River Engineering
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Lecture - 11
Sediment Transport in River

Good morning to all of you. Today we are going to talk about sediment transport in river and that part we are looking basic concept levels that how we can understand sediment transports in rivers.

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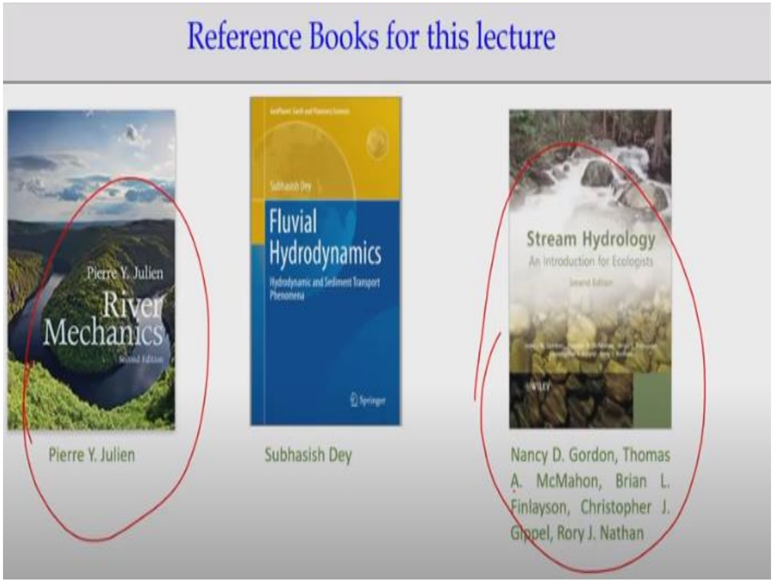

Looking that these are the two books we are more focusing for these lectures. One is stream hydrology, introductions to ecologists. That is the book we are following it which gives a very basic concepts how the sediment transport process happens. And you can look it this P. Y. Julien books, which talks about the river mechanics.

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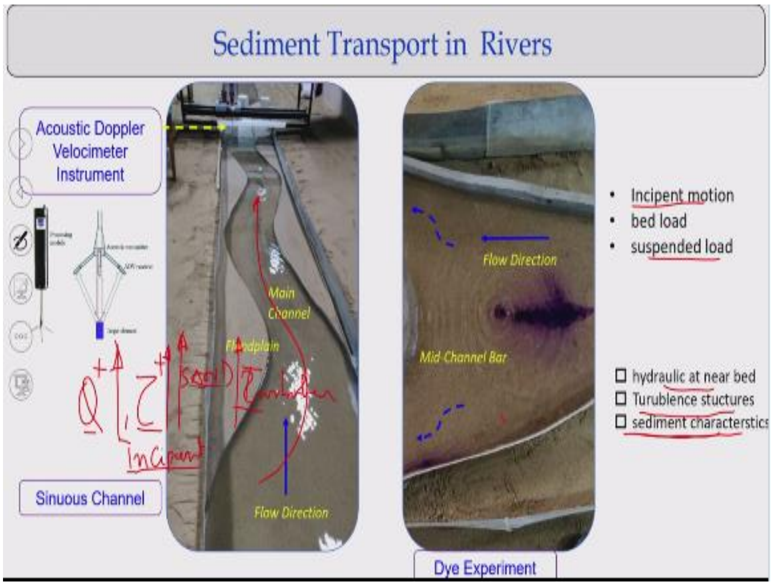

You can see this river channels which is there in laboratory scale which is scaled down models and you are going to increase the discharge okay. So in a channels like this, which is representing this a scale model of a river. So if we increasing the discharge and you have a bed materials like sand, as you increase the discharge as you expected that the bed shear stress is going to increase it.

The bed shear stress is going to increase it. The shear force acting on the bed that what per unit area is going to increase it. As this discharge increases the sediment bed shear stress changes it. At particular instance though as the shear stress increasing, what we can observe is the sediment particles or the bed particles which are lying on these channels they will start moving.

That is what is called incipient motions. That means that is the periods the bed loads are start moving it. Further if you increase the discharge, you can see that a series of the bed materials they move along the bed. And if you are further increasing this discharge what you will see that the bed materials which is moving along the bed that what is remain suspended conditions.

As remain a suspended conditions for a considerable time length because of the increasing the turbulence characteristics. That what keeps remains the floating of the sediment particles which will be as a suspended loads. It depends upon three considerations that what is the flow properties and hydraulics at the near bed conditions, turbulent structures. We are not going more details how the turbulent structures happens here.

And also it depends upon the sediment characteristics like d50, the weight of the sediment particles. All it depends upon how this bed load, suspended loads will go through as the discharge as the bed shear stress increase. Now if you look it next point the channels is moving it and that way you can see this flow moving in the both the sides.

And it is showing that how the flow structure the turbulent structure are changing it and how they are responsible for incipient motions the bed loads and the suspended loads. That phenomena just to visualize the flow phenomena as in a scale models what we are showing to you.

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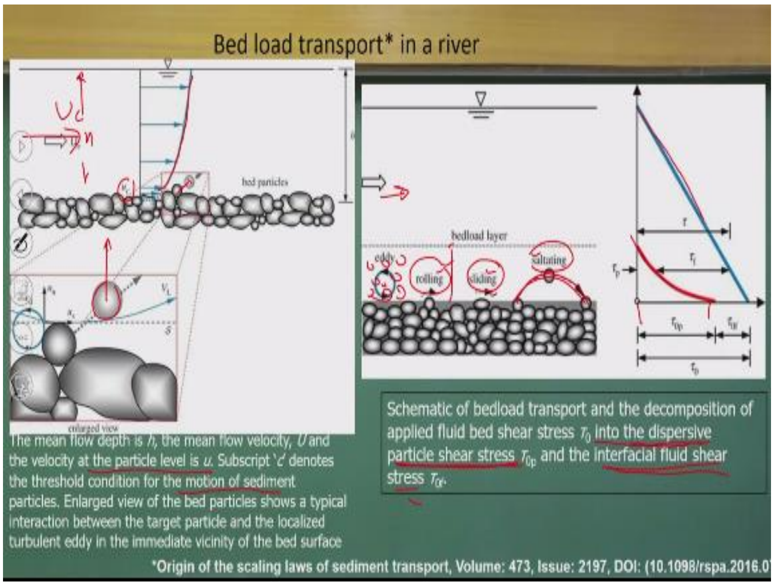

Now if you look it next part if I go to very microscopically, what it happens? When you have let be the capital Uc the flow velocity is coming it and it has a flow depth h and this is the bed materials which is heterogeneous bed material, mixed bed materials are there which is a bigger size and smaller size. And this is what the logarithmic velocity distributions for a turbulent flow.

