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Geomorphology
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Lecture - 51
Fluvial Geomorphology, River System-I

So, friends good morning and welcome to this lecture series of geomorphology. So if you remember the last class we are talking something about this drainage pattern, the basic types of drainage pattern modified basics, their utilities, and finally concluded that the drainage pattern of an area, it is very much important to gain preliminary knowledge about these sub surface properties like the lithology like these porosity, permeability these slopes alluvial cover and something else.

Similarly, there are certain cases where you see basic type has been modified to certain extent. And they are called modified basic in which there is local change in the basic pattern. So, irrespective of this drainage type or a drainage pattern, the drainage patterns are useful to getting the subsurface knowledge about the geology. And this is also important to say about this climate, the tectonics and this rock exposure, so many information can be gathered by closely analysing the drainage patterns, the drainage characteristics in a time series.

So, today we will talk about the river system how the river works, it erodes this sediments, erode the rock materials transports it deposits in particular places like the sinks and the basins. And as we know, that this rivers erosion, it is a function of many factors like the rivers velocity this area and most probably controlled by the base level and base level that means, it is the level beyond or below which a river cannot erode it sediment.

Similarly, there are local base levels also. So, local base levels that means, if a river which is passing through a lake and it is coming to finally, this ocean, the lake is said to be this local base level. So, that means, the base level is that level below which river cannot erode. So, now, we will talk about this river system in detail how they work and how they transport and what are

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these different geological features the depositional features the erosion features, they are associated with the rivers journey from the mouth to head and if you see this figure.

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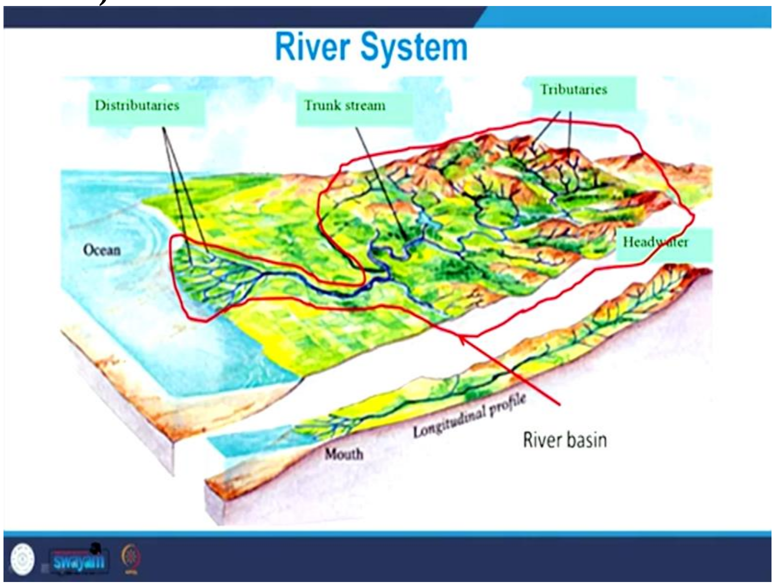

This is a complete model of a river basin and this is these are tributaries and this is the trunk river and finally, these are the distributaries. So, if you see here, these tributaries, this main work is to gather water, so, they collect water for this trunk river and the trunk river transports up to this mouth or up to this basin and that the basin at this junction of this basin the sediment due to sediment load and due to change in slope, the rivers competency and capacity that decreases and finally river is divided into many segments.

Many distributaries and finally, this delta are formed. And in this river's journey, if you see here, it starts from this first-order stream that means, this head up this river basin and finally ended this mouth. So, here there is terminology that is called stream ordering this stream ordering that means, if we are assigned a river basin to evaluate, so, we have to find out which order river basin is it. So, to order river basin, we have to count the streams and we have to know these characteristics of streams how they are joining together and which type of further order they are converting themselves.

