River Engineering
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Lecture – 01
Introduction

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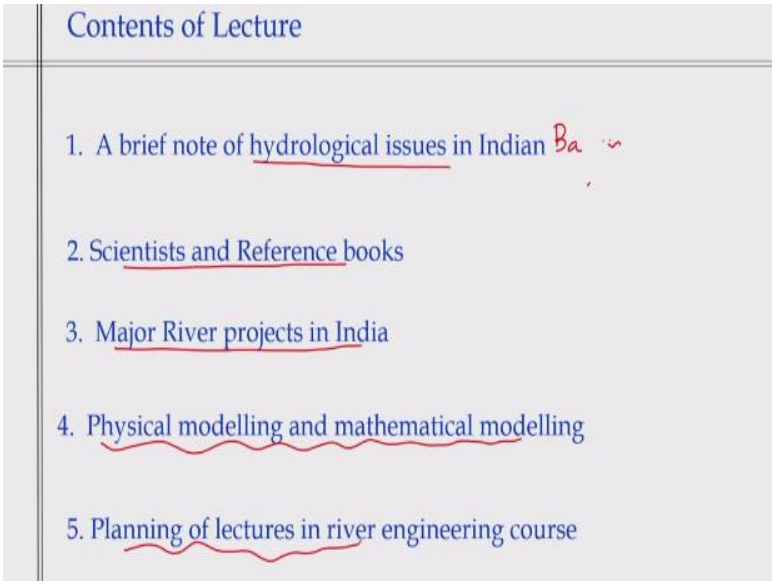

Welcome all of you to this interesting lectures on river engineering. This is an introduction lecture on river engineering. You all know about river engineering and you all have seen rivers in different part of your life, but today we are going to start engineering aspect of river concept that what we are looking at and today's lecture just being an introductions lectures, I will just talk about a brief note on hydrological issues.

What are the issues are there in Indian basins? The basic idea is that what problems are there and what are the reference book and eminent scientists on this subject. Then, also I will talk about major river projects which are constructed and what is their performance, how they are fulfilling their major objective and the recent area if you talk about the physical, mathematical modeling, some of the case studies I will show.

And then I will tell you so what is the planning of lecture series for this course. So, that is what I will discuss in today's lecture.

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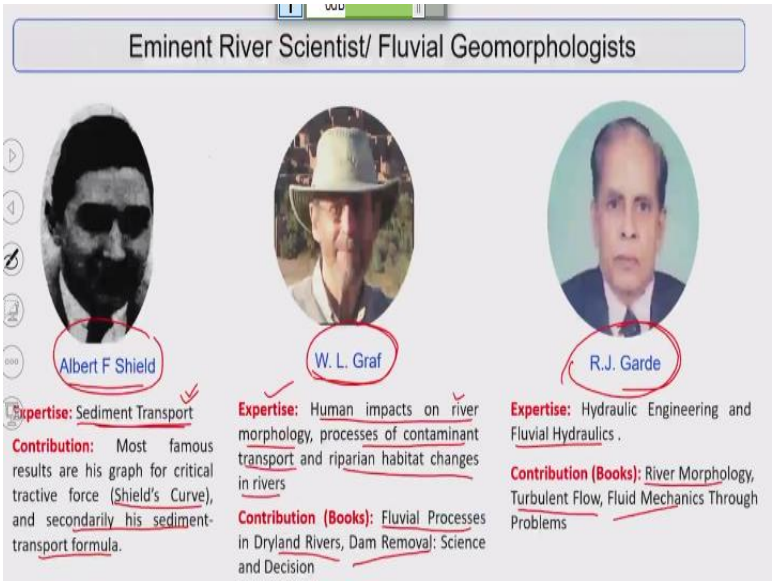

Look at the eminent river scientist. Let me have Albert F Shield, very beginning, considering the fluvial experiment in the flume and tried to understand the concept of incipient motion. How the sediment particles are moving from the bed? that is what you try to understand and try to have a knowledge on the sediment transport because if you talk about the rivers, we have to talk about the sediment, we have to talk about energy dissipation.

So, the famous Albert F Shield developed the sediment transport formulas or the sediment curves which is Shield's curve or Shield number and that is what is very early studies makes us understanding the complex process between water and sediment transports in regional river systems. Then Professor W. L. Graf looking for beyond this rivers, looking for the human impacts on the rivers, morphology.

The process of contaminated transport, riparian habitat changes in the rivers that is what is the present issues. Today for most of the Indian rivers, we have the issue of water qualities, river health. These are studies which are started by professor W. L. Graf and that is what is the fluvial process in dryland rivers, dam removals science and decisions. An Indian scientists you know it, Professor R. J. Garde, he was a professor in IIT, Roorkee.

He has contributed on turbulent flow, river morphology and the fluid mechanics. He tried to combine the morphology, turbulent flow, fluid mechanics and tried to understand the water sediment transport process and established very unique lab set ups in IIT, Roorkee. It was established to study the process of the fluvial hydraulics. So if you look at this, there are many scientists in this field, I just want to highlight it from Albert F Shield to R. J. Garde.

So, a lot of experimental studies were conducted, very precisely tried to understand water and sediment transport process which is the complex processes. As well as professor W. L. Graf, he tried to understand human impacts on the river morphology process.