So you can see that there will be logarithm velocity distributions. And Uc stands for here is that the velocity near the particles. The particles which will be the bed particles which will be detach from the bed materials that is what is the Uc, what could be the velocity.

Because of that velocity and the flow field it will have a lift force and the drag force which will detach this particle from this and once it detach it, it can go through rolling process i.e. rolling of the bed material or it can also be a sliding or with jumping and hopping.

So the bed material can go as a rolling or the sliding or can have a saltating and there will be a formations of turbulence eddies. Now if you try to understand it that when you have the channel flow there will be bed and at bed level there will be the velocity which stands Uc is the velocity at which that threshold conditions of sediment motions will starts.

Sediment motions will start. So if you look it that the bed materials can have a rolling, sliding or the saltating. It will have a certain thickness where the bed materials will be quite significant order and resulting of that because of there is a movement of a bed materials, okay with the flow, what we will see that there will be a two shear components will acting on this.

One is the decomposed in two part which is a dispersive particle shear stress. That is what is acting, okay because of the turbulent structures, as the particles are moving it near the boundaries we will have the dispersive particle shear stress. Also we will have the interfacial fluid shear stress that is try to understand it. Interfacial fluid shear stress is generally we need to have it. But here the shear stress have the two components.

One is the dispersive particle shear stress and the other is interfacial fluid shear stress. And how does they vary along these particle directions. That is the behavior it happens it if you consider as a turbulence flow. As the turbulence flow as you are going it so we are not looking much particles level. That is what is nowadays it is possible to look at the particles level and track each particles and try to know it how the process are happening it.

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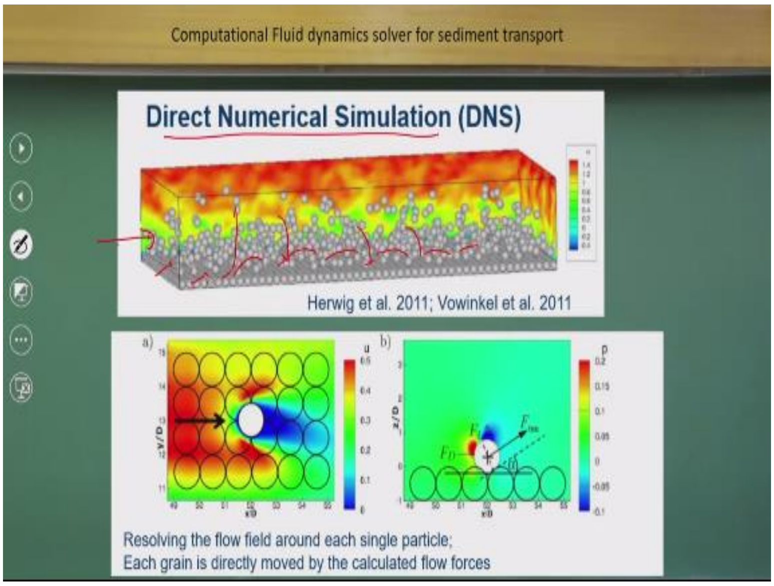

For example, if you look at this the numerical codes which is available computational fluid dynamics as you may have a that it has gone to a certain levels the sediment particles can be represented as a spherical balls, as equivalent spherical balls and if you have flow is going like this, you can see this the all the process of particles are happening it as a rolling, as a hopping or as sliding.

So you can see the particles. And how the particles are moving and also falling downs. All you can look it. Nowadays it is available. So direct numerical solutions you can do at the particles level and the fluid interactions and try to know it how the process is happening it. And more detail at the particle levels you can see that how the things are happening the in terms of the contours and in terms of the force components what is occurring.

So that is what is present era we are working at the particles levels can be possible it. But most of this equations what is developed for sediment transports are not at particles level. They are more understanding at gross characteristics level. Let us try to understand at the gross characteristics level, not at the particles level.

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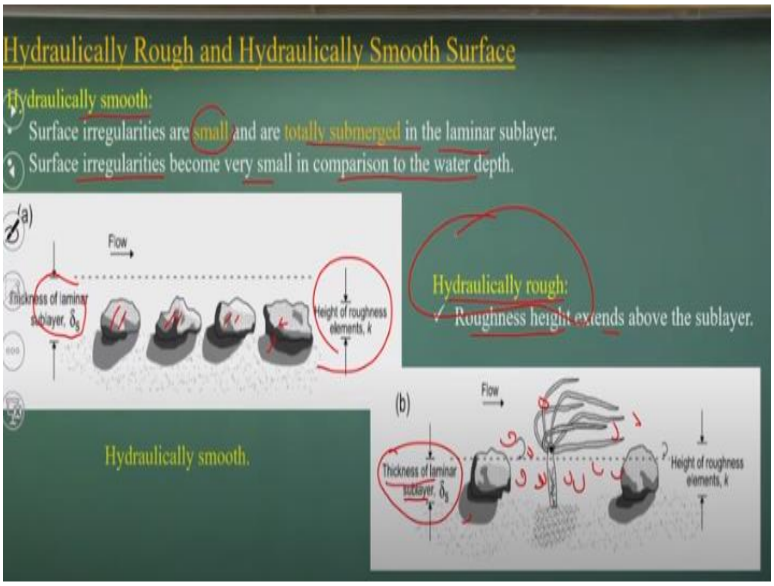

So looking that I am just look it first part is what type of near bed boundary conditions. We talk about in terms of hydraulics both case because as you can have a quite good understanding is that when you have a flow passing through a surface you will have a laminar supply. So you will have the transitions layer, you will have the turbulent boundary layers.

The same concept we can look it that when you have the surface and the fluid is passing through that, we can find out the thickness of laminar sub layers. If its height of the roughness is k that is what in terms of d50 or d85 we can represent it, if you know this bed materials we can measure is what will be the height of roughness okay.

If the thickness of laminar sub layers is larger than the height of roughness k, then we call hydraulically smooth layers. In this case, the surface irregularities are small and totally submerged in the laminar sub layers. Surface irregularities become very small in comparison to water depth. But if you look it the cases which is so often happens in the river flow, which is called hydraulically rough conditions.

That means, the roughness heights is more than the thickness of laminar sub layers. Because of that, you can see this eddy formations what is there in this case and this case will be the different. Because the surface roughness whatever is there they are beyond the laminar sub layers. They are inside the transitions layers.

Because of that the flow turbulent structures will be change it. And most of the river conditions we have hydraulically rough boundary conditions. We have hydraulically rough boundary conditions where the height of submergence is larger than the laminar thickness.