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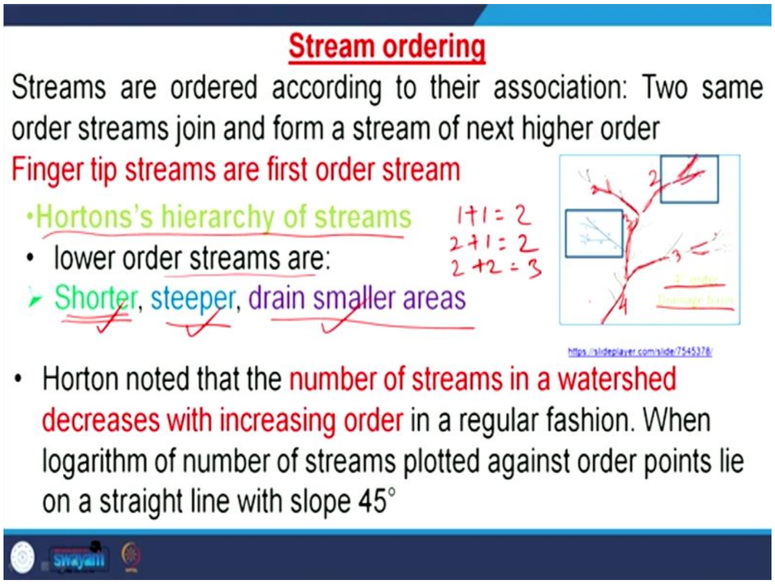

So, here if you see this figure in the right hand side, this is written one, this is a written one. So, these are the first-order streams. That means the early stream. So if you remember when we are talking about the river formation or the channel formation, we are talking some rills, gullies and valleys. So rills that is not mapable scale. But gulley these are mapable scale. So, we can say, these are gullies. And you can say this is first-order streams, they are ephemeral nature.

It is not always that they contain water during rainy season they transport water from this headwater area to this mainstream. And that is why, if you see here, 2 first-order streams, they join together, and they are converting to second-order stream here. Here, this is one first-order stream and another first-order stream they are joining together and coming this is the second-order stream.

Similarly, here, this is a second-order stream because these 2 first-order streams they are mixing, this is the second-order stream and it is, again, second-order and first-order. So, they are coming again it is second-order. Similarly, if 2 second-order for example, here 1 second-order stream is here, 1 second-order stream is here. So, the result is the third-order stream. So, that means, here 1 + 1 = 2 but 2 + 1 = 2, but 2 + 2 = 3.

So, that means, this is the way how these channels or the streams are ordered and the maximum order or the highest order of a river basin. For example, here if you see this is 2 and 2 that means,

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second-order stream and second-order stream. This is the third-order stream and here we are creating a third-order stream here. So, now, 1 third-order stream is coming and here 1 third-order stream is coming. So, this is the fourth-order stream and the highest order of this stream in this basin it is assign the order of this basin.

So, that means it is a fourth-order drainage basins. So, that means stream ordering why we do stream ordering and what are the principles of stream ordering we discussed here. So, the stream ordering, we are following this Horton's hierarchy of stream order that means, lower order of streams are shorter, steeper, drain small area. Now, you see here lower order stream the first-order stream how much they are influencing how much area they are influencing very small area.

So, that means first-order stream or the lower order streams they are shorter in lengths very small length and steeper because they are generated the hilly terrains near this or head of this river basins. So, they are smaller in size and steeper in slopes and drain small area because the slope is a function of area also. So that means lower the slope that means higher area river or a channel will influence and if it is channel the higher slopes like this peidmonts like this hilly terrains.

So, there are spurs. So, every stream that influence less area. So that is why smaller streams are lower order streams, they are shorter in length, steeper in slopes and drain a small area. Horton noted that the number of stream in a watershed decreases with increasing order here in the important observation by Horton is there. The number of stream is decreasing with increasing order. For example, in this drainage basin we are talking about see how many first-order streams are there.