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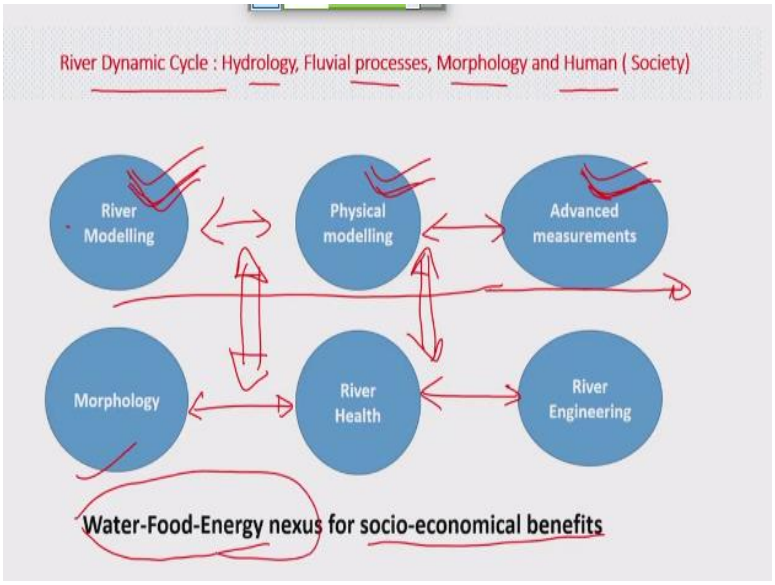

Now, if you look it today what challenge you have? Very interesting challenge what we have today, especially Indian river basins, today there is not having an independent process we will look it like hydrodynamic process separately, sediment transport process differently, morphology process differently, hydrology process are different and the society the human being interventions, all we look it in separate entity that does not happen it, all are very much integrated concept.

If you talk about the river dynamic cycles, how the rivers are changing? it is so dynamic, it is interlinked with hydrology, fluvial processes, the long-term morphology change and also the driving factors like society or the human beings. The river dynamic process are linked to hydrology, fluvial process, morphology, and society. Now, if you look at that, what it happens is, in the last few decades that we have an alternative concept like a river modelling.

There is lot of mathematical modeling concept has come out and tools are available, models are available, helpful to look at the similar behavior what it happens in natural rivers that what we can represent mathematical models. There are lot of significant development happening, physical modellings that is what I will show it. There are good setup of physical model of river models are there.

Not only that there are lot of advanced measurements are happening today, which it was not possible maybe 20 years back, but now it is possible to do the data collection at the river levels. It is a possible that is what I will show some photographs for you. The advanced measurement of the hydraulic parameters are also possible, so that way there are significant development happens in these 3 directions.

Mathematical models, physical models are interacting each other or each one is a complementary to each other's. There is no superiority of physical model or mathematical model along the field data, all are interlinking each other's to enhance the knowledge of the river mechanics. Try to understand the sediment transport process, the hydrodynamic process, the turbulent process in rivers with respect to energy dissipation, nutrient transport.

All we have to try to look it as a river. We try to look at how the process happens it. So, for that reasons, we need to have all these 3 tools i.e. physical modelling, mathematical modeling and also the advanced measurement, all they are complementing to each other's to have a knowledge on the river. The river morphology is also a part of planning in present days which earlier is considered to be a long-term purpose.

But now the river morphology also is considered as a part of planning in river health and the river engineering. So, if you look at this, all are interlinking each other's at applications level. It is an advancing levels of modeling, river mathematical modeling, physical modeling, advanced measurement, similar way if you look at the planning, planning also we should look at river health, I am talking about water quality which is a major issue in our countries.

So river health, the ecological health of rivers, river engineering as well as the morphology all are linked to each other. If you look at these 6 blocks, it is changing its that also we have linked with this part because as we have a knowledge about the rivers that is what will be give us a confidence or to take appropriate decisions on what type of river engineering we should implement it.

So, that is the reasons if you look at that, both the things are happening and as you implement the river engineering, any projects like maybe a barrage project, maybe a river training

works, you have to try to understand using the advanced equipments what is the performance of that structures if that is what you can also look it.

So if you try to look at these figures the river modeling, physical modeling, advanced measurement, morphology, river health and river engineering. And I can bracket into the society, they are the socio-economical benefits that is what is the basic things. Mostly, we ignore one part of the river, which helps us to maintain big cycles at the society point of view, which is water-food-energy nexus. The river also play major roles to make it sustainable, or socio-economic benefits. Let us try to manage, or try to understand how the water-food-energy nexus is happening in a particular river systems, which varies from river to river.

Like the concept what do I develop for the Brahmaputra River, I cannot apply the same things for the Godavari rivers or the same things for the Narmada river. So, all this concept we have to understand locally, at the regional levels and also you should have the broad knowledge at the global scales. That is my concept to bring you this course and based on that concept I have designed this course for you to go next levels.

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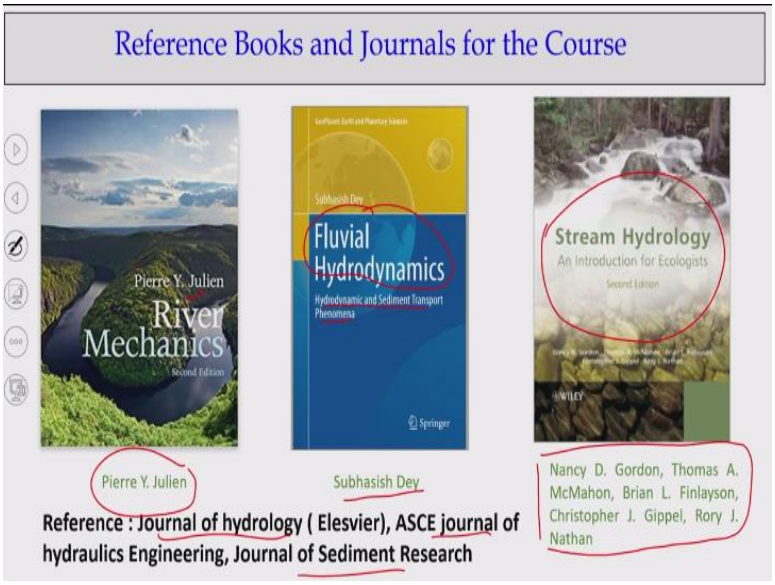

Now if you look at the books what I am going to follow it is, River Mechanics by Pierre Y. Julien which is a very interesting book. Also fluvial hydrodynamics looking at new modeling, new measurement technique, discussing on hydrodynamics and sediment transport phenomena that is what we will follow by the book authored by professor Subhasish Dey. Then we will have a very interesting book looking for ecologist point of view is a Stream Hydrology: An introductions for ecologist.

