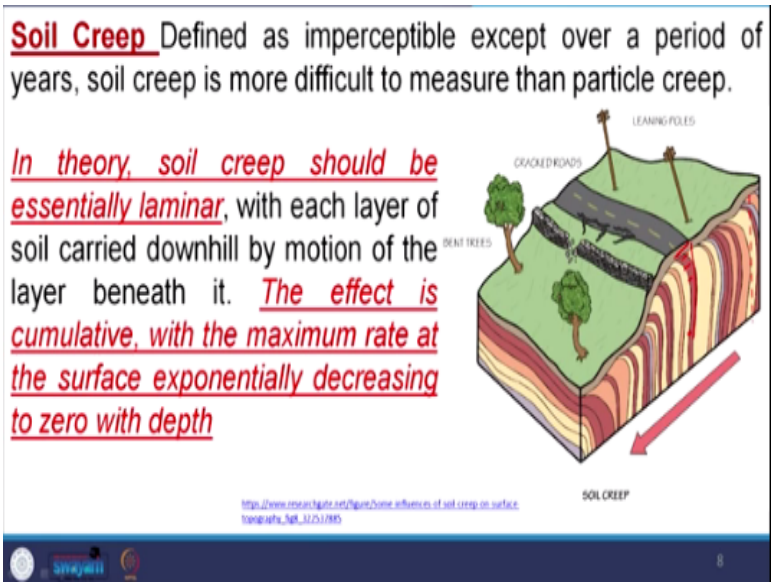

Soil creep is defined as imperceptible accept over a period of years, soil creep is more difficult to measure than particle creeps because particle creeps once we say, we consider as individual particles, individual rock particles but soil it is a mixture, it is a mixture starting from clay particles to silt, sand or so. So, in that case, it will be difficult to measure because each particle would move in different rates.

Soil for example, clay; clay part will expand very rapidly similarly, it will squeeze very rapidly but the sand is the; sand will not expand similarly, depending up on its size, the rate of swelling or the depth to which or the height up to which it will swelled up that also varies, so that is why once it is a mixture of materially associated, it is difficult to assign a particular number in that case, we have to average out.

But if it is uniform suppose, for example, the slope is only composed of clays, that means, it is uniform expansion or near uniform expansion and contraction, in that case it will be easy to understand and assign a number that is why particle creep, it is easy to measure and easy to understand but soil creep, once it is a mixture of material, it is difficult to understand and it is complicated.

Soil creep should be essentially laminar, it is very important here to note than once we say it is a soil creep, it is essentially laminar, with each layer of soil carried downhill by motion of the layers beneath it. The effect is cumulative with the maximum rate at the surface and exponentially decreasing at the bottom, so as we are talking something about 2 minutes back, if you consider here, it is your undisturbed point.

So now, you take this line and here you see this much has been deviated, here this much is the deviation, this much is the deviation, this much is the deviation, so that means, the motion is cumulative at the surface and gradually, it is slow and it is going, reducing with that, so that is why creep movement, it is more at the surface of the slope as compared to if you move downward, so that is why which are shallow depth material.

Those particles which are at the shallow depth or at near to the surface, they move more rate as compared to the particle which is lying below with and gradually, the effect reduces down and at certain depth, this becomes 0 and what depth it will be 0, that depends upon the slope, at what angle and what is the material we are involving, so depending up on the material, depending upon this angle of slope, this depth varies.

