Geomorphology

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Lecture-46
Fluvial Process -II

So, friends, good morning and welcome to this lecture series of geomorphology. Today we will continue with this fluvial process, which in the last class we are discussing, that the fluvial process is the most dominating geomorphic process among others. So, others geomorphic processes like this a glacier like this marine and these aeolian processes they are confined particular domains. However, the fluvial systems the rivers, the channels, the streams, they are well distributed throughout the globe throughout this continental site they 24X7 try to modify the landscapes.

So, in the last class also we are discussing about the stream generation procedures, there are 2 types of flows, one is called this overland flow that is hortonian overland flow and other is saturated overland flow. So, the saturated overland flow it is occurs when there is the pore spaces of the soil or this medium is totally saturated and the medium is not capable to absorb more water so, that overland flow occurs.

And the due to this saturation the adhesive force among these particles, decreases and finally, this particles loosens and try to move due to fluid pressure, so this is how we are getting a channel that means water as well as sediment within the system similarly, we have rills we have gullies, then we have valleys. Rills, they are the small channels not mappable scale, but gullies are mappable scale and then valleys so it size increases.

So, today we will discuss about this a bedrock channels, alluvial channels, channel that which are flowing through bedrocks and how channels longitudinal profile evolves with time with tectonics with climate with rock types with like that. So, here is one called bedrock channel, what do we mean by bedrock channel sometimes you might noticed that whenever you go to field suppose for example hilly terrains or these hard rock terrains.

There are channels throughout this channel bed you will find exposure of hard rocks and within that channel, at some stretches, you will find this hard rock it is completely exposed and some channels or some stretches it is covered with alluvium like sand, silt clay, organic matter like that. So bedrock channels are those channels, where which flows through these rock exposures that are called bedrock channel.

On contrary, there is another type of channel which is called alluvial channel and mostly the alluvial channel flows through alluvium. It is huge sediment like this alluvial channels, Ganga plain channels, there are alluvial channels similarly coastal plain channels there alluvial channels however if you move to peninsular site, the channels which are flowing through hard rock exposure, they are called the bedrock channels.

So, now the question arises if it is a bedrock channel or it is the alluvial channel so, what is its utility to geoscientist? Generally, whenever we move to field for a rock specimen collections, we move along this lower part of this topographic level. So that we can get the exposure of rocks so generally it is a general practice of geologists, they follow these channels. So, because the channels they cut through this rocks and cut through this alluvium and sometimes along these channels, there are rock exposures are found.

So for sampling purpose for rocks sampling or rock specimen collection purpose we move along these channels. So that there are chances that we can get the exposure and through this exposure we can collect these rock specimens.

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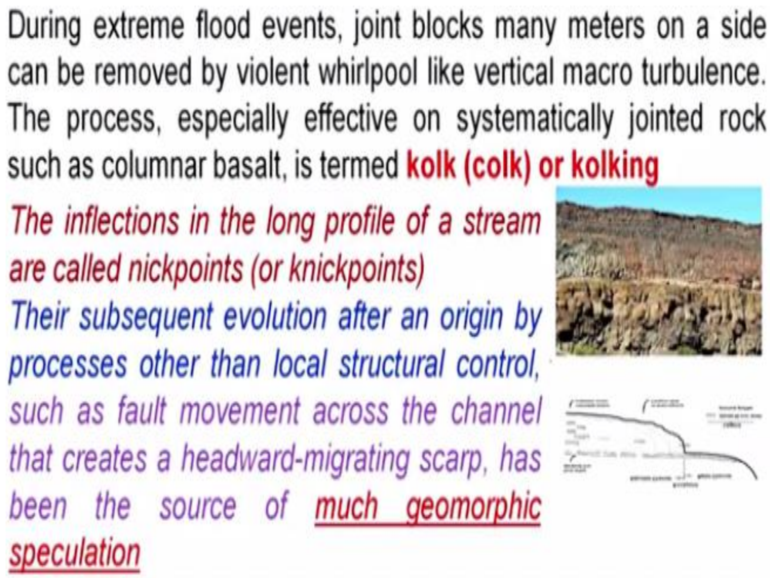

So during extreme flooding, jointed rocks like columnar basalt, jointed sandstone, joint rocks that any rock which is jointed either it is a joint its inherent property or it is later on superimposed. So through this jointed rock if we have some extreme flood events are there so due to swirling action, some of these blocks intact blocks they are carved out from these rocks and this process is called kolking or it is called kolk.