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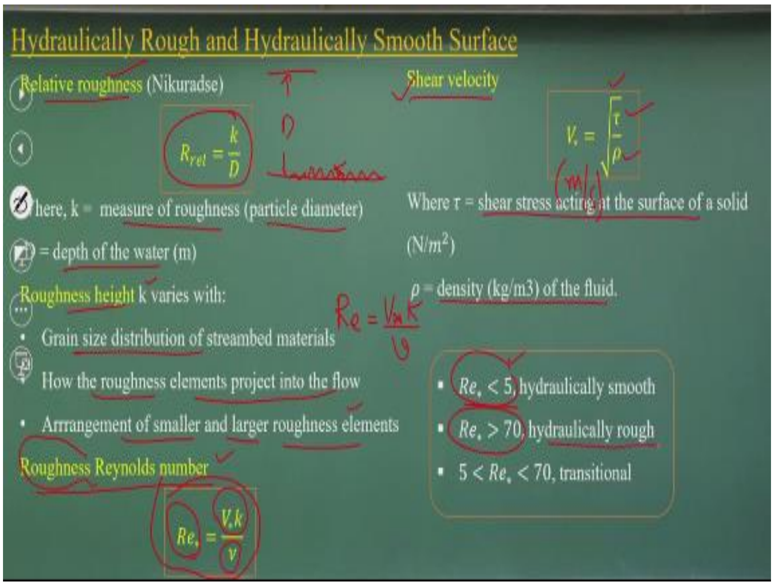

Now if you look at in terms of, if I try to define the relative roughness that means, I am talking about if I have the D is the depth of the flow and the k is the roughness height. k is the roughness it maybe due to boulders or may be small sand. So if the roughness thickness we can define as relative roughness which will be k/D.

This ratio indicating is that what is the k and D values and which talks about in terms of the laminar sub layers in terms of where it decides that. If you look at this k relative values, which is a functions of a simple ratio of k/D value. So k is a measure of the roughness basically the particle diameters and D stands for here is the water depth. This roughness height k varies a grain size distribution of stream beds.

Whether you have a gravel bed, you have the sand bed, so this roughness varies. The roughness elements are projected into the flow. The arrangement of smaller and larger roughness elements also plays the roles. What we try to do is that as you all aware about the Reynolds numbers which is a ratio between inertia forces by the viscous force. The same, the two force components we can look it that defining the roughness Reynolds numbers.

Roughness Reynolds numbers. Here this inertia forces we are replacing with the V*, which is the shear velocity. Here again I will say that what is a shear? It is a shear force defined in unit of the velocity. That is what we define it to make it a non-dimensional form of Reynolds numbers which will be a roughness Reynolds numbers which will be defined in terms of the shear velocity.

It is actually shear stresses in terms of velocity unit. That is the reasons we divide by the ρ and do the square root which will have unit is m/s. So τ is a shear stress acting on the surface. And ρ is you know it is the density. So if you look at that, if you compute the roughness Reynolds numbers as we know from a pipe flow, we separate it to laminar flow and turbulent flow based on the Reynolds number thresholds.

That exactly same way in case of the channel flow where we have the bed roughness and we can compute the roughness heights in terms of particle diameters, we can compute the shear velocity and you know, we know the kinematic viscosities of the fluid, we can compute roughness Reynolds numbers. And if the roughness Reynolds number is lesser than 5.

That is why again I have to rewrite it is a V* is a shear velocity times of k, k stands is a measure of roughness height, why these kinematic viscosity it is indicate for us if you have hydraulically smooth this value will be lesser than 5. So that means it will be the five times than these values. Try to understand it. If I have this roughness Reynolds number is greater than 70, we have a hydraulically rough conditions.

That is what so upon in a river systems we have hydraulically rough conditions because most of the conditions it prevails or we can have a in between that is what is the range of roughness Reynolds numbers between 5 and 70. So now we will try to understand we are hypothesizing this at the near boundary near bed boundary conditions to know it is it a hydraulically smooth or hydraulically rough conditions.

That is what we decide in pipe flow, the laminar or turbulence or open channel flow laminar to turbulent zones the same way here define it in terms of roughness Reynolds numbers, in terms of roughness Reynolds numbers. When the roughness Reynolds numbers is more than the 70 we define is it is hydraulically rough conditions.

That the conditions where you will have the thickness is larger than the thickness of laminar sub layers.

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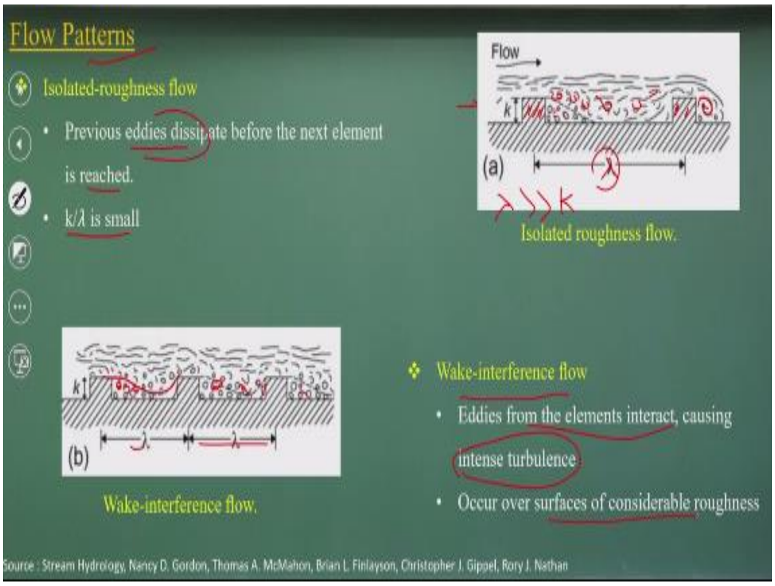

Now if you look how does it happens not at the particle size okay? It is also depends upon arrangement of the particles. It also depends upon the how the flow patterns happens it. So it is a combination of your knowledge on fluid mechanics you can try to understand how it happens it. Like for examples if I have the roughness k height is apart by a distance of λ.

Is a λ distance apart between these two roughness side. When you have the flow what it actually happens is there is will be turbulence zones. No flow or low velocity zones and there will be eddies, there will be steep. So if you look it that when you have this λ is much larger than the k value. You can see that in that case, eddies which is there generated by the first roughness does not affect the flow structures to second one.

So it is reached by λ value is small or the λ is much larger. So we are representing the bed roughness as equivalent of the k height and they are spacing at the λ distance. They are spacing at the λ distance at the looking at the flow pattern behavior why is eddies which is formed by this one, it is dissipated by the time it reaches to the next one. That is the basic idea.

But if you have a wake interface flow, so again the λ if you decrease it that means what will happen is it will interpret it. So that means whatever eddies forms are there that what interact with the next ones. The next one is interact with the next one. So they are not independent like isolated cases. Now you have a wake interfaces flow conditions okay.

You have the λ length. They are interfacing each others. The eddies from these elements interact it causes intense turbulence. The turbulence degree will increase it. The surface will have a considerably the rough surface.