It is more, how many second-order streams are there, it is relatively less and how many third-order stream again relatively less and fourth-order stream, it is only one. So, that means we are increasing the stream order we are decreasing the stream number. So, in this it is in a regular basin, when logarithm of the number of streams plotted against the order point lie on a straight line, which is 45 degree.

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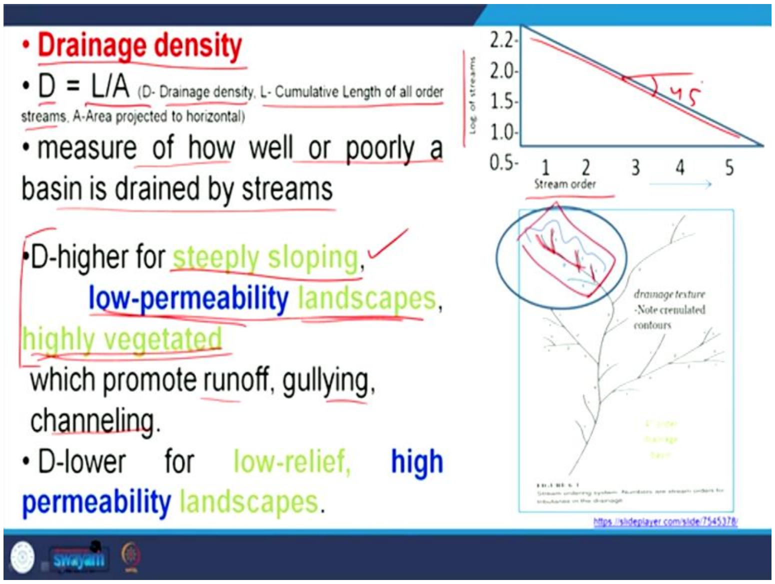

If you see here, this stream order and this is log of streams, it is plotted here and finally, we are getting a straight line, what is slope is 45 degree. So, that means, this is a definite mathematical formula they are following that the number of streams are increasing, the order is decreasing. So, another characteristics of rivers are the fluvial geomorphology is that is called drainage density, drainage density how densely the channels are distributed how densely the channels are distributed in a given area.

So, here the drainage density D is defined by L or A or L / A, where D is the density, L is the cumulative length of all order streams here cumulative length. So, that means, if you are talking about the drainage density of this particular area, so, here this total length that means, this, this plus this plus this, this. So, that means, irrespective of order here total length of the stream or total area. So, here that means, it is a measure of how well or poorly a basin is drained by streams.

If the drainage density the high that means, the channels are well distributed or an area is densely channeled. So, that means here we can say this surface drainage network is high as compared to say, other parts of this area if area which is very high drainage density compared to other area. That means, the surface of this area is highly channelized that means number of streams are more and here this means very closely spaced channels are there.

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D is higher for steeply sloping low permeability landscapes highly vegetated, which promote runoff, gullying and channeling. Here are the things to study this is the interpretation. So, here we can say if the drainage density is high, it means these channels are very densely placed. So, that means what is indicating it is steep slope, steep slope because we know in the earlier classes when talking about the slopes, steeper slopes, they create more drainage, but the length of the drainage are less.

The shorter drainages are there. But number of streams will be more. So steep slopes is the number of streams or more and the length will cumulate this length will add those numbers. So finally we are coming to higher length. So here it is indicating steep slope, then low permeability. This is another important factor to understand here low permeability. For example, we are talking about the granitic gneiss migmatites.

Here it is low permeability is there. Low permeability means. So, that means during raining the surface is filled with water there will be less percolation downward less percolation downward means all this water that will follow the surface channels. So the number of surface channels will be more. So that means this is indirect indicator of this lithology and slope. So here it is low permeability landscapes, highly vegetated, highly vegetated area which promotes runoff and gullying and channeling.

So, these are these interpretations if you are getting drainage density of certain number. So, that means by looking this drainage density we can say what is the subsurface condition, what is the slope condition whether it is vegetated or not. What is this permeable it is the channel flowing and permeable rocks or impermeable rocks like that. D is lower for a low-relief; high permeability landscapes low-relief landscapes.