So it is the either it is a columnar basalt it may be any type of jointed rock if we are removing a piece removing different pieces, different blocks of rock due to swirling motion of this water and due to high flood time. So this process is called kolking so, this inflections in the long profile of a stream are called nick point, nick point means suppose longitudinal profile of a stream, longitudinal profile, it is concave upward.

So, this concave upward it should be smooth like this, it will be concave upward however, it is not as smooth as we think. So, that depends upon many factors that depends upon the rock type through which this stream is passing through and tectonics. So, this faulting across this stream path and there are dams, artificial reservoirs and dams, or natural reservoirs, natural lakes so, all those effects these longitudinal profile of the river or the stream.

So, there are subsequent evolution after an origin by these processes other than local structure that controls such as fault movement if you move to peninsular river in with Ganga plain rivers, there are many subsurface and surface faults there influencing the longitudinal profile of this river. All those major rivers like Ganga, Yamuna, Ghaghara, Kosi, if you take this longitudinal profile, it will not though it is a overall it is concave upward.

But within that concavity you will find local convexity so, here we case here comes this story of this hill slope evolution or these slope processes we are talking during our initial classes. So, this longitudinal profile overall it is though it is concave upward, but within that concavity we get the convexity due to this perturbation of fault, rock types, and other factors like a natural or artificial lake reservoirs so like that.

So, such as fault movement across the channel that creates a headward migrating scarp for example, if you see here, this is the why take this longitudinal profile of a channel will be like this and within that if I am getting here suppose for example, we are getting like this are getting like this. So, that means, these are these places they are of geomorphic speculation that each have geomorphic importance.

Why is your importance there because within that convexity there are many geomorphic feature either it is tectonic feature is involved or this lithologic feature is involved or other features are involved that can be solved from here. So, longitudinal profile whole longitudinal profile is not interest for geomorphologist so, geomorphologist are more interested in the long there is an exceptional in this longitudinal profile where there is convexity.

So, either there is an upliftment is going on there is there in fault movement is going on there. Is there any other rock type which is not exposed, it is there. So, that means all the speculations this comes from this longitudinal profile, where there is an exception. Then we are talking about bedrock channels here we will talk about the alluvial channels as we know that alluvial channels, their channels which are moving through the alluvium completely alluvium field.

So, that is why it is called mobile channel, mobile channel in alluvial channels mostly during flooding, this change their course, because sediments through which they are passing through, it is loose and unconsolidated. So that is why during flooding much chances are there so this river will change its course it is very common in the Ganga plain rivers it is very common in the coastal plain rivers which are flowing through deltaic portions.

So during flooding, frequently change their course so that is why it is called mobile channel this course is not intact. However in contrary if you compare it to this a bedrock channels, bedrock channels they are confined, they are confined course because they are confined through hard rocks, it is very difficult to cut this hard rocks and migrate the channel from one place to another. So, that is why it is these alluvial channels are called mobile channels. So it is proposed by fixed channels in the bedrocks can adjust to fluctuate the stream flow in many ways.

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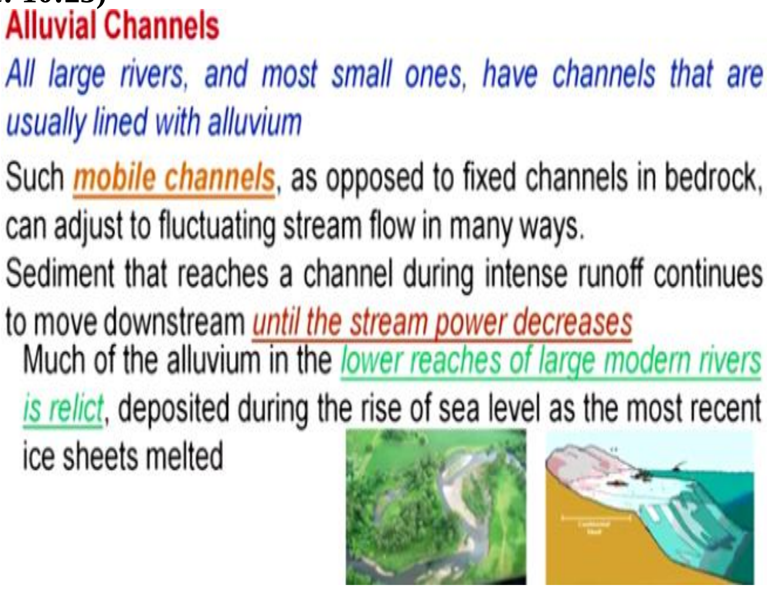

Sediments that reaches a channel during intense runoff continues to move downstream until the stream power decreases much of this alluvium in this lower reaches of large modern rivers is relict deposit during the rise of sea level as the most recent ice sheet melted. For example, if we go to the deltaic portions where the river mouths in the nowadays whatever the river mouths are there suppose for example, if you take this east coast of India we have many rivers.