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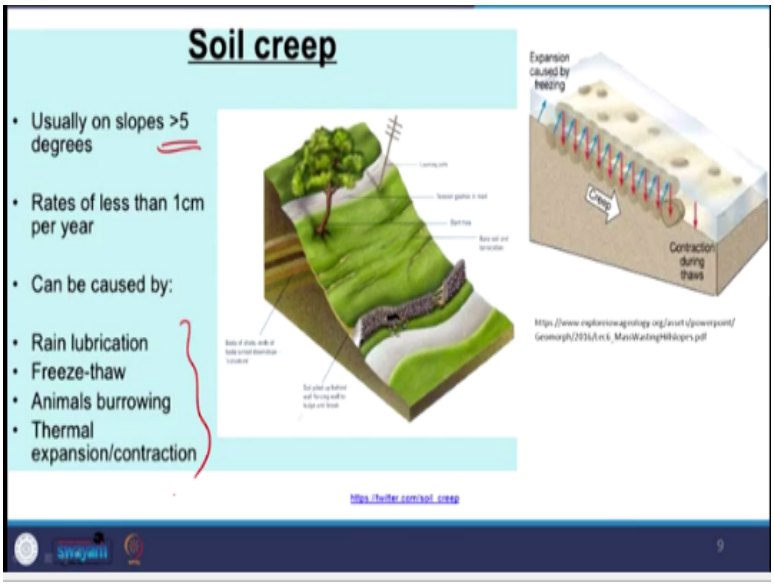

Then certain more information about the soil creeps; usually, on slope greater than 5 degree, so that means, 5 degree is the cut off that it will be noticed but that does not mean those slope which are less than 5 degree, they do not experience creep, it is there but to measure it that means to measure it easily, this 5 degree is the cut off, the rate of less than 0 centimetre, sorry, 1 centimetre per year can be caused by rain lubrication, by freeze and thaw, animal burrowing, expansion, contractions.

So, these are the reasons why the creeps occur but it is starting from 1 degree to more than 1 degree or more than 5 degree.

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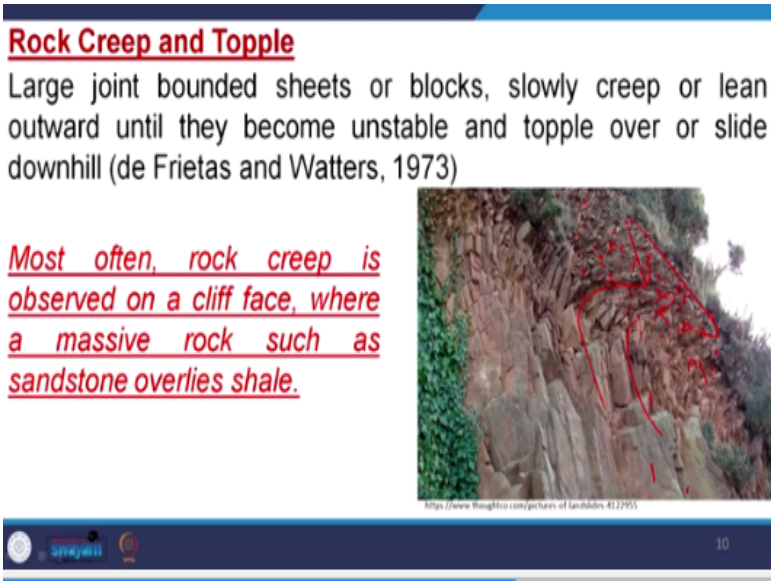

So, then rock creep and topple, so far we are discussing about this soil creep, this material which is mostly of soil expanding and contracting, so during expansion, it is moving up perpendicular to the slope and during contraction, it is vertically falling down and finally, slowly, slowly the particle is moving down slope. Now, rock creep means here, rock is involved, rock fragments are involved.

Large joint bounded sheets or blocks slowly creep or lean outward the slope until they becomes unstable and topple over slides down to the downhill, so this is rock creep that means large boulders are here, if you see this figure, the photograph, here these are this weathered part and

here rocks are fragmented, clast, converted to different clast, those clast try to move down slope and until, unless they topple down.

For example, if this is the free face of the slope and if it is bending down, it is moving here and bending down, this side moving and bending down, so ultimately this will detached this block if you consider, it will ultimately detach from this main body and it will toppling down, free fall will be there, so this is the creep, here you see there are 2 dimensional motion; one is it is moving in the down slope.

Another side, it is moving this side down slope, so ultimately this fragments with time that will topple down from this main rock body and this is; this up to which, when it is detached, when it is attached with the rock body that is called creep. Once the free fall that detached from this main body and topple down that will either categorised under fall or topple depending upon the motion.

