Geomorphology

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Lecture-47
Fluvial Process-III

So friends, welcome to this lecture series of geomorphology and today we will continue with the fluvial processes. So, in the last class if you remember, we are emphasizing on this longitudinal river profile. And finally, we concluded that the longitudinal river profile should be ideally concave upward. But within that concavity there are certain points in there called nick points or kink points, which so the local convexity and those nick points are these locally convex points are of geomorphologically immense importance, because these are these regions.

Which produce more sediment, these are the regions which trap sediments and these are the regions to study tectonics or a fault movement or any basement or any hard rock perturbations like those. So, that longitudinal river profile of a channel that does not remain at the same level throughout its lifetime. So, due to local base level fluctuation, the longitudinal river profile also shifts. So, this was the summary of this last class so today and in this class.

We are going to discuss about how these grain size either it is a coarse grain or it is a fine grain or a dissolved sediments how they define the channels shape. And the channel habit, how is it influenced by this grain transportation and the slope and the amount of sediment that a river is transporting and the stream competency? Channel shape and solid load.

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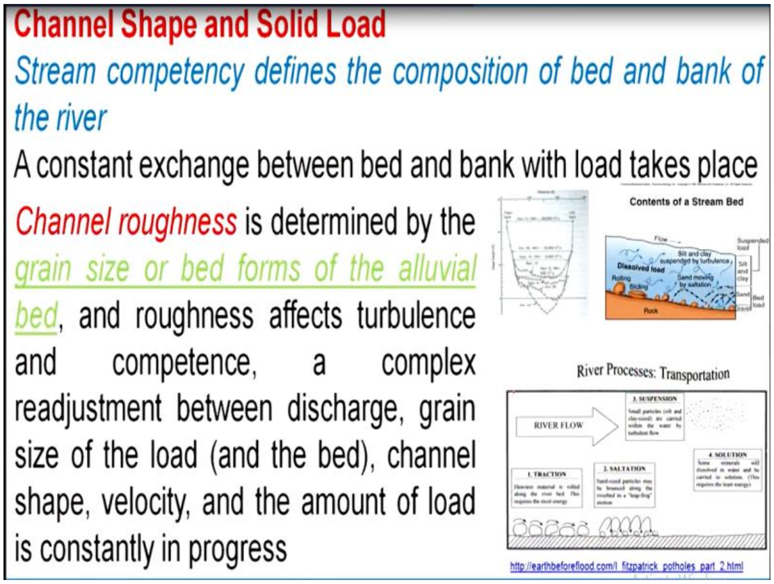

Solid load we have different types of loads as we know one is suspended load that is always in the suspension suspended condition. So, they are mostly the fine grained clay size particles then saltation, saltation means fine sand, sand itself. So it is move like jumping. It is saltation and coarse grain sand pebble cobble boulder. They are transported by rolling on this river bed. They are called tractions and some of the sediment they are transported with the dissolved condition dissolved mode that is not of important in terms of fluvial geomorphology is concern.

So, here, once we say it is a solid load that means these former 3 types of sediments traction saltation and suspension, these 3 types of sediment will deal with, and we will see how the proportionate change of this sediment then how they influence the channel habits. And second thing that during these transportation of the sediments, they always in interaction with the bed and bank sediment sometimes it suppose, river is a transporting some sediment and either it is any type of mode or any type of this 3 mode and this river.

The competency decreases that means, the river water decreases velocity decreases, so, it will remain there. So, during next high energy condition of river during flooding time, that sediment will to transport to other places other further downstream and the same place will occupied by the other sediment. So, this way as sediment is transported from this origin of this river to the mouth of river and some of these sediments.

They reach to this deep sea level and maximum of this element of a river they are distributed and remain within that flood plains, but, whether this channel will be deep enough or channel will be shallow enough it will be wide channel or it is a narrow channel it is a meandering channel or straight channel or it is a braided channel, all those depends upon how What is this sediment particle size, how much amount of sediment is there? What is the dominant sediment type a river is transporting in particular reach.

So, that reach will take that shape depends upon the sediment particle size. So, stream competency defines the composition of bed and bank of this river stream competency, there are 2 terminologies one is stream capacity and other is stream competency, stream capacity, it is the total amount of sediment a river can transport at a particular time. So, it is stream capacity and stream competency is the largest size a stream can transport largest size of grain or largest size of a clast stream can transport this stream competency.