Debouching in Bay of Bengal but if you analyze that river course, all the sediments now found in this river mouth a not sediments which are deposited during the recent days by the river, some of these sediments, they are relict, relict sediment means during sea level rise during deglaciation so, deglaciation means huge sediment was produced or during glacier also during glacier movement huge sediment was produced and deposited along this coastline.

So, due to sea level rise, these sediments are remain there, they are not able to move further downstream or further into the sea within this deep sea portions. So, that is why most of the sediment which is nowadays it is found along this river mouths that mostly there relict sediment and few are these present sediments.

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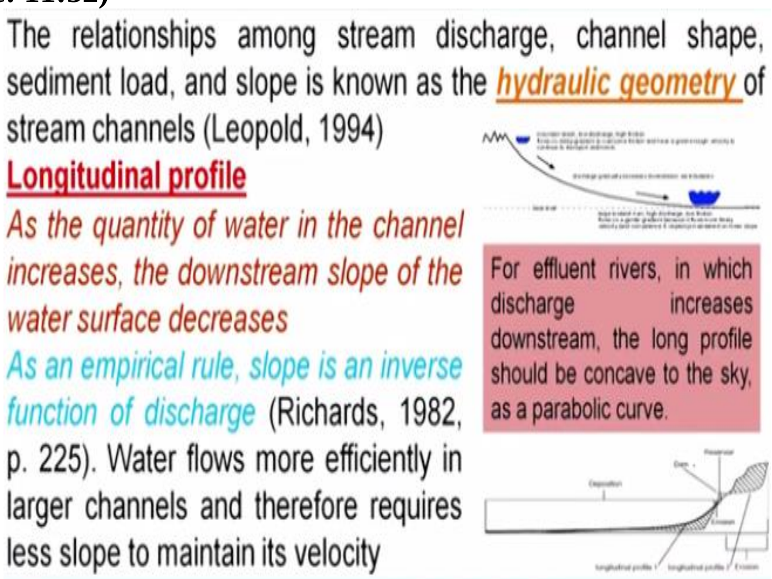

The relationship between these stream discharges, channel shape and sediment load and slope is known as hydraulic geometry, hydraulic geometry that means, we have to establish a relationship between the stream discharge, then channel shape, then sediment load, then slope so, that this hydraulic geometry that means, if we have high discharge and high sediment load, the higher slope these stream shape will be different stream behavior will be different.

At the lower slope, low discharge is there or high discharge is there, so, that means these are the dependent parameters, if you change one parameter or other will change automatically. So, this is called hydraulic geometry, hydraulic geometry that means, if the channel shape is there stream channels shapes how what shape it will take either a meandering course it will be a braided course it will be a straight course, or the valley height to width ratio.

How much would be the height to width ratio so, all those factors that this is combinly called is hydraulic geometry and this hydraulic geometry is dependent upon these factors. So, change one factor, the other will change automatically so, they are the dependent variables. Now, we are talking about this longitudinal river profiles so, this longitudinal river profile the quality that means, longitudinal river profile if you see here.

This is the ideal longitudinal river profile that is concave up, but, as we are talking within that concavity there is if there is some convexity some local convexity is there. So, that means, it is the proportion this portion or this interest for this geomorphology to work out why this convexity is there. So, the quantity of water in the channel increases the downstream slope of this water surface decreases so, as an empirical rule slope is inverse function of discharges.

Higher slope lower discharges lower slope higher discharges so water flows more efficiently in larger channels and therefore requires less slope to maintain its velocity. So, this is the thumb rule, if we have higher discharges, then lower slopes that means, rivers which are at the lower slope that can discharge more water as compared to the higher slope. For effluent rivers effluent means in the last class we are taking some of the influent rivers and effluent rivers.