So, creep the terminology, only and only is restricted up to which it is attached with the slope, attached with the main rock body, the it is the creep, once it is falling down, that will be either it is fall or topple that will be depending upon the type of motion involved. Most often, rock creep is observed on a cliff face, where a massive rock such as sand stone overlies shale.

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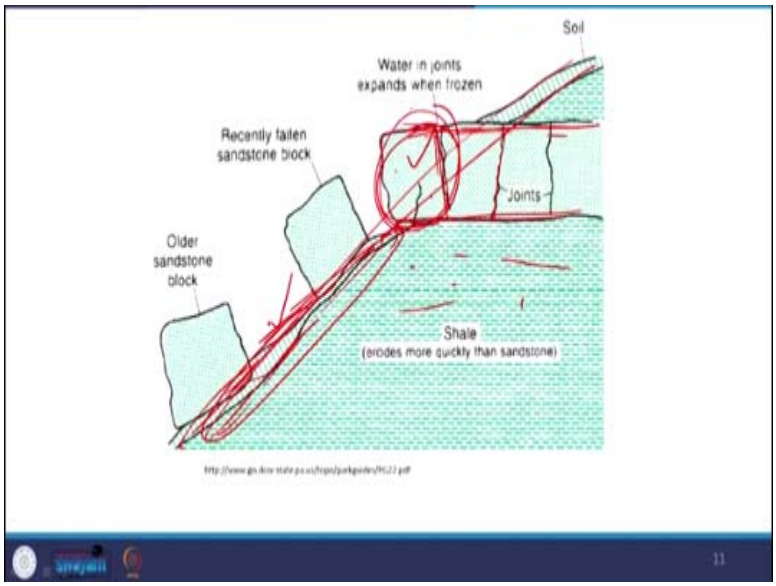

If you see here this photograph, suppose, we have a shale body here and this is a bed of sand stone here and this is the slope where it is exposed, so we know shale, though it is clastic but mostly, it is clay size particles, so alternate expansion and contraction will be there. So, here what is this sand stone is there, so here cracks are developed and through cracks, if you see this these blocks will tend to lean towards the slope, this is rock creeps.

So, here we will find soil creeps, the soils, mostly the soil with is moving down but here wherever, the sand stone is exposed that will experience rock creep, so rock creep and soil creep but mind it the creep movement here in the soil and the rate of movement here may not be same because the material property is different. The slope is different so, within a one slope also, if we have different type of material involved, the rate of movement will be different.

Here, that will be somewhat different rate, here somewhat different rate, okay and mostly, when the rock creep, it is either if it is a sand stone body which is embedded within the shale, this part is very easily seen.

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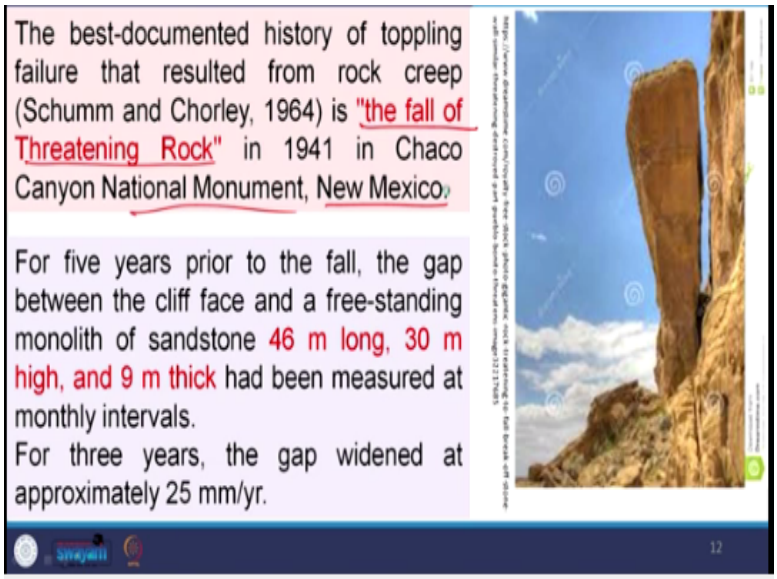

The best documented history of the rock creep is here the fall of threatening rock, it is National monument of New Mexico, it is a story behind it for 5 years prior to fall, the gap between this this cliff face and the free standing rock monolith sandstone, it increased, so this sides of this

rock monolith was 46 metre long, 30 meter high and 9 meter thick and every month, it was measured how it is detaching from this main rock mass.