So, stream competency defines the composition of the bed and bank of the river. Either this bed will be rough, the bed will be smooth, the bank will be a narrow bank or it is a wider bank, it is a shallow bank like that. So, although there is a smooth or is a rough surface that depends upon the stream competency and throughout this life span of a river if you take a time window of 100s of years or so, this channel shape that does not remain same.

For example, if you see here, this is a figure, which is taken from bloom now you see, this is the channel shape in a particular time and the same channel is like this with another time again it is same time again another time. So, that means, I want to say with time, this shape of this channel, the cross sectional area of the channel its changes that depends upon this amount of sediment that depends upon the erosional capacity depositional capacity.

And through which bedrock through which the river is transporting climatic conditions, tectonic scenario all those factors that defines what would be the channel shape. So, in a particular space with a different time, the channel shape can vary. So, constant exchange between the bed and bank with load takes place during transportation. So, there will be some sediment there will be interact with the bed, some of the sediment.

They will interact with the river bank and there will be constant exchange between this sediment and water bed at bank and this load that always takes place during transportation and channel roughness, it is determined by the grain size or bed forms of this alluvial bed. So, channel roughness how rough this channel will be or smooth the channel would be either it is symmetrical channel cross section will be symmetrical or it is asymmetrical.

So, all that depends upon the grain size or the bed forms of the alluvial bed and roughness, affects turbulence. Now if it is a rough channel through which the river is transporting, so, river will always in a turbulent mode so, turbulent mode means now the competency increases and this complex adjustment between discharged grain size of this load and channel shape velocity and amount of load is constantly in progress.

So, that means, all those factors grain size there of this load, then channel shape velocity, amount of load all those factors that will be changed with this roughness channel roughness and that means, these are the dependent variables. So, if channel smooth this will change or if coarse grain is supposed a river is transporting only the coarser part. So, this generally rough so, that rough channel again it will increase the turbulence in turbulence increase the competency. So, that means one factor is changed. So, it will affect the another factors so, how much water is discharged in a cross section in the last class we were talking about.

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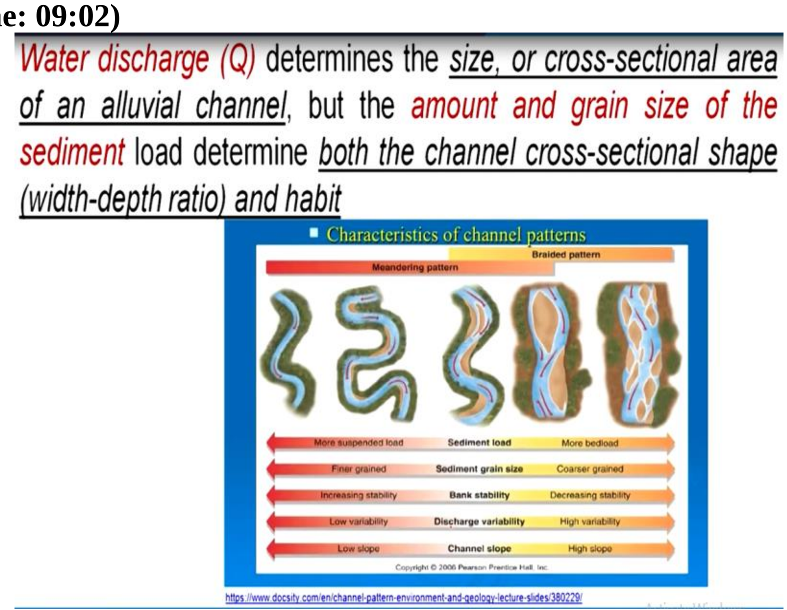

The gauging stations there are many stations gauging stations throughout this river course. And constantly we are monitoring with different time interval, how much water is passing through how much sediment is passing through, what is the velocity of this river and how much sediment in traction mode how much in suspended mode saltation mode in a particular time in a particular gauging stations. So, this totally an entirely it is keeping this track of this discharge of sediment discharge of water.

So, water discharge of a particular segment of a river at particular point it is Q, it determines these size or cross sectional area of an alluvial channel. But the amount and grain size of the sediment load determine both the channel cross section shape width depth ratio and habit. So, what would be the width and depth ratio what should the channel habit, channel habit that means, if it is a meandering channel, it is a straight channel, it is a braided channel or there called the channel habits.