So, effluent rivers that means they are collecting water from this groundwaters table and influent they are going inside gradually decreases this discharge decreases downstream that is influence river and this water amount increases downstream due to this contribution from this groundwater that is called effluent rivers with the discharge increases downstream this long profiles should be concave to the sky as parabolic curves.

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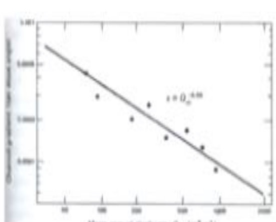
For *alluvial channel that is well adjusted to its discharge* and sediment load, the relationship between slope (S) and mean annual discharge (*Qm*) is:

$S = Qm^{-0.55}$



However, it is noted that many rivers have straight segments or even convex-skyward segments as part of the overall concavity.

For a group of 79 rivers in Kansas, mostly with coarse sediment loads, $S=Qm^{-0.25}$, and slope decreases only slightly as discharge increases (Osterkamp, 1978).

So, for alluvial channel that is well adjusted to the discharge and sediment load, the relationship between this slope S and mean annual discharges Qm it is as follows. So, this is for alluvial there is valid for alluvial channels. So, slope S = $Qm^{-0.55}$ it is mean annual discharges to the power -0.55. However, it is noted that many rivers have straight segments or even convex skywards segment as part of this overall concavity.

But in a experiment in the Kansas group of 79 rivers was taken and which rivers mostly they transport coarse sediments. So here, this slope = $Qm^{-0.25}$ to the power - 0.25 and that means the slope decreases always slightly as a discharge increases. So, that means, here this discharge this slope, they are interrelated and that depends upon the which type of channels you are dealing with what type of sediment it is transporting

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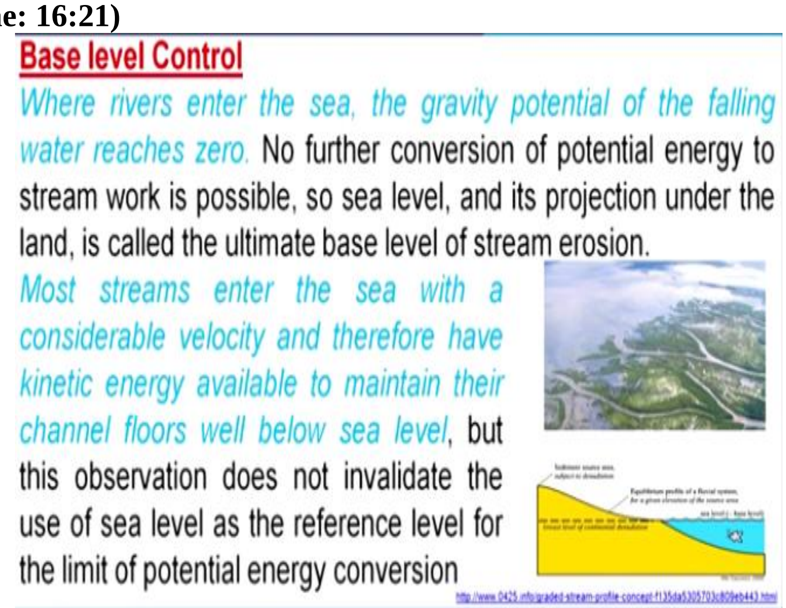

That another component of fluvial geomorphology and influence greatly to the fluvial geomorphology in the base level so, whenever we say it is base level that means, it always comes in our mind that, base level is the level through or beyond or below which the river cannot erodes that is base level. Generally, in base level, once we say always the sea level comes in our mind or the sea level which is projected.

It is a horizontal projection of sea level to this continent that is called base level but it is not always true. So, base level once we say that means there may be base level or there are 2, 3 base levels in a river profile, but one is permanent base level which is true which is the mostly the sea level and other base level which is above the sea level they are called local base levels for example, a river which is passing through a lake and then it is going down.

And again falling within this a sea so, this sea is the base level, but this lake is the local base level. So, if you compare this longitudinal profile of this type of rivers which is passing through many local base levels, you will find there are many concave convexity within that concavity for example, if you see here, here, this is the sea level and this is projected sea level and that is called base level.