For 3 years, the gap widens at approximately 20 millimetre per years and it was become a National monument in New Mexico.

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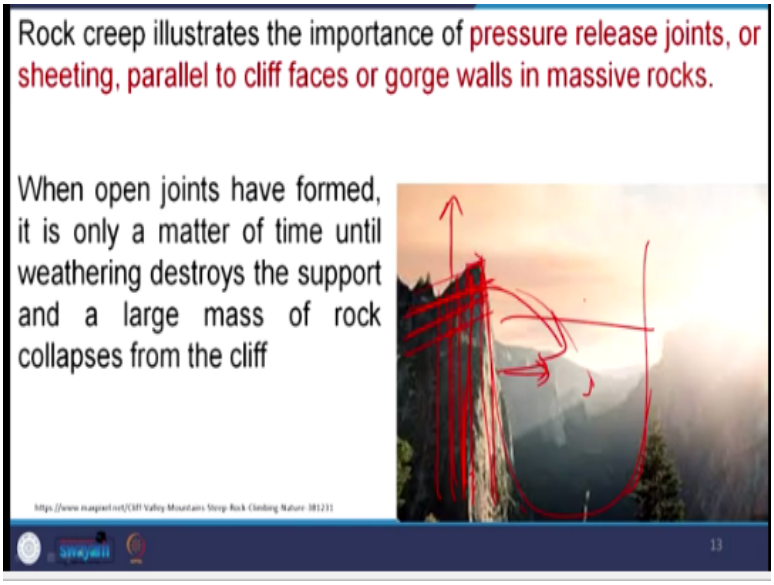

Rock creep illustrates the importance of pressure release joints or sheeting parallel to the cliff face or gorge in the massive rock mass and here, some points has to be understood, the rock creep, they are everywhere present in the cliff faces either it is the pressure release joint; pressure release joint means, you might have heard about this plumose structure, tree like joints, joint planes which will tree like appearance, it is called plumose, okay.

So, plumose structure or plumose joints or sheetings; sheetings you can remember when there is pressure on loading, there are sheets parallel to this open surface, if you see here this is this cliff surface and this is the valley, this side is the valley, this is the cliff surface and the cliff surface, once this side is open to the air, you will find sheeting joints like this similarly, we have sheeting joints like this because this is open space, this is open space.

So, once pressure releases there, joints will be parallel to the surface, joint will be parallel to the surface, so once these joint and these joint they interact, these block will be removed okay, so

this is sheety joint parallel to the cliff face and gorge wall, gorge; when there is a river, which is flowing here, very deep valley, this is called gorge. When open joints have formed, it is only a matter of time until weathering destroy the support and the large mass of the rock collapse from the cliff.

Here for example, few minutes back, we are talking something about the rock of this threatening wall, here the fall of threatening rock here, similar things now see, this is the gap, it is annually, it is increasing and finally, this part is toppling down. Similarly, in this case you see, this is the sheeting joints, these are the sheeting joints, so with time it's become attached from here, this part will fall down here, is not it?

So, this will rock creep that means, slowly it is being detached from the main body and with time, it is toppling down to this valley, it is rock creep.