That means if it is low-relief, that slope is less. Similarly high permeability if high permeability like sandstone or fracture limestone or something whatever can be so, or alluvial. So, that means, it will percolate, the water will percolate downward. So, once water percolates downward surface runoff reduces and surface runoff reduces that means it discourages for this stream formation.

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So, that is why we can say this looking this drainage density by analysing the data that we can say about the subsurface geology.

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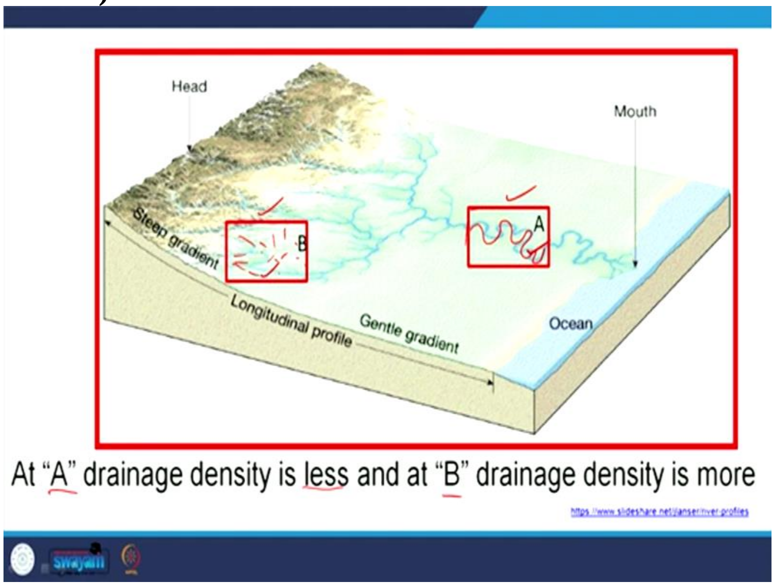

So, example here is same drainage basin within here 2 equal area in 2 parts. One is B and another is A is a rectangle, it is for where drainage density to be measured of equal area. So, now you see here the channel length will be this much and the area will be this much. Here the channel length you see will adding number of channels are there we are adding here. So, that means, at A drainage density is less as compared to B. Here area and we can say here drainage density means it is length or area and here the length is very less as compared to here. So, that means, we are getting a high drainage density and low drainage density in this respective areas.

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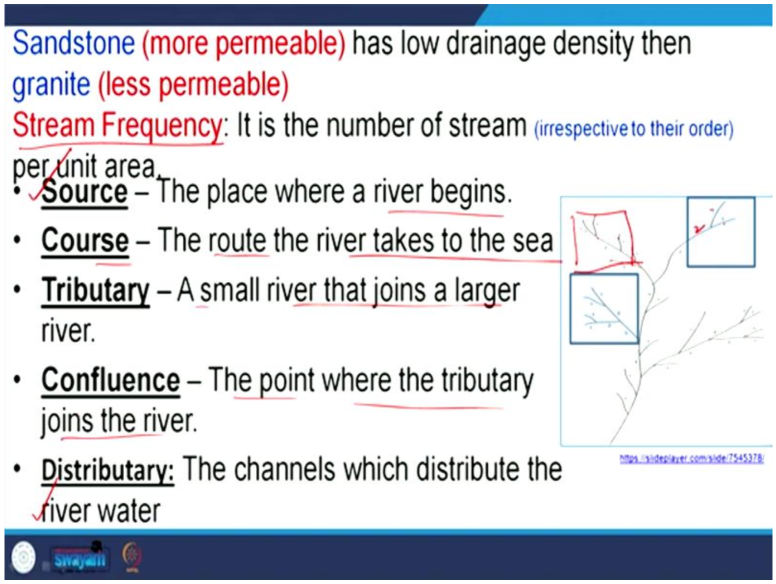

Sandstone for example, it is more permeable has low drainage density then granite which is less permeable, because it is surface runoff is more and subsurface percolation is less in terms of granite. But in sandstone the reverse is true. Then another terminology in the fluvial geomorphology is stream frequency. Stream frequency how frequently we are encountering stream it is the number of streams irrespective of its order per unit area number of streams only for example, here the stream frequency that means, first-order stream 2 second-order stream 1.