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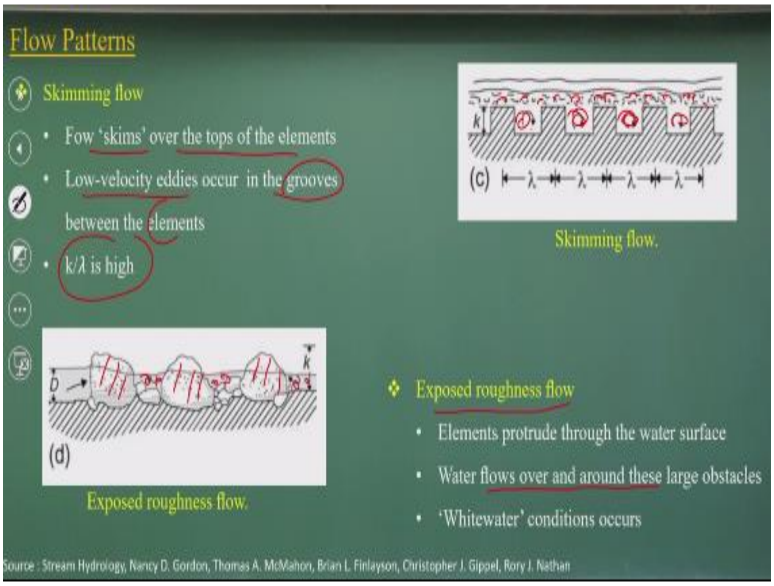

Now if you look at the next part what I am showing it that if you for the λ if you decrease it is that the case will the flow like skimming it? That means you will have a zones where the flow will have that not have a much eddies formations, but they can go off and there are the flow structures which are not much going to affect much the eddies structures. So that can be conditions.

There will be a low velocity eddies occurs in the groups. Okay that is what is there between the element and k/λ value is high here and the flow skims over the top. Okay flow goes over the tops and these are the low velocities eddies formations will be there. Or you can have exposed roughness flow.

In that case that is what it happens many of the smaller rivers if you have the big boulders and all during the low flow, you can have a flow, water flow can over and around this large obstacles and it can protrude it. It can have a flow separations, the eddies formations and this.

These are understanding we should have it how the roughness behaviors are coming it, how these aquatic ecology are there in a river systems if you are trying to understand that.

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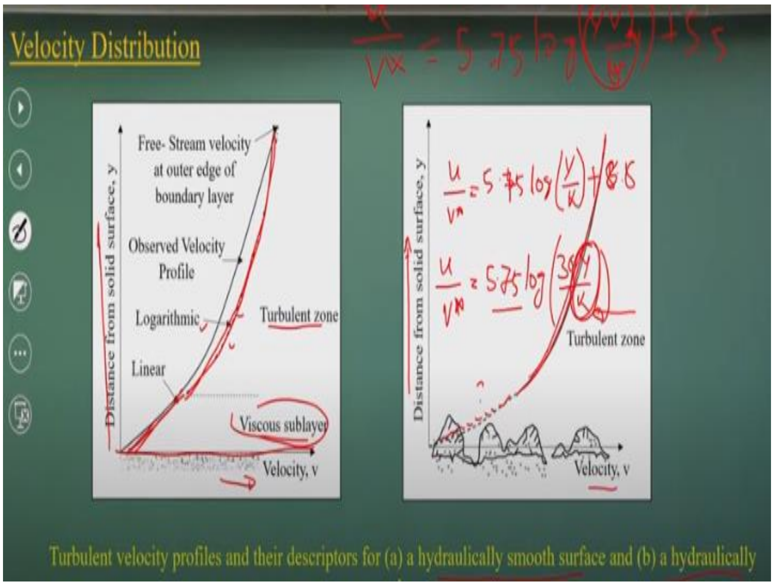

Now, let us talk about velocity distributions as we discussed it, it follow the logarithmic distributions. If I plot between distance from the bed okay, this is the bed and this is the velocity, I will have a viscous or laminar sub layers and we will have the turbulent zone. That is what we discuss very beginning. Linear path is a viscous sub layer path.

It is a linear part of velocity distributions in a laminar sub layers in case of hydraulic smooth surface followed the part by that it is a logarithmic or velocity distributions. But there will be the difference between observed and the logarithmic profiles. If I write the velocity distributions, the velocity distributions follow like this. U is velocity distribution into V*.

$$\frac{u}{V*} = 5.75\log\frac{V^{*}y}{\vartheta} + 5.5$$

So this is the velocity distribution equations. If you look it that it is a logarithmic velocity distributions in terms of why V* is a shear velocity by the kinematic viscosity values. So we can find out the U is the velocity at the y distance is a functions of a logarithm velocity functions we can make it.

But in case of hydraulically rough as we have discussed the hydraulically rough zones. In that case, there is no laminar sub layers. And this closer to boundary this velocity distributions we predicted from the velocity what we get it as a logarithmic profiles as a logarithmic profile of the velocity distributions, V versus and the y okay. So that is what is the hydraulic rough so the velocity distribution.

And if I write the velocity distribution as I written there the same form.

$$\frac{u}{V*} = 5.75\log\frac{y}{k} + 8.5$$

The ratio between the velocity at the y by the shear velocity will have the functions of same way 5.75 the log here we have the in terms of y/k okay. The depth by the roughness heights plus 8.5 or we can simplify it that is u /V* the ratio between flow velocity by and the shear velocities if I simplify this equations we also we can get it 5.75 log 30 y /k.

So that is quite interesting and these distributions already we whenever we conduct the lab experiments, we have seen that in case of the turbulent flow it follows the logarithms and more or less the same equations follow it with having this here the parameters is y/k. And here it is in terms of yV*/μ which is a form of the Reynolds numbers okay, y is the depth of the flow.

But in case of when you talk about the hydraulically rough zones, the velocity distributions not depends upon the viscous force components it depends more on relative roughness values y/k, the relative roughness values and that is the logarithmic profiles. So this is what the velocity distributions when you have hydraulically smooth surface and hydraulically rough surface.