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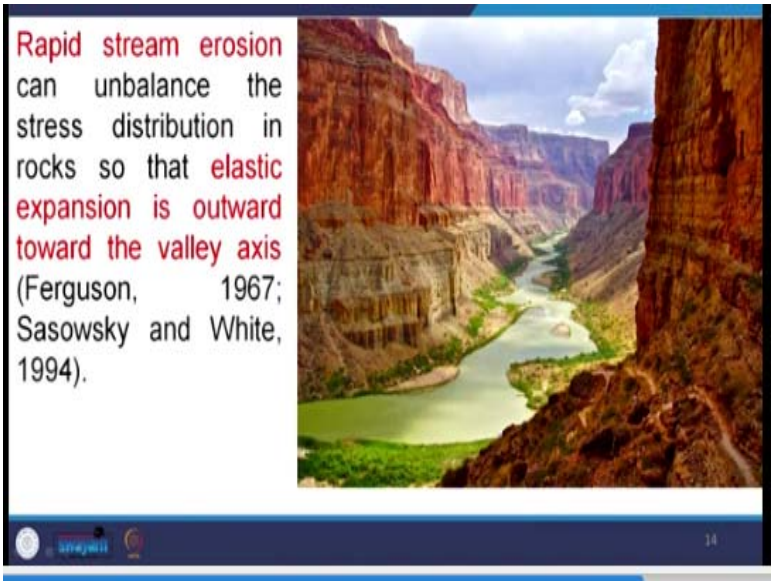

Rapid stream erosion can unbalance the stress distribution, so that this elastic expansion outward toward the valley axis, it is very important to understand, here rapid stream erosion mainly, this occurs in hilly terrains like the Himalayas if you move, there are many valleys, many rivers which is flowing through gorge; gorge means very deep valley and suppose, there will be a rapid rate of erosion, rapid rate of erosion either the river is rejuvenated or the whole system is uplifted.

In Himalayas, it is a tectonically active zone, active mountain belt, here once the system is up lifted, so river has to down cut the valley, once river down cuts the valley , rapid rate of erosion occurs, so more rock is exposed, for example suppose, the earlier this was this valley level and this much is expanded or it is up lifted. So, now river has to flow this level, so this part is again exposed to the surface, so earlier when this part was intact with these, so it was pressure balance was there.

But once this part is exposed, so that means, there will be free expansion towards valley, similarly there will be free expansion towards the valley, once there will be free expansion towards the valley side that means there will be joints developed and those joints are the expansion joints and through the expansion joints, the rock creep starts. So, once the rock creep starts, this is the expansion, and this is the free space.

So, that means, this block will try to lean down towards the valley, slowly and slowly and with time, this part will totally topple to the valley floor, so this is rock creep, it is one reason is the rapid rate of stream erosion. Then another type of mass movement, it is called flow, it is the incoherent rock debris may be mobilised sufficiently, so that it flows like a viscous fluid, so that means here, water to certain extent is involved, it has to flow.

The rock mass is to be or the rock debris has to behave as a viscous flow, viscous fluid, it is moving like this landslide, when there is cloud burst, there will be cloud burst in hilly terrains, the whole mass moves as flow that is called rock flow. The criteria for defining flow or evidence of internal turbulence and either discrete boundaries of a narrow margin zones of shear.

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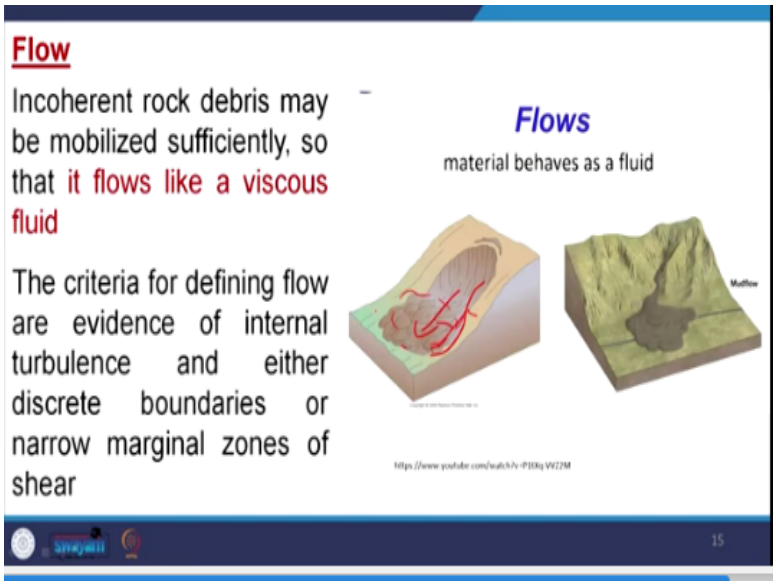