So, here number of stream is 3. But here we are getting the number of stream 1 2 3 4 5. So, that means stream frequency in the how frequently the streams are we are getting how frequent streams are there in any area. So, that is stream frequency. Irrespective of order number of stream only the numbers it is concerning. So in drainage basin there are a few points where this river starts its journey to its mouth. And one is the source the place where river begins. The course, the route the river takes to the sea.

The tributaries the small rivers that collect water and confluence the point where the tributary joins the river, distributaries the channel which distribute river water. So, through which this river starts from source and ends at the river mouth. So within that, it transports, it erodes the sediments from this catchment, it transports to the trunk river deposits at the river mouth. And through this river journey it creates many geomorphological features, some of them are erosional and some of them are depositional and erosional mostly erosional geomorphic features.

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They are found in the upper reaches of the stream. And because mostly in that part, these main work of the river is to erode this topography and the depositional landscapes, mostly it found in the flood plain or when it comes to the slope break from this hilly terrain to plane land where there is a measure of slope break it starts depositing sediments here and in the flood plains, it deposits sediment and in this river mouth, it deposits sediments. So, that means, mostly these lower slopes or lower reaches of river, the depositional landscapes are dominating. And in the higher reaches of this river, these erosional landscapes are dominating.

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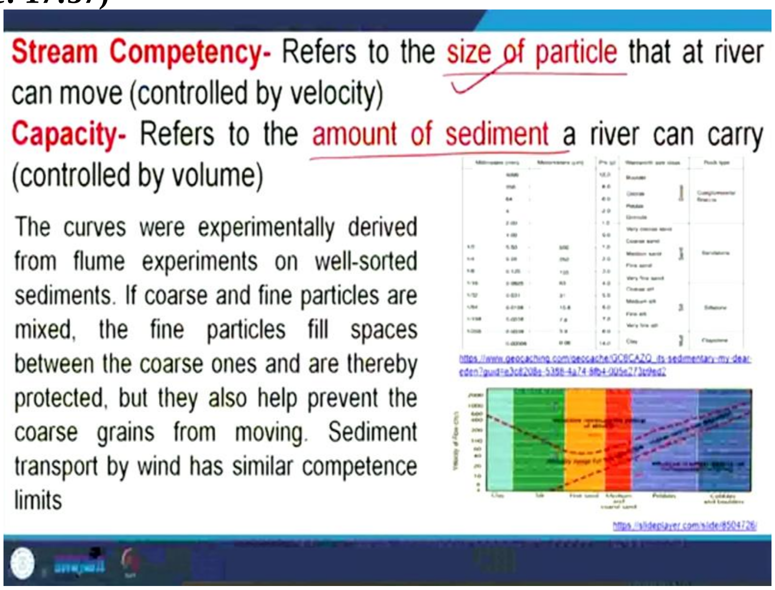

Then, stream competency, competency means, how competent a stream is. For who for which work for what?. Competency means, competency for what? Competence refer to the size of a particle that river can move or controlled by velocity. So, it is competent to move a particular size of sediment. So, suppose a boulder river which is transporting which can move a boulder that means its competency is more it is capable of transporting the boulder. Boulder means a larger size or a larger clast.

Similarly, if it is transporting only it is capable of transporting clay size particles sand size particle, so its competency is less. So, that means, it is the competency it is the degree of measure of its force, how it river how powerful a river is a stream is to transport a particular size of boulder. Then capacity rivers capacity means it refers to the amount of sediment here is the size of sediment the competency and the capacity. It denotes the amount of sediment a river can carry, controlled by its volume.