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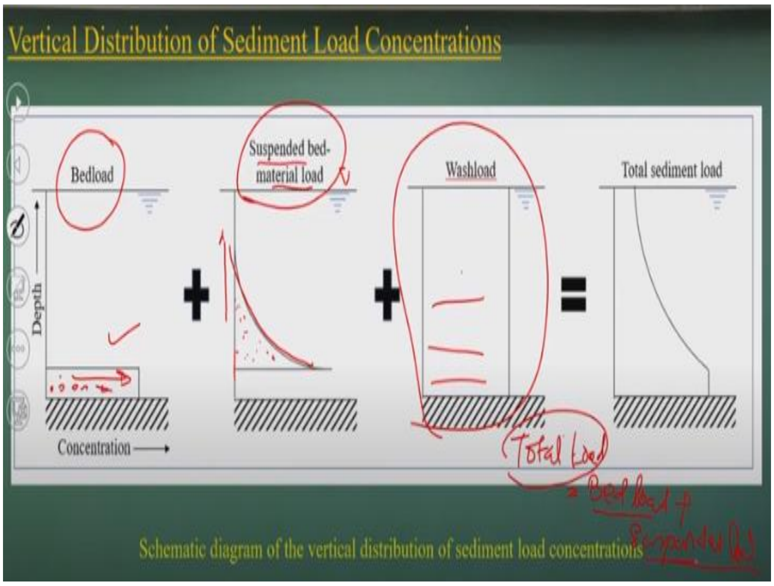

Now, let go for to very interesting part how does the sediment transport happens it? What is the distributions of sediment transports okay? Earlier also we discussed it but just to add to this because the velocity distributions as follows is a logarithmic distributions the sediment particles near to the bed can have a bed load like this. There is a certain thickness where you have a bed load.

Beyond that you will have a suspended load. It is all these bed materials which are there goes as a suspended levels it remains in suspension because of turbulence lift and also the buoyancy forces the both is a lifting that suspended particles. That what will be exponentially decay it as we go from the bed to the free surface. This is what the free surface.

This is what the distributions of bed load and the suspended bed material loads. And the sometimes we have the wash load which is a very fine particles can be a very uniform throughout this depth. Okay throughout the depth it is a very uniform and if you put it all we will have a total sediment loads. Many of the cases we do not talk about this wash load because wash loads does not it is very finely silt contents which are not much effectively in terms of morphological change.

We talk about the total load which is a summations of bed loads and the suspended load. So more often we neglect the wash load components. So please try to understand it how the sediment concentrations particle distributions. Bed load, suspended load and the wash load. If you consider the wash load the total diagrams will come like this.

But total load for morphological political point of view if you look it we have a combinations of bed load and the suspended load. That is the concept what we follow it.

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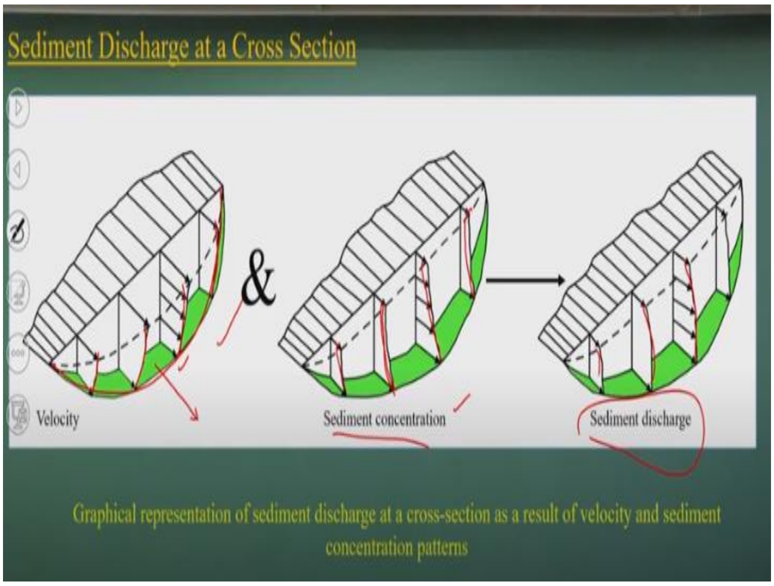

And now if you look at next part, how it happens at the river levels as river has rough substances like this, okay. And you can see that velocity distributions will change it as you move to the center points. Is the flow directions okay. The velocity distributions will change it. The sediment concentrations if you look it that what is follow especially decay.

So values like this okay so will be high and especially it will decay it as go off okay. The sediment discharge which is talking about the sediment mass per time that is what is a multiplications of the discharge and the sediment concentrations they will follow these diagrams. Looking these ones I will talking about that when you talk about how complex the river systems. It is not a uniform.

It is not a channel. When you talk about a channel flow which is typically you have seen it is a very simple diagrams, but when you come to a river there are the special variabilities are there in terms of velocity distributions, in terms of sediment concentration also in sediment discharge. That is the knowledge we should have or we should try to understand how this happened it.

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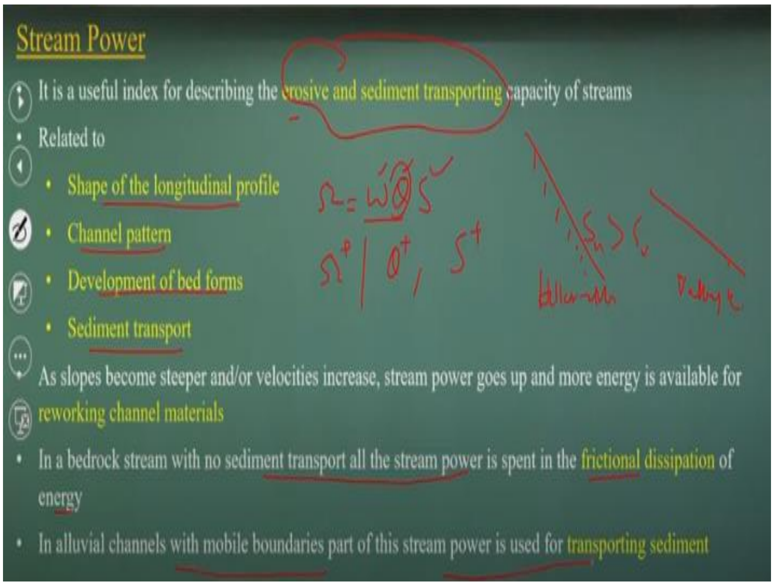

Another point what I want to introduce you that the stream powers. The stream power is nothing but it is the potential energy losses in a stream for a length of L. That is what clear cut indicates that based on the stream powers we can know it how much of sediment transport capacity is there or the erosive power is there of the streams. That is the reasons we compute stream power.

That is related to the sediment transport. It is related to the bed forms. It also depends upon the channel pattern, the shape of the longitudinal profiles. So we will define the things more details. The stream powers define as a functions of unit and Q S. More details will go in the next slides. So your stream powers defined as a unit weight discharge and the slope. That is the friction slope.

So if discharge increases okay the stream power is going to increase it okay that is we can know it that or if the slope is increasing it also the stream powers is going to increase it. The river that means hilly river which is more slope, the hilly river which is more slopes having the more stream powers with a same discharge if it flow in a valley rivers. Okay because the slope of this is larger than the slope of the hilly area and the valley area.

More the stream powers are there. That is what we define as a potential energy part energy dissipations what is happening it we take Q discharge and all. Similar way if I having the more the discharge more the stream powers. The basically it is a stream power is spent in a frictional dissipations of the energy. In case of alluvial river the boundaries of the stream power used for a transporting the sediment. We will talk about more details when you talk about sediment transport.