So, here once the system is flowing, the whole system there will be internal turbulence in between them and it is a narrow boundary where which defines or demarcates from the main body to this flow mass. So, this line or this plane is defined the zone of shear, so shearing motion will be here and here internal turbulence will be there and with the help of water, with the help of gravity, the whole mixture it is coming down as a viscous fluid, this is called flow.

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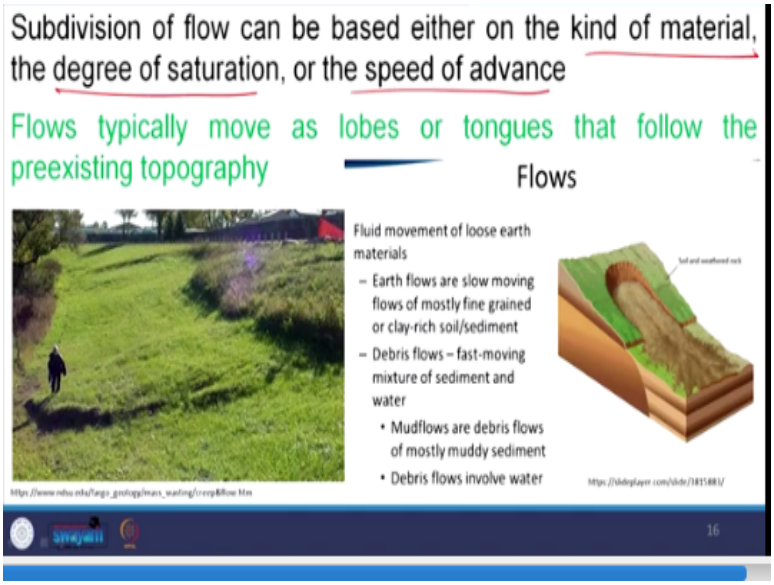

Subdivisions of a flow can be based on either the kind of material involved, the degree of saturation and the speed of advance, flows typically move as lobes or tongues that flow that follow the existing topography. So, when this material is involved and the speed; once the speed,

the degree of saturation, the kind of material, so either the material is totally of debris or this totally of rocks, is totally of a clays and the degree of saturation, how much water is there?

If water is less, the movement will less, similarly if the slope is less, the movement will be less, the speed, if it is on sloping surface; highly sloping surface, this movement will be advanced, the movement will be very high, if it is slow or this sloping surface is very less slope is there, so that means the movement will be less. So, depending upon this material involved, depending upon the degree of saturation, depending upon the degree or the speed of advance, this flow has been subdivided.

One particular type of flow, it is called solifluction; solifluction, if soil is saturated with water the soggy mass may flow downhill in a few millimetres to few centimetres per day or per year, this type of movement is called solifluction. Solifluction, this term sol; sol is from soil, so that means here, soil is involved, so soil involved and if soil is saturated with water, it remains on a sloping surface, it will move as a lobe.

For example, if you see here this is one lobe, this is another lobe, this is another lobe, this is another lobe, so that means, once the system is moving downward with the help of gravity, with the influence of gravity and it is water saturated, this type of lobes are generated and this occurs, this essential criteria should be there that the water is not released, once water releases, that means water will be free from this material and it moves out, this movement will stop.

And or the movement; movement will not stop, it will slowdown, so that means there should be a criteria, there should be a situation, there should be a condition in which water should not escape from the system, so that this movement will continue for long distance.