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So, that means it the amount of sediment irrespective at sizes the total amount total volume of sediment it is transporting. And here this competency means the size, the maximum size of this particular a river is transporting. So, now, you see here these curves, this one is it is velocity necessary for a peak of erosion, here it is velocity for transport and here it is deposition. So, these curve this which is separating the erosion, transportation and deposition.

It is based on this experimentally derived from flume experiment flume experiment you can remember, we are talking something when we are talking about the modelling geomorphological modelling the river system and how this flume experiment is carried out to change its slope change lithology to create different types of channels there. Similarly, this experiment this curves is based on this flume experiment.

So, if coarse and fine particles are mixed the fine particles fill space between these coarse one and are thereby protected, but they also help prevent these coarse grain from moving. Sediment transport by wind had similar competence limit. So this graph is valid both for fluvial transport and for aeolian transport if you remember when we are talking something about this aeolian system the arid zone geomorphology.

We have discussed how the wind velocity it is defined defines the particle or wind speed and wind velocities defining the particle size distribution within that aeolian system. Competence is the measure of stream ability to transport a certain maximum grain size of sediment here. The keys maximum grain size sediments, maximum grain size means how large particle can be transported by a river.

So, competence depends primarily on stream velocity, although channel shape and shape and degree of sorting, setting of sediment particles, a amount of suspended load and water temperature can also affect competency. So, these are these parameters that are affecting the stream competency.

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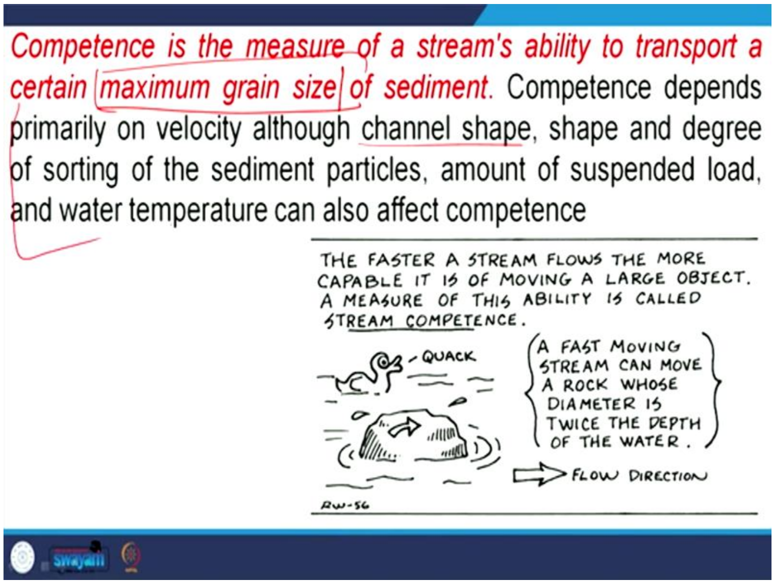

The first depends upon the primary velocity, higher velocity that means larger boulders can be transported also the channel that depends on also the channel shape, how the channel shape is? If channel is narrow or channel is wider and then the shape and degree of sorting, degree of sorting it is also affecting degree of sorting means this grain size distribution is very close, there is well sorted and distribution is range so starting from clay size to boulder, so, it is not well sorted or poorly sorted.

So, depends upon the sorting of this grain size, amount of suspended load, how much suspended load is created from the source and this water temperature that water temperature the cold water, it is in hot water and the warm water. So, that means these are these parameters, there are defining the stream competency.