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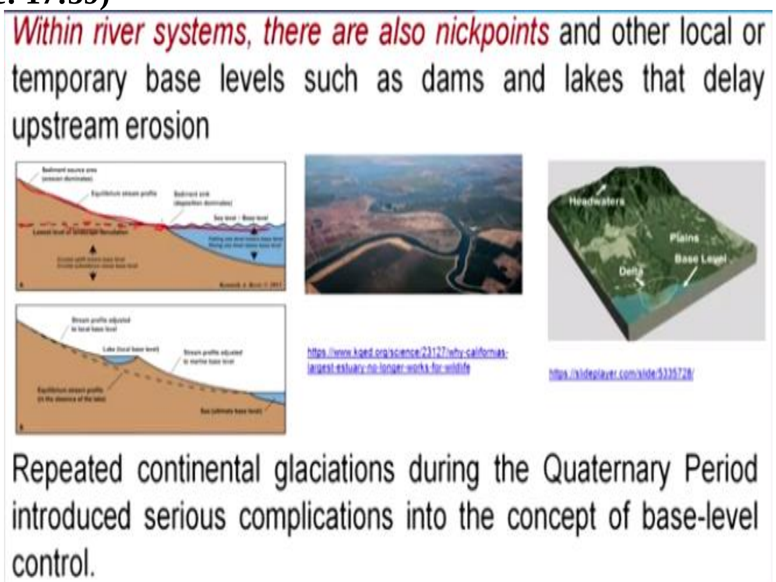

This is the longitudinal river profile, however, in this case 2 this is sea level and this this is a lake. So, this if you see this, this is the longitudinal river profile. So, the difference is that here we are getting a local convexity and this here once it is here it is a concave upward, this is concave upward or what here convex upward, but here if you see it is a steep gradient again this is slow gradient is less, but here it is maintaining a steeper gradient.

So, that means it local base level at the downstream of this local base level either it is a lake or an artificial reservoir. So, these are called serve this local base level and mostly these river create small deltas at the downstream or this upstream or the upside of the reservoirs, upstream of the reservoirs small deltas as form. So, where river enters the sea, the gravity potential of this falling water reaches 0.

No further conversion of potential energy to stream work is possible. So, sea level and its projection under this land is called ultimate base level of stream erosion. So, beyond which erosion is not possible, most streams enter the sea with a considerable velocity and therefore, their kinetic energy available to maintain their channel floors well below the sea level. But this observation does not invalidate that the use of sea level as the reference level for the limit of potential energy conversion.

So, that means, though this sea level, those, this river, this is high velocity that can pass through this sea level and creates its own channel its own channel width is maintained, own channel depth is maintained, but still, this sea level is called the or it is considered at the base level and it is assumed beyond which are below which below that level river cannot erode. So, if this type of artificial reservoirs or natural lakes is there within that river profile.

There are also nick points or other local temporary base level such as dams, lakes, that delay stream erosion. So, this upstream erosion it is a function of also base level its base level increases. So, the erosion capacity decreases, its base level decreases the erosion capacity increases for example, during these glacier time in most of these waters, they are in the glacier form, this base level was much below the present day.

So, though there was no water, but at this time when this glacier melts and the rivers become activated, their erosional capacity has more because the base level was much below. So, that the most of the sediments they are eroded and this valley widen take place. The repeated continental glaciation during quaternary period, introduced serious complication into the concept of base level control so, that time base level fluctuation was there. Nowadays whatever the base level is there, due to increase of sea level, the base level also increase to river erosional capacity and decreases and sediment transporting capacity decreases.

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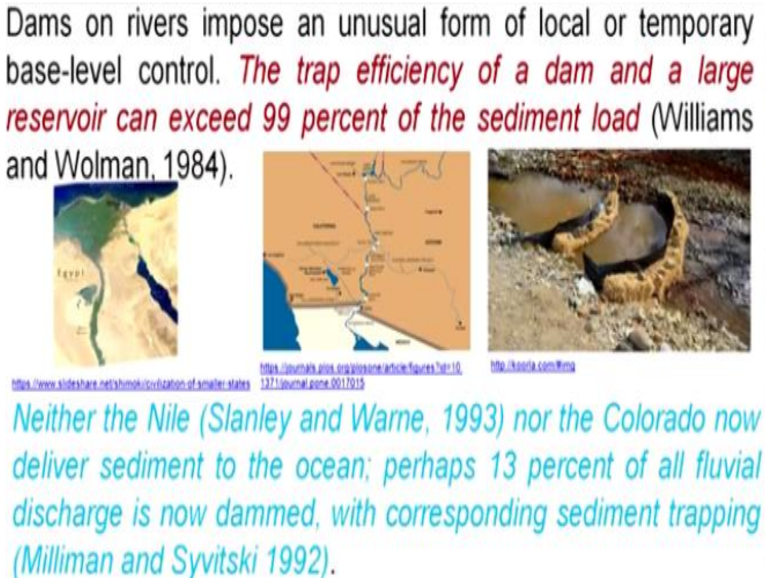