A group of professors have written this book, very interesting book. So, what I have to tell you that, it is a combination of, one side is river mechanics, the fluvial hydrodynamics and the steam hydrology: an introduction for ecologist, not only that we have to follow some of reputed journals like journal of hydrology, journal of hydraulic engineering and journal of sediment research.

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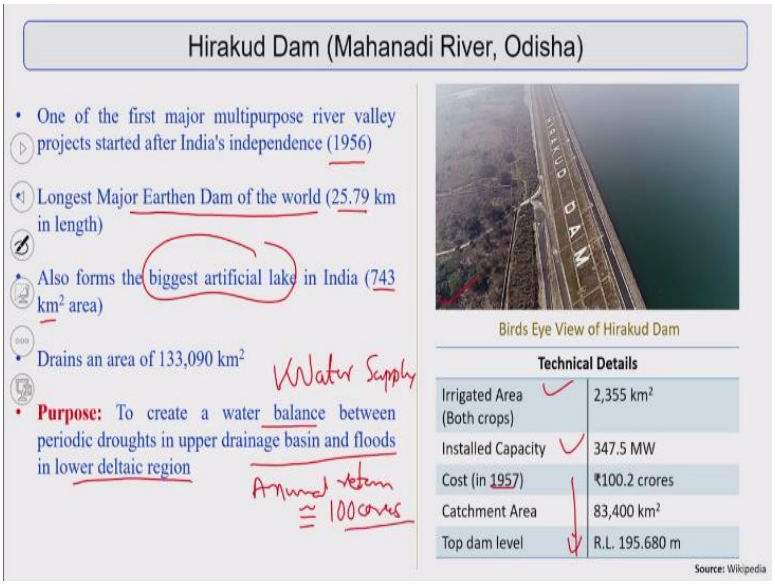

Now, if you look at some major projects in our country the Hirakud dam projects which is located on Mahanadi river in Odisha. We can look at the dam projects here in this Figure. If you can see this bird's eye view of Hirakud dam project, this project is a one of the projects what was initiated in 1956, way back close to 70 years back. Longest major earthen dam of the world which is having closely 26 kilometers.

The biggest artificial lake in India which covers 745 km^2 approximately, close to 750 km^2 area of artificial lake that is what is to create for the flood management, water balance and also nowadays this is a major source for water supply for industry and the domestic purpose. So if you look at this project which is 70 years old projects still it is running it with a hydropower, the irrigations.

And the project cost in 1957, it was 100 crores. In the last year I just discussed with river project authorities, The annual return from hydropower and the water supplies is coming very close to 100 cores for years, so that is what I have to tell you that these big projects what is there we can look in 1956 that is 100 crores, now the annual return of this project is coming

from water supply to industry, the domestic and the hydropowers that is what is close to cores.

This is the lifeline for the water resources in the state of Odisha. So if you look at that, this is what one of the major interventions we did.

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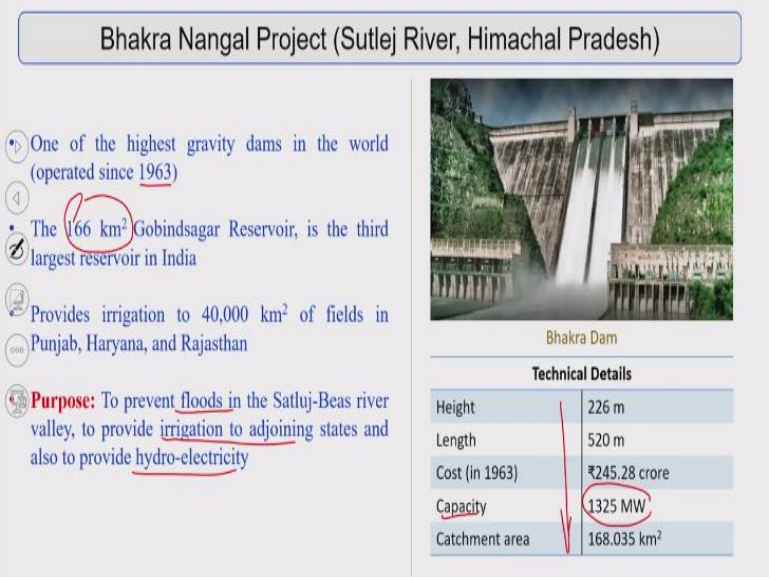

Same way if you look at this Bhakra Nangal project which is the interesting projects we will be having. The reservoir of 166 km^2. It is began in 1963 and is constructed basically to prevent the floods and provide the water for irrigations requirements and the hydropower projects, that is what if you look at that how basic features, the power generation part as well as this is the projects part.

If you look at that what I have to say that there are the projects existing in our countries and that is the interventions we have done for the rivers.

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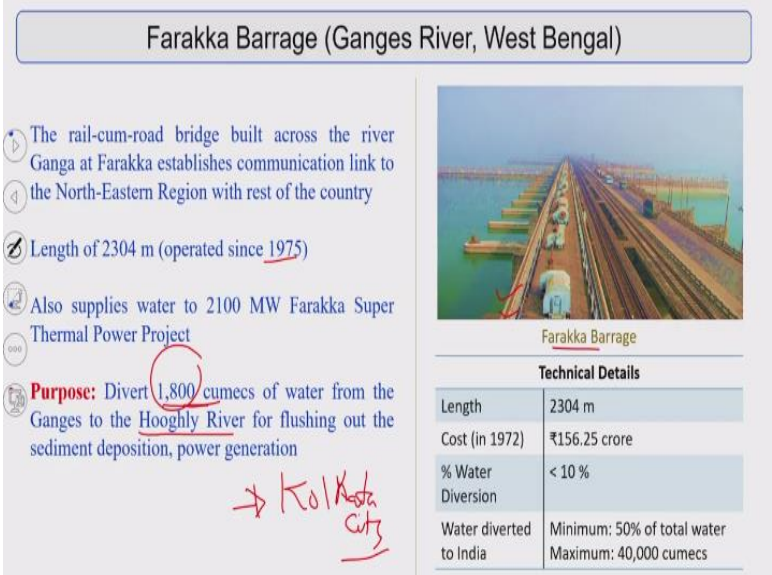

Same way if you look at very interesting project which is the Farakka Barrage project.