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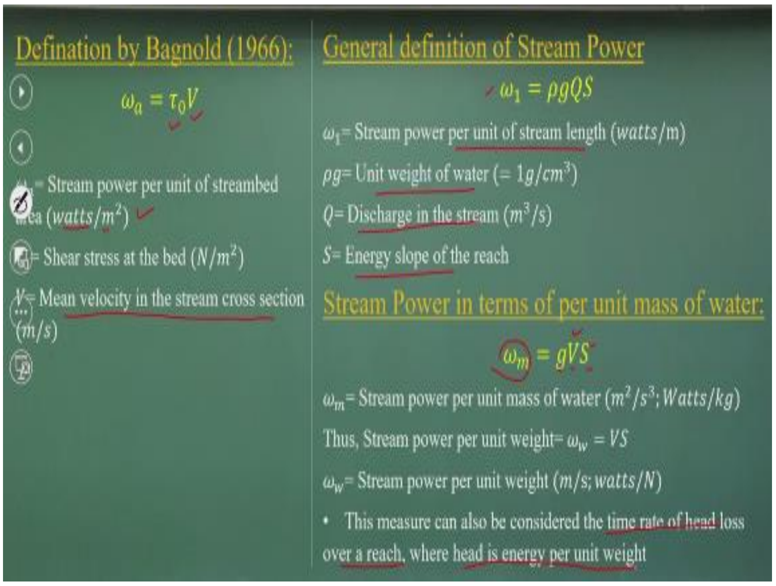

Now if you look it how you define the stream powers. The stream powers is if you look at the energy per unit area that is what stream powers is defined as a product of bed shear stress, shear stress at the bed multiplied by average velocity, the mean velocity across the streams. Unit weight of waters discharge in the streams S stands for energy slopes. That is what but if you are looking it the units of in terms of unit mass of the waters.

Just you divide the mass of the waters is ρ into volume. That will be give it in terms of this the stream powers was for kg that is what will come to us as a gVS. V is the velocity. You can consider the mean velocity. S stands for the friction slope which consider the energy time rate of head losses over a reach where the head of energy per unit weight. How much of energy losses are happening it as we have the stream powers.

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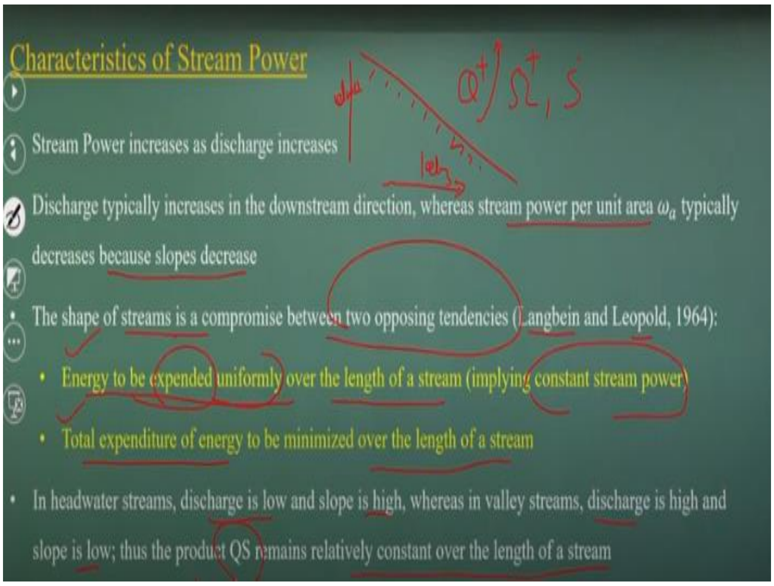

Now if you look it what it actually happens is that so as a river okay it is a longitudinal profile, this is the length and this is the elevations. What happens is as we are going to more the downstream okay we expected it that discharge will be increase it. As you go downstream, you will have more in case of discharge. Also that what will facilitate to increasing the more stream powers.

That means the energy dissipations are much more necessary as you go to the more the downstream. But because discharge stream power per unit area is a typically decreases as the slope decreases. But as we know it as we go the downstream, the slope is also decreasing trend. Slope is a decreasing trends. So if you look at this as you go from the river from upstream to downstream the discharge increases slope is decreases.

And that is the reasons what the hypothesis we have river is shape of the streams is always two opposing tendencies. That is what is Langbein and Leopold in 1964 it is opposite tendency. That energy to be expanded uniformly what the length of streams okay. Stream the river it tries to make it such a way the cross section and this longitudinal slopes transport slopes such a way that it will be try to expand it or dissipated uniformly along the streams okay.

Or it will have a constant stream powers. Or it can look it always river will try to minimize total energy expenditures over the length of the streams. Based on these two hypothesis we have a lot of studies what we discuss about the Lanes concept and all.

All they follow these two hypothesis which opposing tendency. That is what is derived by observing the river how it is happening it.

Headwater streams, the hilly streams, where the discharge is low, slope is high. When the valley streams we have discharge is high. You have the slope is thus the product QS remains relatively constant along the river of the stream. That is the concept what is there. The energy to be expanded uniformly are making a constant stream power will happen it from this headwater to the valley.

Because in headwater discharge is low, slope is high. But at the valley streams you have discharge is high, you have slope is low. So he tried to make it the product of QS which is a stream powers remains relatively constant over the length of the streams. That is river try to adjust toward that. That is basic concept of the river.

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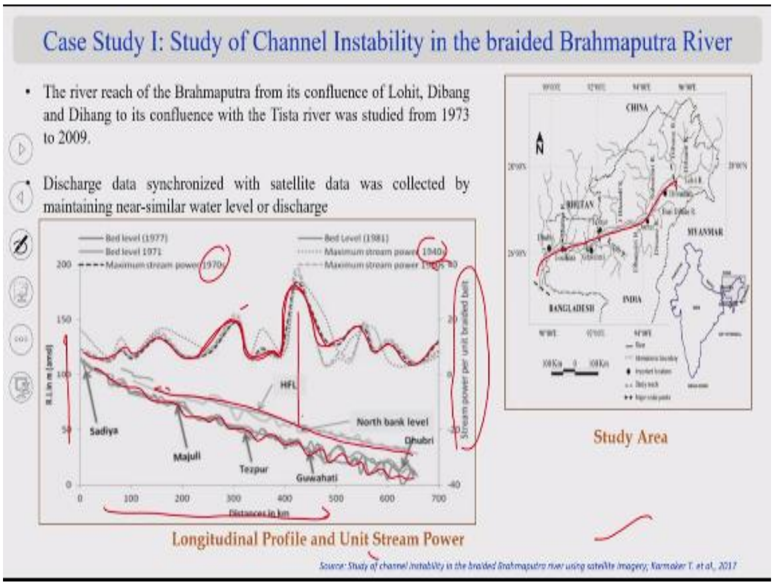

We derive it for these studies, which is available on this paper. So what I am just looking it that if I have a 700 kilometer length of the Brahmaputra rivers, starting from river reach all the data 700 kilometer length, and this is the elevations. If you look it that how the bed slopes are changing it. This is our original data, okay. These are the bed slope how is changing for a 700 kilometers of the Brahmaputra rivers.