Dams on rivers impose an unusual form of local or temporary base level control. the trap efficiency of a dam and a large reservoir can exceed 99 percent of the sediment load. So neither the Nile, not this Colorado now delivers sediment to these ocean because most of these rivers are there dammed. So that this sediment is not transported to this local or the base level and they are restricted for example, if you engineering geology.

We prepare check dams before constructing a main dam or main reservoirs at the upstream and we create check dams you see here, these are the check dams. So, the check dams are nothing this main purpose of the check dam is to restrict or to arrest the sediment transportation. So, once we arrest sediment at the upstream and less sediment is deposited less sediment is contributed to the reservoir so that the reservoir life is expanded. So that means for longer reservoirs life we need to you need to construct check dam at upstream, so that we can arrest the sediment movement to this reservoirs.

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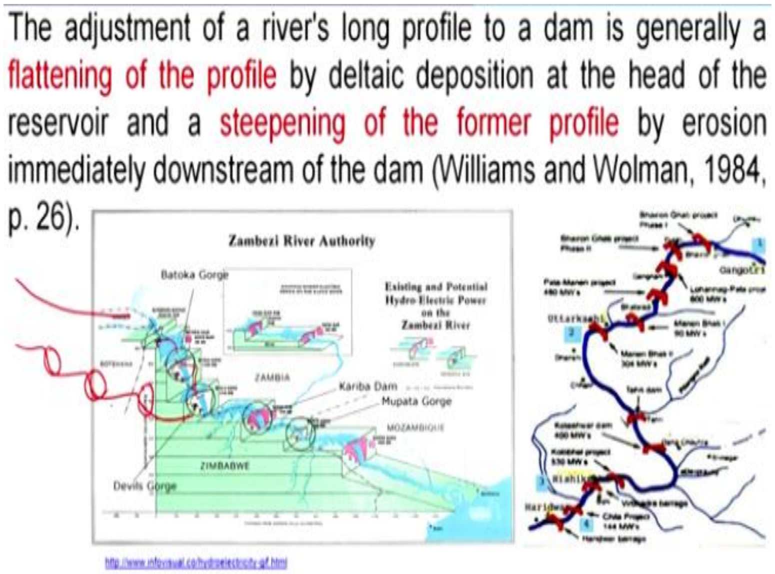

The adjustment of rivers long profile to a dam is generally flattening of this profile by deltaic deposition at the head of this reservoir and steepening of this former profile by erosion immediately downstream of the dam as we have already discussed, if you see here this river, if is a terraces type occurrence, suppose, we have lakes or whatever is there. So, that means, instead of the longitudinal profile like this, it is like this.

So, here, steep profiles are there and steep profiles, longitudinal profiles that will erode more, so, more erosion takes place at the downstream head of this reservoir and more sediment is produced. So that this longitudinal profile it is very much important to know what type of river behavior channel behavior will be how much sediment will be produced and what are the different, what are the potential point where the much sediment production is expected.

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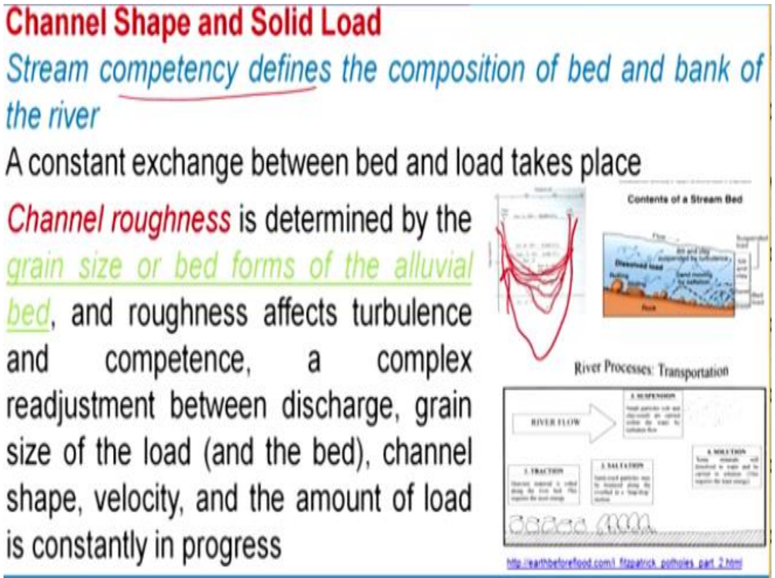