So, what should be the cross sectional area how if you look at cross section on how it look it is a narrow channel, it is a symmetrical channel, it is an asymmetrical channel it is a wide channel. So, how to look and how this channel if you looking from the top how to look for example here, if you see here this figure, this meandering channel this is straight channels. So, the straight channel will be like this meandering channel.

There a sinuous channel is there braided channel is there so, that means in a cross sectional look how to look similarly in aerial look how it look that all depends upon this discharge and grain size, amount of sediment all those factors the defines what should be the overall look of a channel. So, if you see here it is some of these points has been described here in terms of this figure suppose we are taking sediment load as a factor.

So, once we are coming from towards the straight of the straight channel and it was a braided channel, so, here more suspended load, this side is more bed load. Similarly, this side is more finer grained, this is coarse grain sediment then increasing stability, it is decreasing stability that means, bank stability is concerned similarly, sediment grain size is concerned. Similarly, discharge variability if we see low variability discharge it is monotonous discharge, but here high variability discharge.

Then channel slope it is lower slope it is higher slope. So, that means those factors here that means, if it is finer size and this side is coarser size. So, if increasing slope, decreasing slope, increasing suspended load decreasing suspended load, all those factors that define how a channel will take its shape what should be the channel habit.

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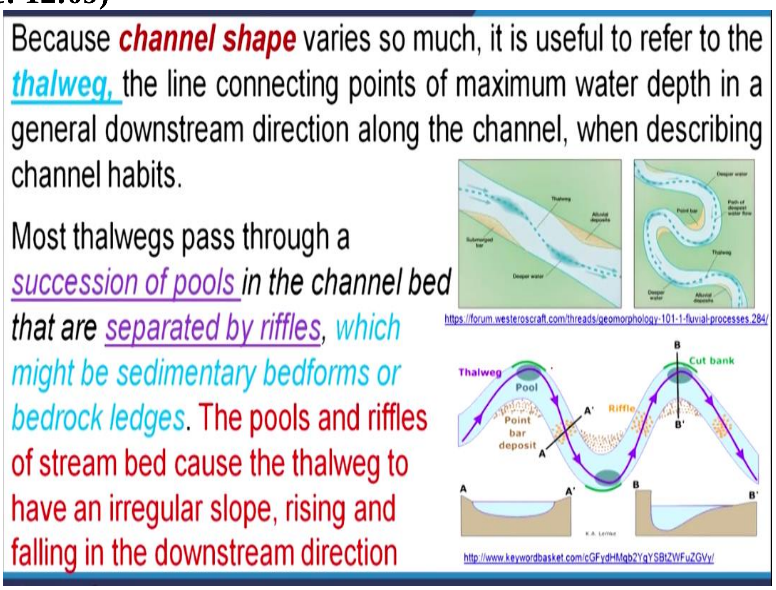

Because channel shape varies so much, you see as we have discussed here, somewhere it is a sinuous channel somewhere is a meandering channel somewhat it is a straight channel. So, there are a number of variations are there. So, if we take this channel banks, if you take this trace of the channel bank, we will find a different variables. So, it will confuse the system it will hinder our calculations.

So, in that case what we generally do to define the channel shape whether this channel is straight channel is sinuous it is a braided or an anastomosing channel like that, we take the help of these thalweg, thalweg means it is the line connecting the points of maximum water depth in a general downstream direction along the channel when describing channel habit. So, how a channel habit will be either straight channel, channel habit is straight or it is a straight channel or it is a meandering channel or a sinuous channel.

So, all that can be defined through the thalweg through this shape of this thalweg. So, thalweg is the line, which is joining the highest water depth of a channel in different points. For example, if you see here, this line this dotted line is defined thalweg, so, this thalweg means it is representing this highest water depth here is it suppose, for example, this is the point here higher depth.

This is the cross section we are talking about this highest water depth will be here, see the cross section we are taking the highest water depth will be here in this cross section here, higher water depth will be here. So, once we are joining those points, so it will taking the shape so, we will define either it is a straight channel or it is a meandering channel in the meandering channel, you see here this channel the thalweg it is moving like this in a straight channel, this is moving like this.