How these, the high flood levels are changing it. But if you look it the stream power per unit braided belt per unit width. It is quite interesting. The steam powers are varying it and that is what is varying from 1940s, 1970s. And this one. So river is try to have as I am giving examples of the 700 kilometer length of the rivers, the Brahmaputra rivers starting from Sadiya to Dhubri you can see that how these rivers the stream powers are there, the energy dissipations are there.

The potential energy difference is there for unit width. That is what is a very interesting indicating how this energy dissipations happens it because it is all related to the sediment transport mechanisms.

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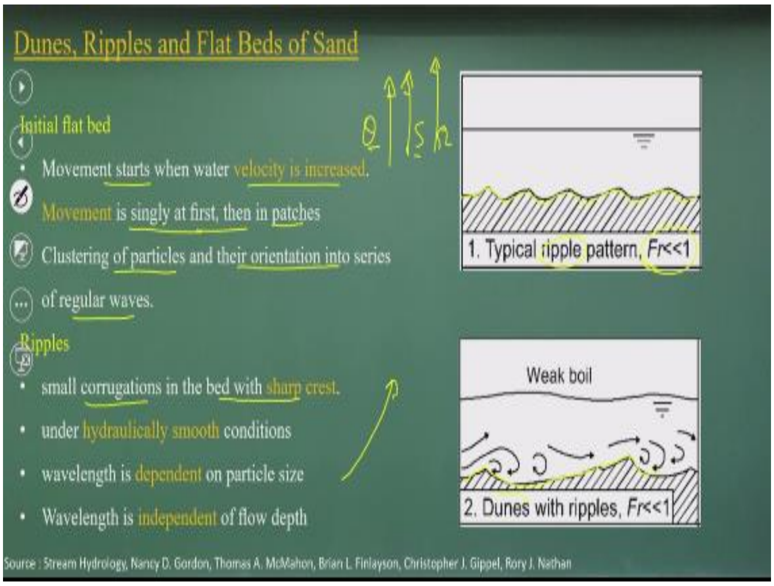

let us discuss about the bed forms. The river beds are not the flat bed and as we increase the discharge or changing the slope okay. You can have the two conditions either the slope of a channels we can change it or you can change the discharge of a channel, river channels the flume in a laboratory levels are that what can a conditions where the slope is changing and the Q is changing it.

We are increasing the stream powers. As it increase the stream powers, bed material start moving it. Because of the bed material moving particles are starting it they forms a different bed forms. The different bed shapes its form. So that what we are looking it. As the stream powers increases in a flume we can understand it or if you go to the field you can see these riverbed forms okay?

When you have a typically a flow Froude numbers is much less than 1. In that case, you will have a bed form with a small amplitude okay, with very small amplitudes and these thickness is not bad. So the sand particles will make a small type of ripples patterns will form it.

Ripples patterns will form it, which will be as the velocity increase momentum starts it and that is what it make it as a patches and the clustering of particles they are oriented to make a series of ripples waves, Initial bed forms then will have a series of the ripples forms. The smaller corrugations in the bed with a sharp crest.

And you have a sharp the crest and if you have a further increase it if you have the further increase of the flow if you look it this ripples will form like this. So that is the dunes with ripples. That we can try to understand it when you have the channels and you are increasing the slope or increasing the discharge you can see it that initially will be a flat bed.

Then it will come as a ripple patterns. Further if we increase the discharge or the stream powers, you will have a formations of the flow like this. Formations of flow like. So that will be the end of the backside of the eddy dunes, there will be eddies formations will be there. And that what is the ripples will be hydraulically smooth conditions and the wavelength is depend upon the particle size.

In the ripple case, the wavelength of these ripples that is what it depends on particle size independent to the flow depth.

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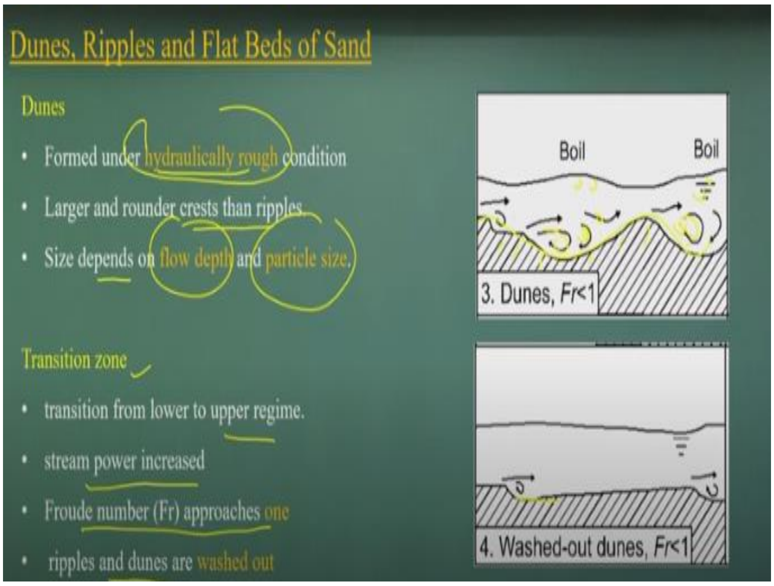

But in case of the dunes, you will have a hydraulically rough conditions will come it. So if you look at this further if you increase you will have the dunes. The step you try to understand like the sand dunes in the desert. Okay that the same conditions happen in the riverbed levels. Riverbed levels, you will have the dunes formations as you have seen it the dunes in desert.

The same conditions will happen it and you will have eddies formations make up that. That is the hydraulically rough conditions will prevail it and larger, rounder crests than the ripples and the size it depends upon the flow depth and the particle size. Now it depends upon the flow depths and because of this sand dune formations there are the boils will be there.

There will be vertical vortex presence will be there. If you further increase it okay and the flow Froude numbers coming closer to 1, then these dunes will be washed out. It will be away a transitional zone, which is lower to the opportune of the stream power increased the flow Froude numbers approach to the close to the 1. The ripple and dunes will be washed out, will be washed out. That is the conditions will be there. Again it will come a plane surface. Again it will come as a plane surface.