Then another component and the most important component of fluvial geomorphology is the channel shape and solid load. So, we have different types of loads, one is solid load and other is is dissolve load within their solid load that means, we have some tractions some of the sediment there are transported within this river bed. Some of these sediments they are transported by jumping it is called saltation and some of these finer particles.

That is the finer to finer particles, they remain suspended within this water and as it is they are transported to this deep sea, so their suspension so, apart from that we have some dissolved salts they are transported through solutions. So, solid load once we say we say about these 3 component that is this saltation, traction and suspension or suspended mode of sediment transport so, depending upon these type of proportionate contribution of different size fractions the shape of this channel vary

and second thing that the shape of this channel throughout the geological time or throughout it is a lifetime of a channel, it does not remain constant. For example, if you see this figure here, this figure is taken from Bloom and here the shape of this channel is in the earliest time it was here. So, in the later time, you see, the shape of this channel was like this again the shape of this channel like this.

The shape of this channel like this so, that means I want to say with time, the channel shape changes the height to width ratio changes. So, that does not mean the channel will always aggrade that this is called channel aggradation. So, it may possible that, this shape of this channel with geological time of or a 1 prodding event or 2 prodding event or so, this channel will take this shape we cannot deny it.

So, that means, I want to say the channel shape whatever the shape we are discussing here that does not remain constant throughout this geological time and throughout the lifespan of a channel. So, that means, this, how this channel shape how this either it is a symmetrical or asymmetrical it is in a way that is mender or is a straight or braded that depends upon the load of the system, how much sediment is transported.

So, stream competency defines the composition of bed and bank of this rivers stream competency and stream capacity. Stream capacity means the total sediment transported by this river it is capacity, stream competency means how much sizes of sediment particle what is the largest size of this sediment particle that a river can transport. So, the stream competency stream competency defined the composition of the bed and bank of this river.

What should be the bed and bank shape so, that depends upon the competency of this river, how larger particles this how much larger particles this river can transport, if it is transporting very finer particles, then the shape will be different, if it was transporting coarser particles, the shape will be different in the mixture of shape will be different and either it will be a meandering course it is a straight course that also defined by this sediment transport nature of the sediment.

So, a constant exchange between bed and load takes place so, because once we have confined system river it is a confined system 2 banks are confining the river confining this water, amount of water and water velocity or transportation system. So, here once it is transporting sedimentary being transported through a river it is always interacting with the bed interacting with the bank and interacting with the water.

Sometimes during swirling action these sediments they are under suspension what is comes in the suspension mode. So, once it is reaching to a reach which is near about straight or that will be the sediment that will move different ways. If it is in the meandering channel, it will be passing through meandering channel at the inner curve that will be deposit the outer curve there will be erosion so, that means, so that means during the transportation of a sediment particles from this head of this river to the mouth of the river, it undergoes different type of transportation.

Depending upon the river competency depending on the flood situation depending upon the slope, so that it is it is complete that means, it is a constant interaction between the sediment and this bank and the bed it takes place throughout its transportation. So, if channel is smooth or channel is rough that also defines what type of transportation will be there and what type of channel roughness it is determined by the grain size on the bed form of this alluvial bed.

So, if it is rough channel, it is that means, that depends upon how much what is the larger size of the particle it is transporting. If it is a smooth channel, then probably it is clay size particle it is transporting, it is rough channel boulder size particle transporting. So that means I want to say the channel roughness the channel shape these channel properties, all those depends upon this what type of sediment is transported, transported through this rivers and how it is interacting these sediments these interacting with this bed at banks.

So, I think we should stop here and in the next class we will talk about depending upon the sediment sizes depending upon this interaction of these sediments with the bed and bank how this channel shape is changing and how it is behaving, how it is influencing this channel flow and the stream capacity, stream competency and how it is influencing our day to day life and our infrastructure development or any development project. So, thank you very much, we will meet in the next class.