So, that means, this channel shape will be defined by the thalweg of a river the line joining maximum points maximum depth. So, most of this thalweg is passing through successive pools and riffles. So, what are the pools and riffles for example, if in a channel is this channel if you talk we are talking about, so here is this violet line is defining the thalweg within that thalweg within this channel, some part of this channel it is deeper part and that contain water throughout this year.

And in between if you see here, we are getting water here, water here but in between here where we have sediments. So, the sediments they are called riffles and this is called pools. So, that means thalweg passing through pools and riffles and we know riffles that means, it is somewhat elevated part because sediment is deposited their pools, they are the deeper part somewhat lower elevation compare comparatively lower elevations.

So, that it thalweg is passing on upward or downward if you see this cross section height elevation of thalweg in downstream thalweg is not in a straight line, it will move up and down move on, though overall it is moving downstream, but within that we will get this type of structures. So, that means, thalweg it defines the channel habit. So, that means, here we have succession of pools and the riffles these are the riffles that is those parts which are filled with sediment, these are called riffles and those part which contains water that is called pools.

Which might be sedimentary bed forms or bedrock ledges so this riffles not necessarily to be always sedimentary deposits it may be bedrock that means rock exposure should be there. So, that means irrespective of it is either it is a sediment deposit or it is bedrock exposure. So, that means we have no water there. So, that is why it is called riffled and pools we have water there. So, the pools and riffles of stream bed cause the thalweg to have an irregular shape rising and falling in the downstream direction.

As we are discussing here, these thalweg it is moving rising at these riffles and falling at this pools again rising at the riffles and falling in the pools. So this rising and falling of thalweg occurs in a cross section. Similarly in a plan view, this movement of this or the shape of this thalweg the movement of this thalweg that defines what type of channel we are dealing with either straight channel or it is a meandering channel or the braided channel like this.

So if you see here once we are saying about these thalweg moment. Now see this is the cross section A to A' here this riffles, you will find a channel, which is symmetrical shape. But if you see here at the pools we are taking a B to B' is a profile and we are getting an asymmetric channel. So, at pools this channel will be asymmetric and a riffles channel shape will be symmetric.

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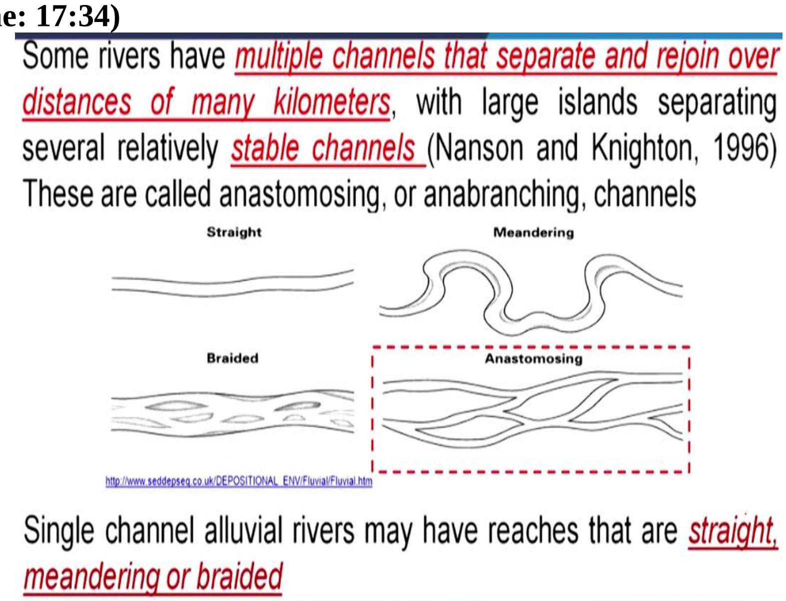

And some of these rivers they have multiple channels, not a single channel multiple channels and they bifurcates at some point of space, and again rejoin with this main channel and after few kilometers and they encircle or they encompasses some of these islands in between them. It is mostly the permanent islands or this stable channels are there. And permanent island with a large island separating several relatively stable channels, for example, which are called the anastomosing channel or anabranching channels.

For example, anastomosing channel and anabranching channel that means you see, it is channel it is bifurcating here and there fitting here again, so, and these are these islands, these are these islands, they are separated by somewhat stables channels this channel are stable. So, this type of channel are called anabranching channel, single channel alluvial rivers may have reached that are straight meandering or braided.