That is the bridge connecting between northeast and the West Bengal. So, this bridge is there and four lane bridge with a barrage structures is known as Farakka Barrage. If you look at the major objective of this barrage is, to divert around 800 cumecs of the waters from Ganga to Hooghly rivers which was a dying river before this project's implementation.

Before the implementations of the diversions projects, the Hooghly river which was earlier known as the Ganga river, many of the people also believe that is a part of the ganga systems. Hooghly river is regenerated by this Farakka Barrage project, which have been providing 800 cumecs of discharge diverting from Ganga to the Hooghly river systems.

It is a quite successful projects, no doubt there are disadvantage and advantages, but because of this projects Kolkata city is sustained today because the existence of the Hooghly river talks about the existence of the Kolkata city. This project is implemented in 1970s and it is really a big project helped our country to survive a dying river like Hooghly river just about in 1975, just 50 to 60 years back.

And this is what helped us to survive the Kolkata city as well as the Hooghly river. So if you look at that all the projects tells us a successful stories on how we managed our river systems.

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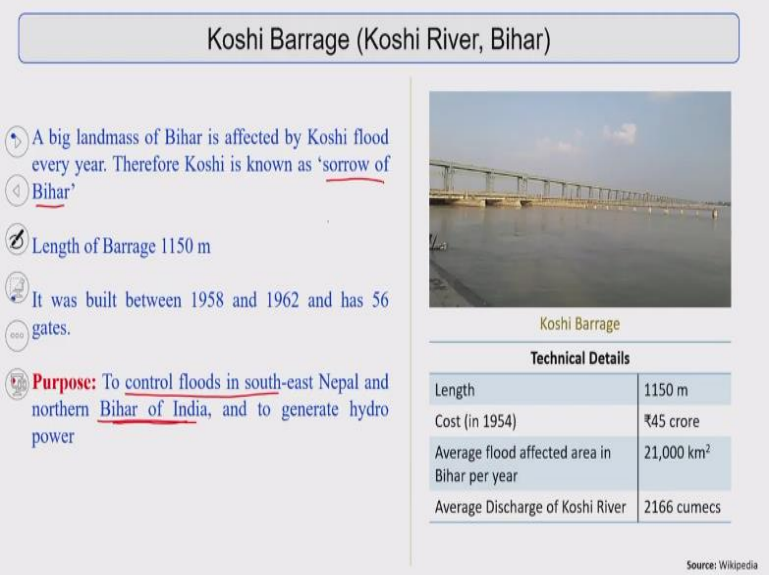

Same way if you look at this another interventions what we did, it is Koshi Barrage, just it is situated at the border of India and Nepal and this barrage help us to mitigate the floods, which was earlier is annual floods, because of that the Koshi's was known to sorrow of Bihar. It has been successfully managing these floods but still the issues are there to how to manage the floods.

The barrage and the embankments are helping to reducing the floods in the Bihar where earlier it was known as sorrow of Bihar. So if you look it that way, the 50 or 60 years back we are supposed to a leader on river interventions, leader on the knowledge of river, the sediment transport, river dynamics, the sediment transport, the nutrient transport and we are well managing with the rivers with some intervention structures.

So if you look at this Koshi barrage, the details, information on how we have done the interventions of the major rivers in India, like Koshi barrage, the Farakka barrage, Mahanadi Hirakud Dam project, all it says that there are certain amount of knowledge we had and we also tried to do managing the river in different ways in having understanding about the river systems.

It is necessary to develop knowledge pillars on river mechanics, the sediment transports and the nutrient transport or the energy dissipation. The course is meant for that giving it to you the glimpses.

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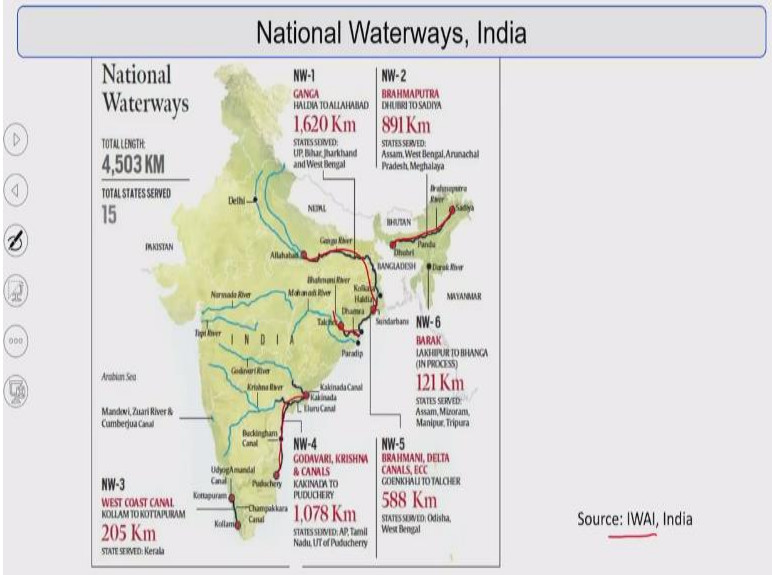

More interestingly, now you look at like national waterways. So, there is national waterway-1 which is connecting from Allahabad to Sundarbans, Haldia port, national waterway-2. We have a national waterway-5. So if you look it like a national highways, we have a national waterways. There are lot of issues, lot of improvement we can do to make this river navigable and what is the advantage to have a river navigable?

You can go through the websites of Inland Waterways Authority of India which will talk about how we should develop national waterways and how we can develop the tourist, the river will be navigables. We can develop the tourist, we can have a goods movements and we can think in the transport mechanisms what we presently have road network based transport mechanisms or the railway networks.

The inland waterways also can play the major roles for us in these centuries, and thus still we have lot of challenges to implement as a waterways of national waterways-2, 5 and other case. So what my point is that there are a lot of opportunities for us to understand the rivers now and try to have this the best options what is available to us.