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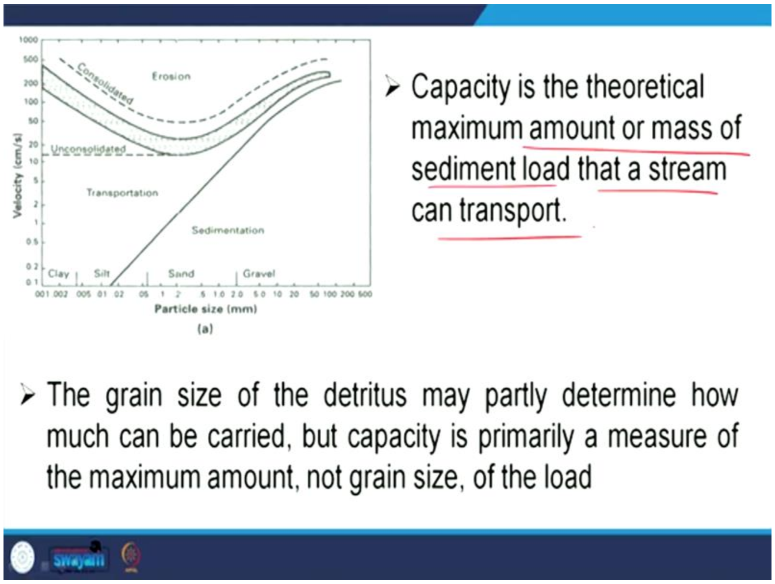

Capacity, it is a theoretical maximum amount of mass, maximum amount of mass of sediment load that stream can transport the capacity maximum amount of mass of sediment. The grain size of the detritus may partly determine how much can be carried, but capacity is primarily a measure of this maximum amount, not grain size of the load. So, it is the maximum amount not the grain size again size for competency but the amount is for capacity.

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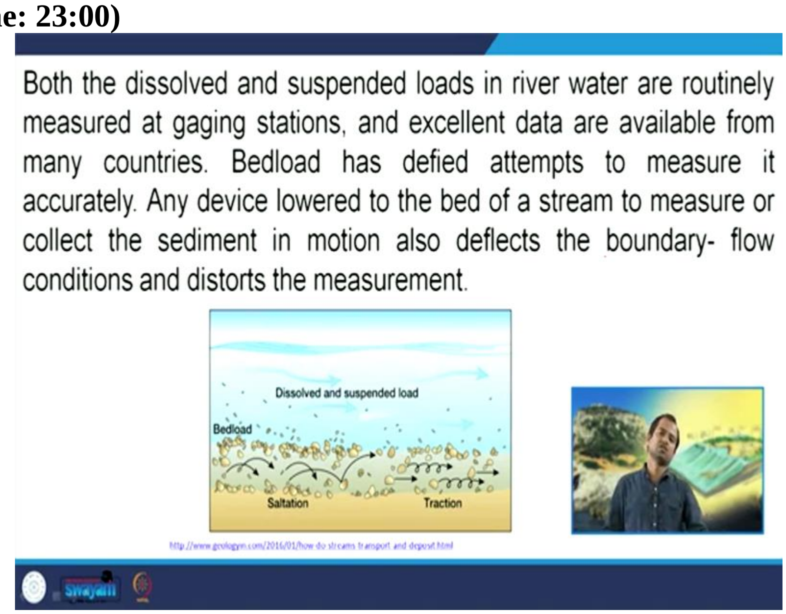

Both dissolved and suspended load in the river water routinely measure at gauging stations any device lowered to the bed of the stream to measure or collect the sediment in motion also deflects the boundary flow conditions and distorts the measurement. So, that is why this bedload data we are getting it is not as accurate as we expect.