So that means once we say multiple thalweg that means we are talking about these anabranching channels, but single channels that may be straight channel that maybe meandering channel that may be braided channel. So braided channel is only single channel, though there are branches that are, but these are not permanent here the difference between these 2, this anabranching channel and this braided channel is that these are permanent.

And these are stable channels but here these are not permanent and this is not stable channel. So, that means once we are dealing with single channel we are talking with a straight channel we are talking about meandering channel and braided channel, but multiple channel that means we are talking about anabranching channels.

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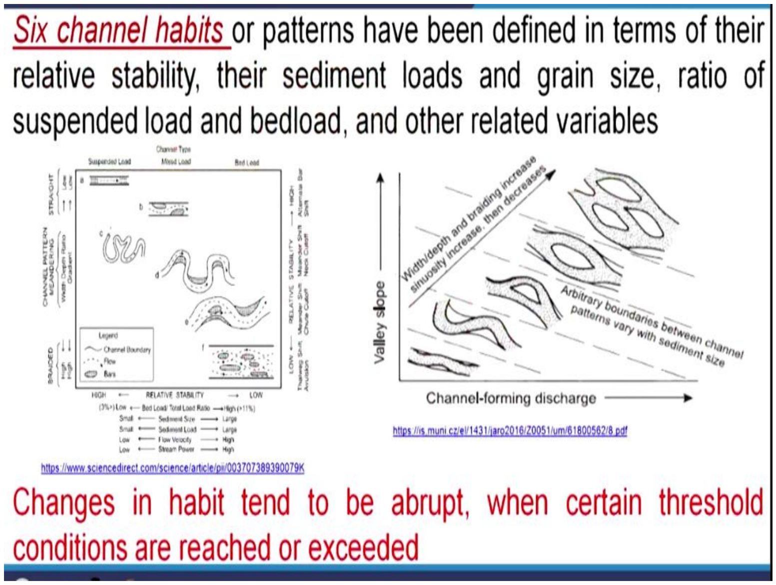

So, depending upon this thalwegs is this bifurcation on this reunion and a single thalwegs or multiple thalweg. We have 6 channel habits or channel patterns have been defined in terms of their relative stability relative stability it is important that means one end it will most stable channel at the another end the least stable channel, there sediment load and grain size, some of these channels they are exclusively transporting course grain particles and some part on this channel are some channels.

That are exclusively for fine grained particles ratio of suspended load to bed load that means, how much suspended load is there if you suspended load is dominating or bed load is dominating and other related variables are there. So, depending upon this there are 6 channel habits have been identified and it is given in this figure if you see here, if you see this axis at the side is the suspended load, this side is bed load that means those channel which in this side their bed load dominated and those channels.

Which at this side they are of a suspended load dominated and some of the channel they are transition. Now, similarly, if you see here it is braided channel pattern is meandering it is straight for example here it is a straight channel. Straight channel that means here if you see these are some variables are given a relative stability, relative stability means in straight channel it is high that means, straights channel are highly stable.

And this side it is braided channel, braided channels relative stability is low. So, that means, braided channels are low stability wise their lower stable or less stable as compared to straight channels. So, that means straight channel if it is there for more time, you can see it straightness is remaining there. But in braided channel, always it is changing here and there. Sometimes water is flowing the sides sometimes water is flowing that side here river bars are there sometimes the bar is migrated to that.

So, it is most unstable channel then it is if you are coming further downward, so, changes in habit tend to be abrupt when certain threshold conditions are reached or exceeded. So, whatever these parameters we have taken sediment load grain size ratio suspended to bed load ratio, all those subs limit is there for a particular channel, this should be the bed load to suspended load ratio. So, if it is extending if it is exceeding to the threshold limit that is straight channel.

We will convert it to meandering channel again if it is exceeding that limit, then that will convert to again meandering channel and this is a transition and finally, it is coming to that braided channel. So, here if you see here valley slope and channel forming following discharge and here it is increasing. So, that means discharge will be more here and it will be less here. So, sediment it is suspended load this side will be more bed load this side is more sediment grain size, coarser grain this side finer grain in this side then flow velocity.

It is high this side at the low this side stream power it is high this side, low this side. So, that means all those parameters that have certain limit within limit for example, for straight channel, these parameters have certain limits. If that limit it is exceeding or it is decreasing that limit this channel will change to different pattern. So, first let us talk about this straight channel.