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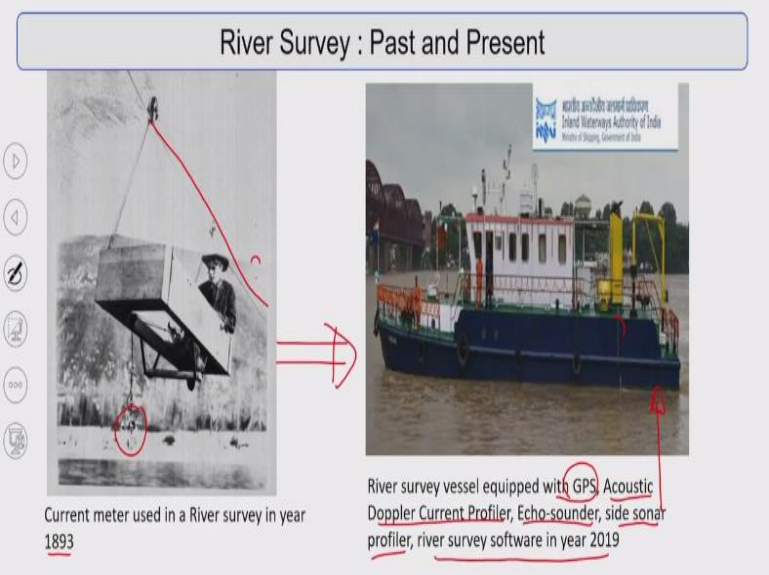

Now you look at very interesting photographs of 1893s. If you look at this cable connected with that and person is sitting on this, holding the current meters. This is what the current meters and the persons are collecting the data, so you can see that how much of risk the person took to just do a survey in rivers, but today we have a much more technology-driven river surveys.

Like if you have the river vessel survey, it can equipped with GPS, global positioning systems to know where it is, you can have an Acoustic Doppler Current Profilers, for measurement of 3-dimensional velocity components. You can measure the sediment concentrations, you can measure the flow depth, you can have an Echo-Sounder, you can have a side sonar profiler and there are the software inbuilt.

We can also look at that with the previous data of flood plains and river courses, all these informations can integrate it and that is what you can do it with having a very good facilities like the river survey vessels. So, we have transformed ourselves from these manual device of velocity measurement in the river to a very advanced equipments with a survey vessels, GPS, Acoustic Doppler Current Profiler, Echo-sounder, side sonar and river software, the many mores.

Nowadays, the technology are coming to inbuilt, make a river surveys much simpler as compared to earlier.

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I will show what we did it as a water resource fluvial group. We conducted river surveys in these stretches, 3 locations, and if you look at the Brahmaputra rivers as the google earth images showing it that this width itself will be more than 10 kilometers. So, that is the reasons we cannot do a traditional survey. This width could be more than 3 kilometers.

This would could be more than 4 kilometers. Just look at the dimensions of the rivers. So if you look at this river and if you do the survey with this type of survey vessels integrated with advanced river surveying equipments, very interesting knowledge we get it. Just trying to show you the velocity distributions.

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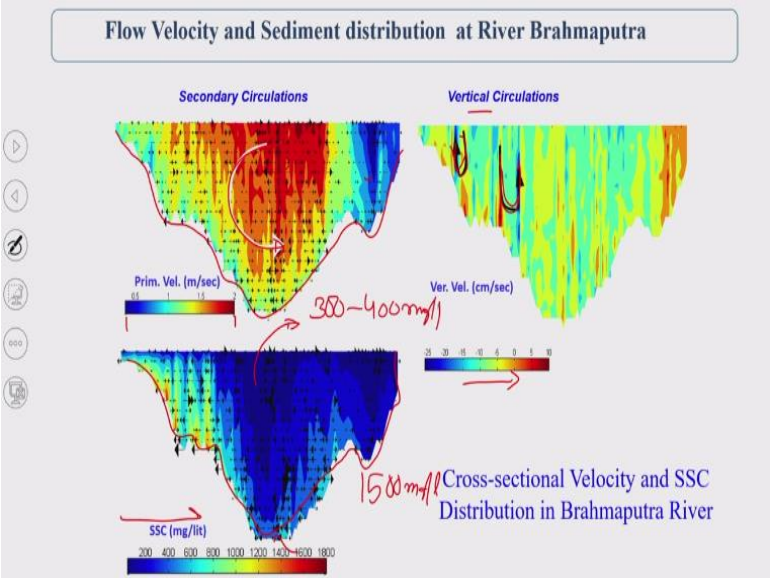

If you look at the data of river survey what we have done it and this is the bed and you can understand in the high velocity zones and low velocity zone, there are the secondary current

formations are happening. The vertical circulations are also happening. This is what the field level of measurements. The primary velocities are varying from 0.5 to 2 m/s.

The vertical velocity is not that higher, it is cm/s and there are the vertical circulations you can see. So if you look at today we can measure at the river levels, how these velocity distributions are happening. Not only that you can also have a sediment concentrations variability. If you can look at the sediment concentrations variability in the rivers in some cases it can go as high as it is about 1500 mg/L.

And in some cases, in average conditions the sediment concentrations can be 300 to 400 mg/L. So what I am telling you that if you do a river surveys you can understand it, how the transport mechanisms are happening, how the velocity fields are happening, the primary velocity, the vertical velocities, secondary currents, vertical circulations all the informations now today we can get it if you do a thorough survey in a river like Brahmaputra where we have a lot of challenging tasks.