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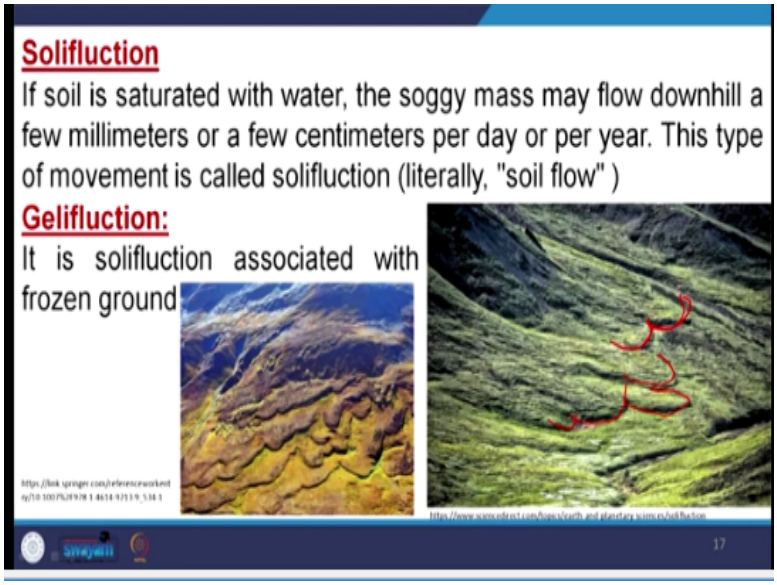

Then another is called gelifluction, it is the solifluction with frozen ground that is called gelifluction, so soliflcution and gelifluction; 2 different aspects, the same thing once it is under frozen ground that is called gelifluction.

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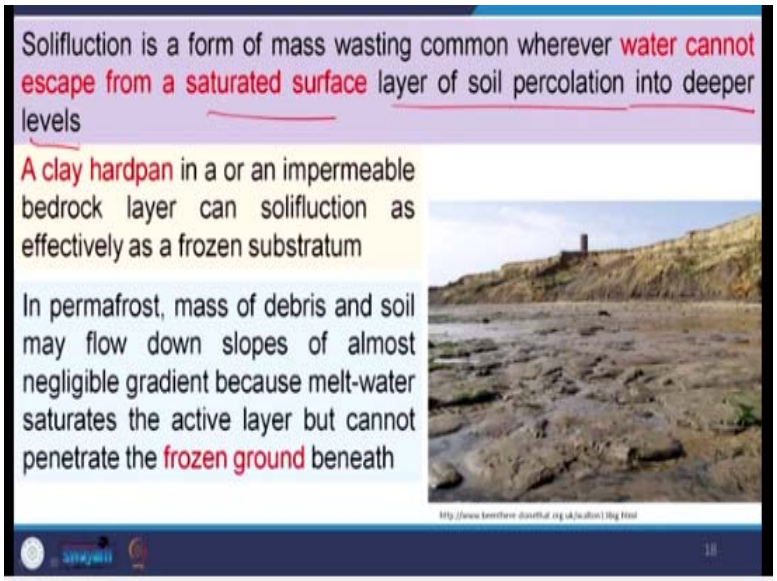

Solifluction is a form of mass wasting, common whether whatever water cannot escape from the saturated surface, layers of soil percolation into the deeper level, this is solifluction. A clay hardpan is in a or in impermeable bedrock should be there, so that it will prevent water to percolate down, so that means, I want to say water should be within that system, so that it will accelerate the movement, it will continue the movement.

In permafrost, mass of debris and soil may flow downward slope and almost negligible gradient because melt water saturates the active layer but cannot penetrate the frozen ground beneath, so that is another, once water is there within the system, the movement will continue. In frozen ground generally, the pore spaces, it is filled with ice, so once its pore space is filled, it behaves as an impermeable member.

Similarly, salt pan, hard pan, clay, if it is below and above the soil, this water which is within the soil or the saturated soil, the water cannot penetrate down, cannot percolate down, so that is why the water remains in the upward layer and with the help of gravity, the whole system moves downward, so this is the essential condition for the movement that water should not percolate down.

If water percolates down, then evapotranspiration occurs, so that this mass, which was moving with the saturation conditions with water that becomes 0, so movement will stop there, so this is the essential condition has to be fulfill. So, I think we should stop now and we will meet in the next class, thank you very much, thank you for your attention.