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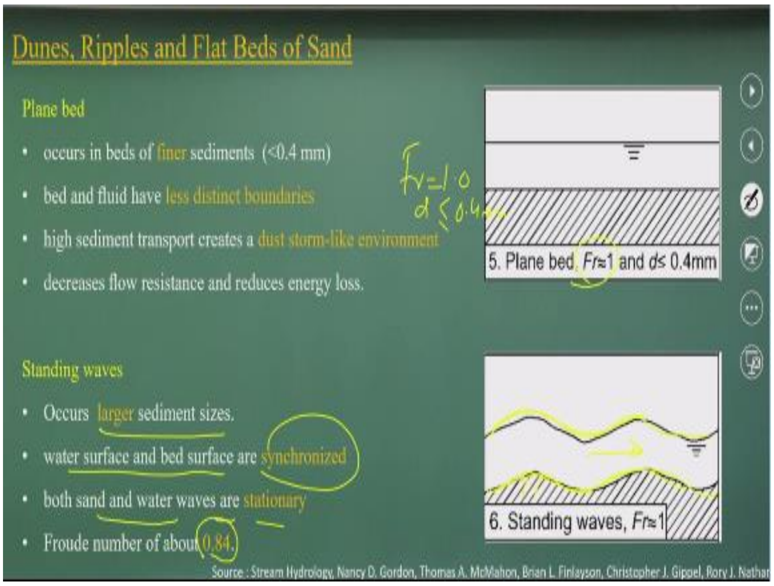

Now if you look it the next ones, again this plane bed surface you can see it okay when the flow Froude numbers closer to the 1. Flow Froude numbers is closer to the 1 you will have the plane beds. When you have the d is much smaller than 4.4 mm but if are not that is conditions you can have either standing waves that your shape of the wave formations of the sand and the water shape will be the same.

Okay that will be the standing wave type of conditions will come it where is larger sediment size and the water surface and bed surface the wave that is what is synchronized it and the both the sand and water waves are stationary, okay. They will move like a same, the water wave and this sand wave. And that is what it happens it when you have a flow Froude numbers is closer to the 1 or it is equal to 0.84.

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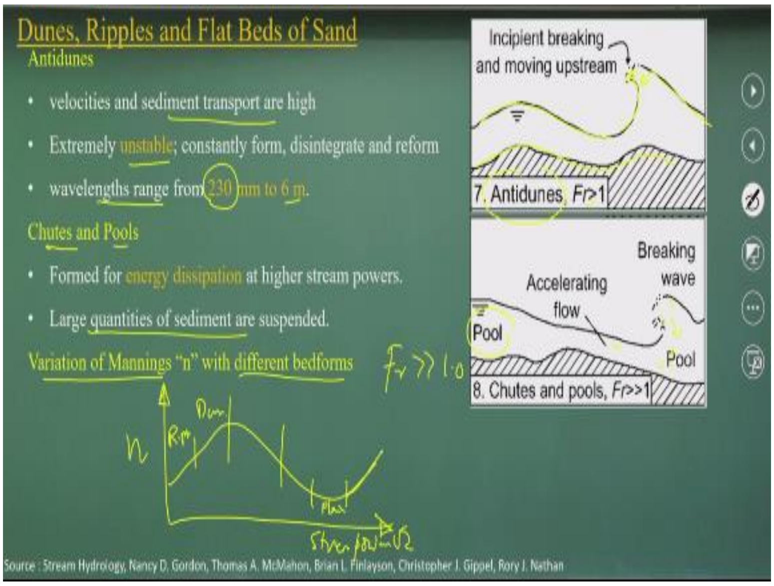

Further if you look it okay further if you increase the flow Froude numbers okay, greater than 1. What which will happen is if this is the bed, it cannot sustain this standing wave. So it will be start it and flushing this water and come back it, okay. So that is an antidunes. That is what antidunes formations will happen when flow Froude number is greater than 1.

The velocity sediment transports are high. Extremely unstable conditions will happen it. You can see this the wavelength of the range from 230 millimeter to the 6 meter. It can go up to the wavelength of the 6 meters. Further if you increase or if your flow Froude number is larger than 1 value, then it will have a this pool and the chute regions. There will be a pool and there will be a chute.

Chutes and the pool, the chute is accelerating zones, okay. So if you have that there is a large quantity of sediment will be the in the suspended conditions and the flow

Froude number is much larger than that. But if I try to look it how does Mannings roughness n values varies with the bed forms. If I plot stream power versus Mannings roughness values, I will get a shape like this.

The first part is repeat. Second part is dune. Then we have a transitional states. Then you have a plane surface. That in case of the plane surface, the n values will be low. In case of the dunes, it will be the high n value. High flow resistance will be there. Then as is go for antidunes it will increase. So n value which representing the flow resistance or the energy dissipations, it is also depends upon the stream powers and the bed forms.

Stream powers and bed forms. Beds are not perfectly planes. It changes its beds from ripples to dunes to antidunes. Then you have a plane surface. All these surface the chain of the process what it happens it as we have increase of the stream powers, the n value is varies like the surface. That is what we should know it.

That is the reasons the river makes a lot of nonlinearity when you observed the stage discharge curves because if there is a bed is changing from these ripples to dunes to antidunes to plane surface the n value also varies it. As you can interpret it from Mannings equations the velocity and the flow depth are related with n values, which is simple or n value variations are indicating by that.

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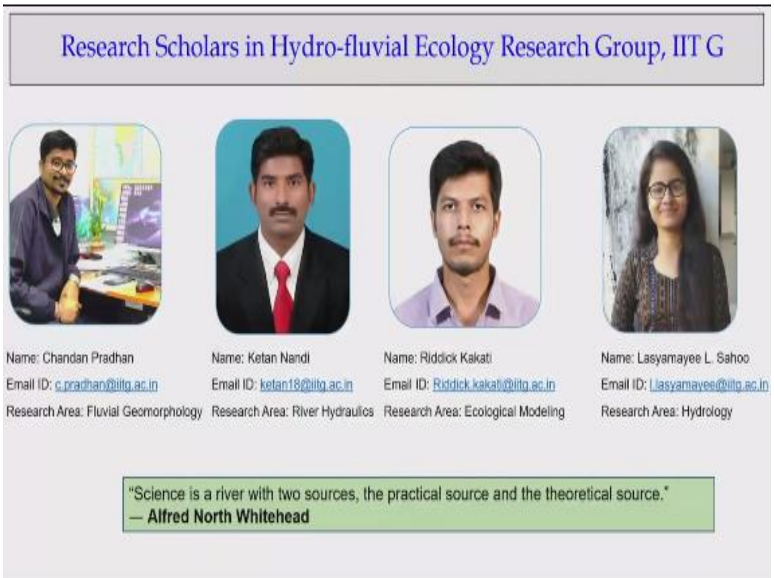

With this lets I conclude this lectures with having these quotations from Alfred North Whitehead. Science is a river with two sources, the particle sources and theoretical sources. I think river mechanics follows the two parts. One is theoretical knowledge and other is practical at the river scale knowledge. That the combinations gives river engineering in different facets. Thank you very much.