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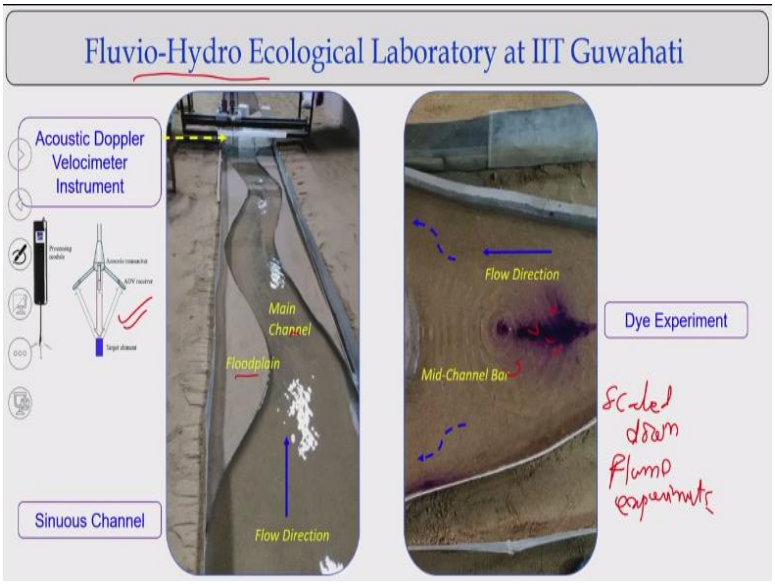

Same way if you look it if I replicate the river into my fluvial-hydro ecology lab. So if you look at the river meanders with the floodplains and we can use an instrument like Acoustic Doppler velocitymeter and with a colored dye, you can see how the turbulent structures are happening in it, all these energy dissipations are happening in it. So this is the scaled down model flume experiment. Now if you look at we have real field conditions, also we have the lab conditions.

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The same way if you look at another lab setup which is the physical river modeling at NIT, Rourkela. See if you look at the river meanders, and you can have these instruments to measure it exactly how the velocity distributions are happening, how the secondary current formations are happening. I tried to tell you that once we have the laboratory setups, we can understand the river mechanics at the flume level.

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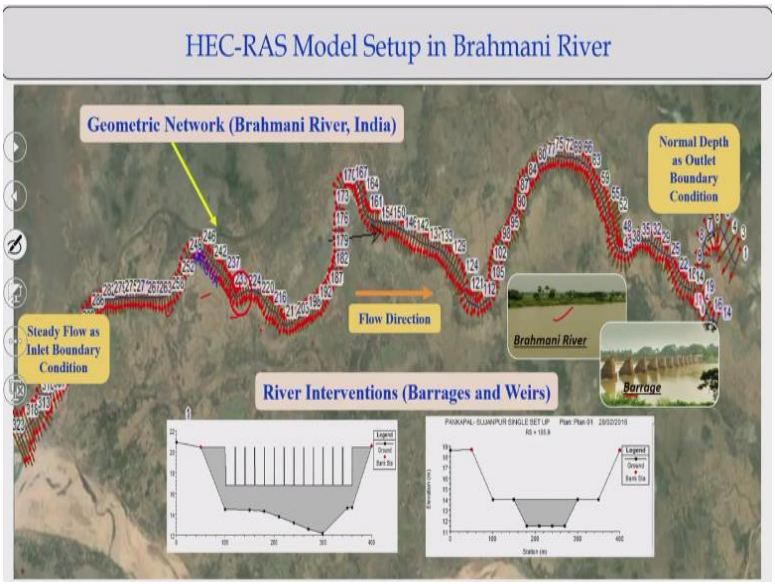

The same way if you look the study we have done for Brahmani river, which is shown in this photographs. The barrage and detailed river cross sections were incorporated in mathematical modeling. With a very detailed cross sections data, and with mathematically putting this same barrage structures here and the cross sections are this like this.

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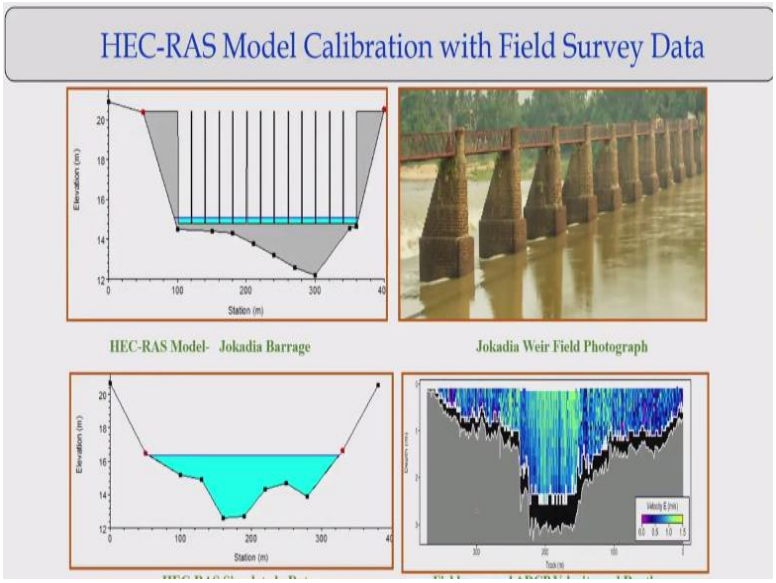

If you look at that, we also got very interesting results by conducting this mathematical models. This is what the observed velocity distributions. This is the real field conditions and that is what mathematical model simulations. So, you can try to combine mathematical models with the real field conditions and understand the model predictions performed with some sort of approximation in mathematical models, which we will discuss in detail later on.

And we have the velocity measurements at the field levels as well as the mathematical models. I just tried to show you that how the advanced tool of river models can be used to predict how the flow behaviors are there.

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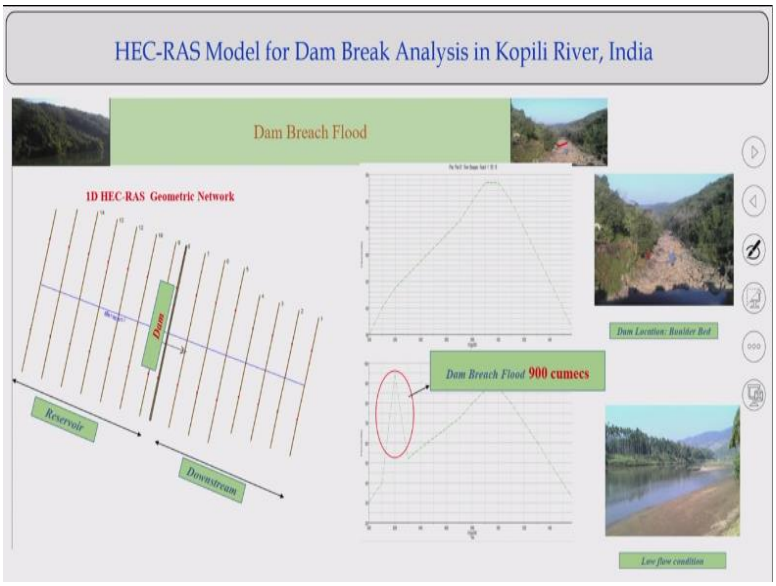

Same way also we conducted the Dam Break analysis for Kopili river in Assam. If you look at the river model setup photographs and by considering the dram breaks, we tried to look

how the flood is propagating downstream and with help of HEC-RAS and the GIS we can able to show these type of photographs.