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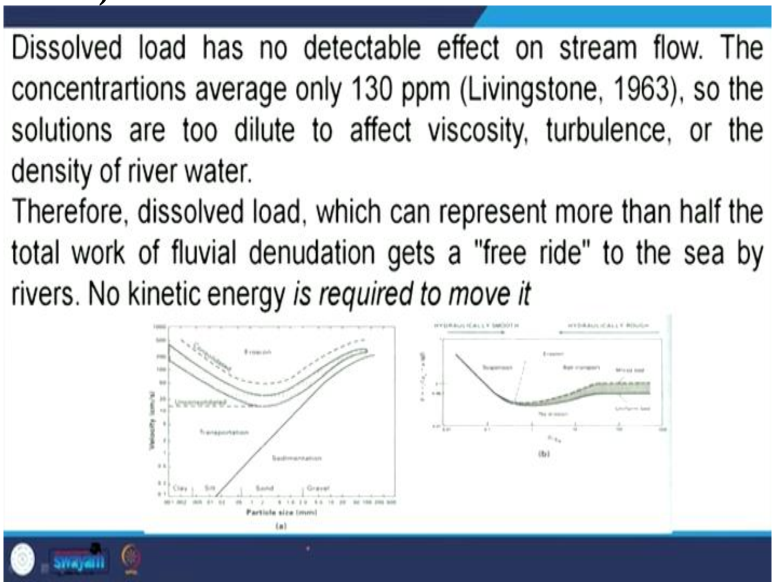

Dissolved load has no detectable effect on stream flow; the concentration average only to 130 ppm. So, these solutions are too dilute to affect the viscosity turbulence or the density of this river water. Therefore, dissolved load, which can represent more than half this total work of this fluvial denudation gets a free ride to sea by rivers, no kinetic energy is required to move it. So that means the dissolved load has negligible or even if no effect on the river transport.

So, whatever the dissolved material dissolved salt is there, it gets free ride from head to mouth of the river. So, it is effect the suspended load the bedload, but here the bedload whatever the data we are getting, it is not of accurate measurement because as we know this during the high flood time, so, if we are inserting our instrument, it will deflect the system. So, it will be deflected it will not be able to measure it accurately. So, that means, whatever the data we are analysing, for sediment transportation, sediment load calculation, river competency river capacity or whatever it may be. So, it is based on this suspended load mostly

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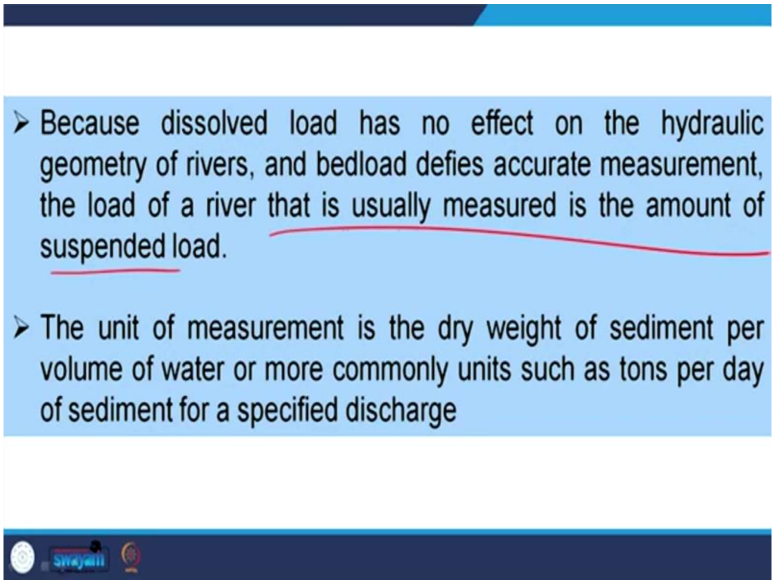

Because dissolved load has no effect on this hydraulic geometry of river and bedload defies accurate measurement, the load of a river that is usually measured is the amount of suspended load. The unit of measurement is the dry weight of the sediment per volume of water or more commonly units such as tons per day of sediment for a specific discharge. So, that means this whatever the data whatever the calculation, whatever the models that we prepare for this river system and fluvial geomorphology for application purposes.

We must always concentrate on the suspended load, though bedload affect, but as we cannot measure it accurately, so, only we assume that this percent of bedload is there, or that percent of bedload is there. So, I think we will stop here, and we will meet in the next class with the rivers journey and I stopped here. Thank you very much.