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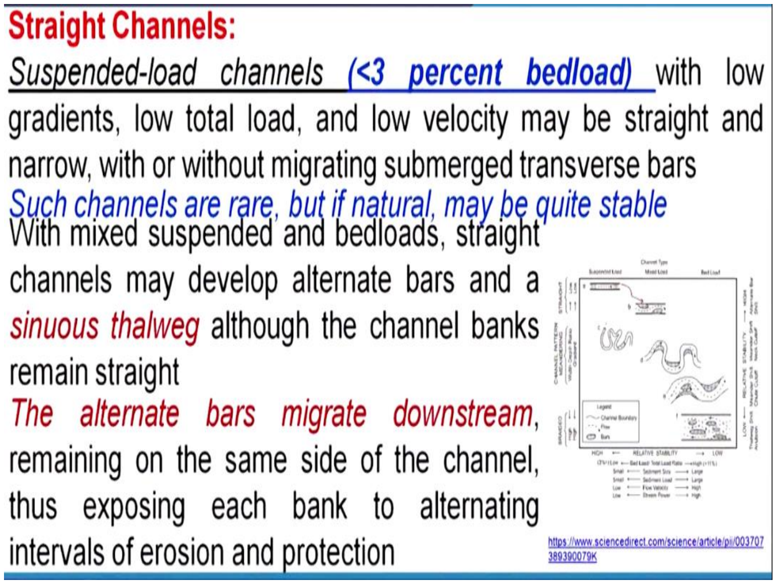

Straight channel it is a suspended load channel, that means here in the here previous figure, we have discussed here, this is suspended load to straight channel mostly dominated by suspended load and low velocity with low gradient, low total load and low velocity may be straight and narrow with or without migrating submerged transverse bars. Such channels are rare, but it is natural, maybe quite stable. in nature senso-stricto.

straight channel, rarely found, but if it is there, it will sustain for a long time it remains stable it is there with mixed suspended and bed load straight channel may develop alternate bars and a sinuous thalweg although channel banks remain straight. So, here if you see suppose we are increasing the bed load certain extent. Though the channel habit remains straight but we are creating some bars and once bars are generated, the bars migrate downstream. So, due to this migration of this bars, the shape of this thalweg changes.

So, as a result, this straight channel will convert to a meandering channel. So, if you see here and these sinuous thalweg although the channels banks remains straight the alternate bar migrate downstream remaining on the same side of this channel, thus exposing each bank to alternate intervals of erosion and protections. So, now, here if you see, suppose, this bar is generated here and this bar it is migrating in this way and this way suppose we are talking about suppose this is this channel and we are creating a bar here.

And this is the channel we are creating a bar here. So, this is thalweg is here, it is and thalweg is moving this way. So, that means here we are getting erosion here we are getting erosion here, deposition and deposition, but this bar migrates, so once it migrate, that means here sides of erosion become protected. Here the sides of erosion become protected. And that is why this erosional side becomes gradually protected. And these protected sides become the sides of exposure to erosion. So that is why the channel shape channel habit change with time.

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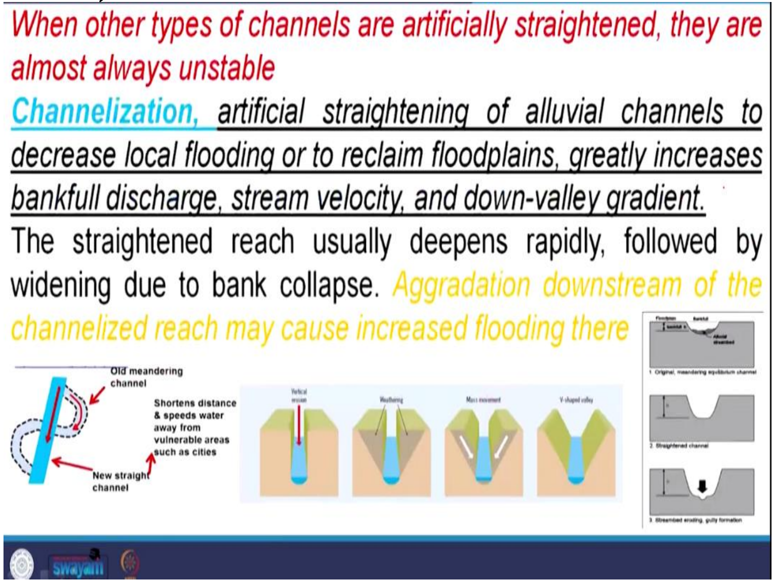

another types of channels that is artificially created are these natural channels they are artificially straightened. That is called channelization. The process is called channelization. So channelization is the artificial straightening of channel, if you see this see coastal area toposheets from 1990 to recent days 2017 or 2015. You will find drastic change in channel habits due to this flood control program most of this channels natural channels they have been artificial straightening.