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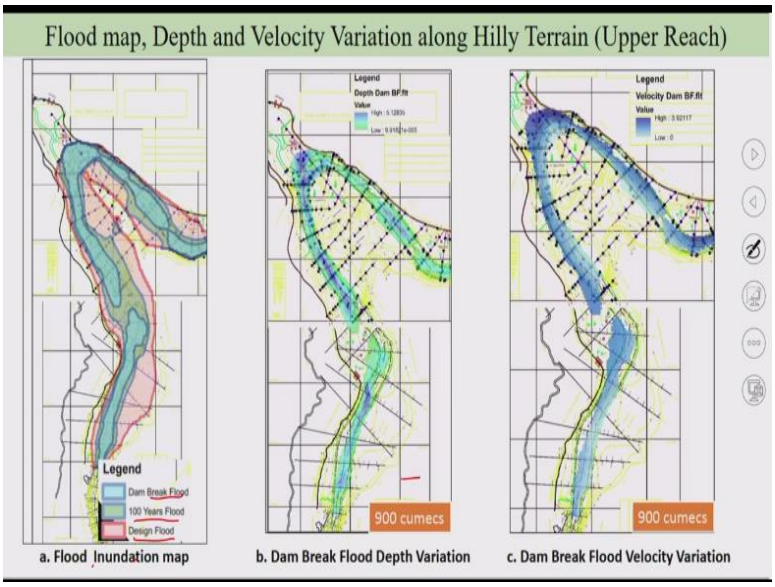

This type of maps clearly indicating to the people, the planners, the flood inundation map for dam break conditions and flood depth variations and the velocity variations. So if you look at these figures, the flow depth variations are there with a 100 year return period flood, design flood and dam break flood. So, you can prepare this type of flood zoning map by conducting a mathematical modeling with detailed cross section informations.

And then if you prepare this type of the data, I think this will be really great help for planning the flood management strategies which we generally do it. So, my point is that we can look at this way, how efficiently data we are getting and what will happen even if there is a dam break, 100 years flood or the design flood which can be obtained by conducting the dam breaks artificially.

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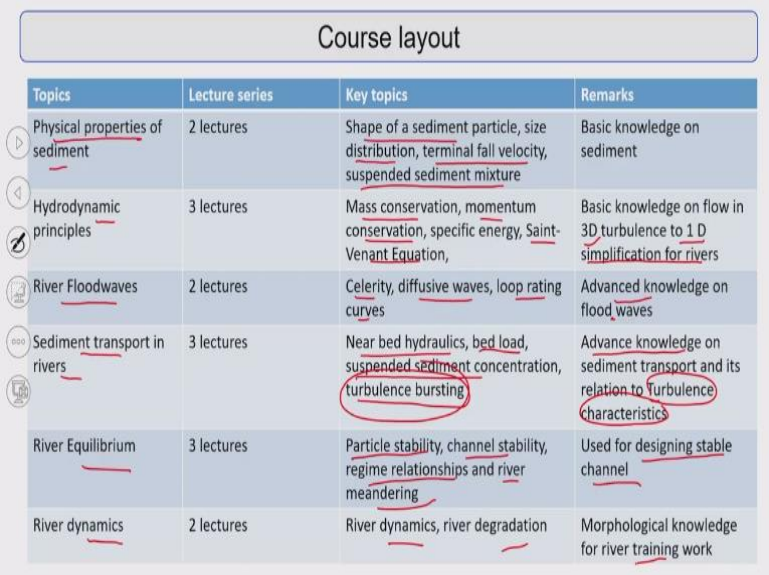

Course layout

Topics	Lecture series	Key topics	Remarks
Physical properties of sediment	2 lectures	Shape of a sediment particle, size distribution, terminal fall velocity, suspended sediment mixture	Basic knowledge on sediment
Hydrodynamic principles	3 lectures	Mass conservation, momentum conservation, specific energy, Saint-Venant Equation,	Basic knowledge on flow in 3D turbulence to 1 D simplification for rivers
River Floodwaves	2 lectures	Celerity, diffusive waves, loop rating curves	Advanced knowledge on flood waves
Sediment transport in rivers	3 lectures	Near bed hydraulics, bed load, suspended sediment concentration, turbulence bursting	Advance knowledge on sediment transport and its relation to Turbulence characteristics
River Equilibrium	3 lectures	Particle stability, channel stability, regime relationships and river meandering	Used for designing stable channel
River dynamics	2 lectures	River dynamics, river degradation	Morphological knowledge for river training work

So, in similar way, I can have lot of examples which I will be discussing in my lecture thoroughly. So if you look at that part I need to design the course layouts in the 3 ways. One is basic knowledge. Second is advanced knowledge we should have. Third is that you should have a design practice, what is the design practice happening because we have to protect the river bank, we have to have the planning of the floodings.

Also we have to look for the water qualities from the ecologic point of view. Looking at the first few lectures we will discuss physical properties of the sediment where we talk about shape of the sediment particles, size distributions, terminal fall velocity, suspended sediment mixtures which is a basic knowledge of sediments.

Then, we will talk about hydrodynamics. Here I will go for mass conservation equations, momentums and energy kind of equations. From 3 dimensional to 2 dimensional approximations like Saint-Venant equations part.