So, artificial is straightening channel has some positive as well as some negative impact. For example, suppose, there is a channel earlier it was moving like this and during flood, the water are distributed throughout this area and it is getting inundated or flooded. Now, due to channelization we have made it straight so, that for this particular area, we have solved the system solve these flood problems, but, once we have straightened the system now, you see we have a straight channel gradually this bank erosion takes place.

So, once the bank erosion takes place, so, more and more sediment is produced. So, more sediment is produced and transported to the straight channel it once the straightness is decreased or the straightness ends, the sediment will be deposited there. So, that means in the downstream the sediment will overloaded and finally to create some again the flood problem will be there. So, that means, though artificial straightening had some advantages that for a particular time or a particular area.

We are solving this flood situations and straightening that means for our communication purposes we have reduced the time we are saving this fuels like it but it is had some problems. So, that is why artificial straightening should be done in judiciously with depending upon this population populated area or depending on the area which is under active use or it is abundant. So, artificial straightening of alluvial channel.

To decrease local flooding to reclaim floodplains greatly increases bank full discharge, stream velocity and downstream down valley gradient. The straightened reach usually deepens rapidly followed by widening due to bank collapse aggradation downstream of this channelized reach may cause increased flood there. So, that means, we are solving 1 problem and again we are creating another problem.

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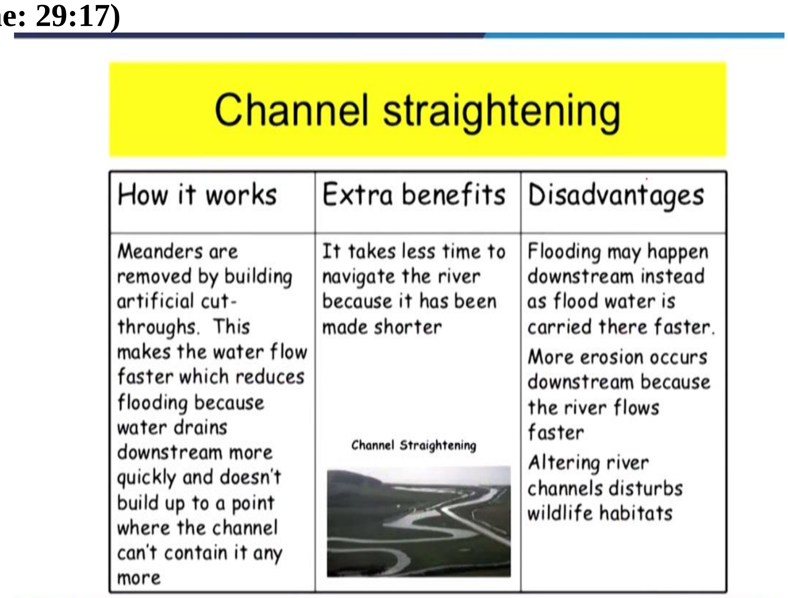

Then the same thing is written here, how it works extra benefit and disadvantages. So, if you see here meanders are removed by building artificial cut-throughs this makes this water flow faster with reduces floods because water drain downstream more quickly and does not build up to a point where the channel cannot channel cannot contain it anymore, but extra benefit is there. It takes less time to navigate the river because it has been made shorter.

Disadvantages flooding may happen in downstream instead of flood water is carried there faster so that means so artificial straitening. That means we are moving water faster than it should move naturally. So that means in downstream we are creating more floods as compared to this earlier situation. So these are some advantages, disadvantages and how it works. So this is all about the straight channel, channel habits.

And in the next class we will talk about the remaining channel habits like the braided channel, like the meandering channel, how they work, how they sediment capacity, how they sediment characteristics that changed the channel habits in a different reaches of a river. So I think we should stop here. Thank you very much.