So basically we will go for 3-dimensional to the 1 dimensional with a simplifications for river models, so which is advanced knowledge and that will be discussed. The river floodwaves which is very critical which we talk about celerity, diffusive waves, loop rating curves with advanced knowledge on the flood waves that is what will be there.

Then we will discuss sediment transports in the rivers. So, basically we will talk about near bed hydraulics, bed load, suspended sediment concentrations, turbulence bursting, this is a very interesting problems, the knowledge recently last two decades what has happened, the

turbulent characteristics, the sediment transport which are all advanced knowledge in this subject, that will be discussed.

Then we have river equilibrium and river dynamics which is required for designing a stable alluvial channels. We will be discussing regime relationship, channel stability, particle stability, river meanderings. Same way we have a river dynamics, which is morphological knowledge, necessary for appropriate river training work.

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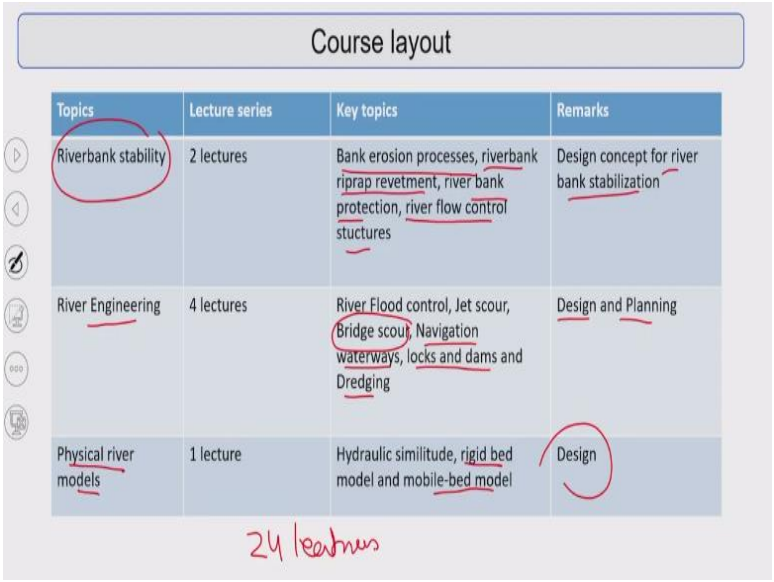

Not only that there are very interesting river bank stability concept. In this we will talk about bank erosion process, river bank riprap, revetment which is a design concept, river protections work, river flow control structures which all will be discussed for river bank protections. River bank stabilization, mostly the design concept, the difficulties and the designing will also be discussed.

Then we will come to river engineering where we will talk about more interestingly bridge scour, navigations waterways and discussion on national waterways, locks and dams, dredging. So, this is the advanced level of designing and planning for the rivers. Then we will have the physical river models which will have a one lecture talking about the difference between rigid bed models and mobile which is part of the design. Whenever you do any big projects, we do mathematical model as well as we do the physical river models

We plan all these topics in 24 lectures including today's introduction lectures.

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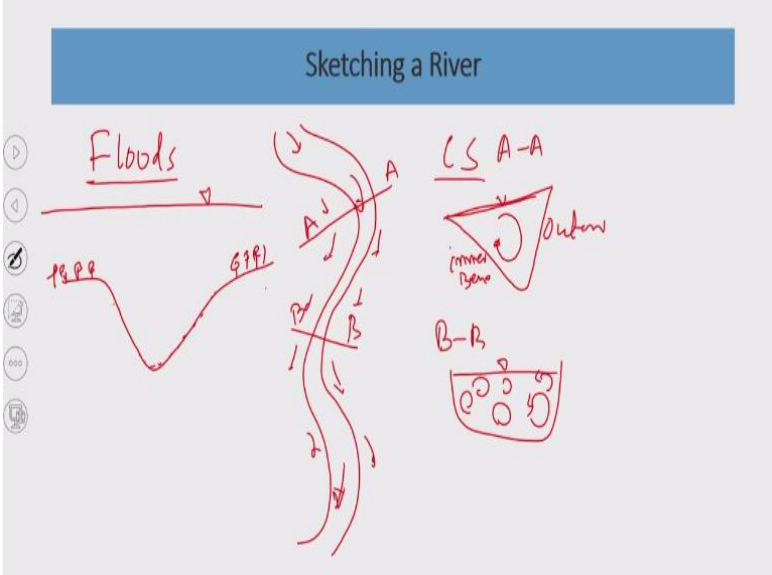

Before leaving for today, I just want to show you that whenever you try to understand the rivers, first try to sketch a river. When you sketch a river, you will have a knowledge about the rivers, just a preliminary sketching is what I am doing. The river if you look at the plan form it never follows straight path.

The concept is that as it never follows a straight path. I take the cross sections at the different points, point A and the point B. The cross sections of A because of centrifugal forces you will have these values. If you look at that you will have a cross section shape like this, so that means you will have, this is the outer bend and this is the inner bend.

And you will have this super elevations, you will have secondary current formations, at section A and to A, same way if you talk about B and B you can have a simple parabolic cross-section shape with having smaller current profiles. So here, at A-A, the centrifugal forces is making a strong secondary currents, the same way at B-B secondary currents will be there here but that strength will be much lesser than A-A.

So, similar way if you always sketch like this, same river if I have the floods, that means the river and the water will be there in floodplain regions. See if I just sketch it, the cross sections will be same way and here, there will be the vegetations in the floodplain area and here if you have a bed materials and you have vegetations here and this is the flood levels.

So if you sketch a river, you can try to understand how the river processes are happening. So, what I am trying to say it whenever you have not understanding the river mechanics, I try to encourage you to sketch a river. If you are sketching a river, then you can try to understand what is happening. You just try to make it a sketching practice as a river engineering specialist, you can do a sketching and can try to understand it how the river process is happening.

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With this, let me conclude today's introduction class by talking these quotations which is given by Mohandas K. Gandhi. The earth provides enough to satisfy every man's need, but not every man's greed. That is the basic understanding we should have for a river management concept. They are Ph.D. students who are helping for preparing these course materials and I would thank you for them to be part of this, but with this let me conclude this lecture. Thank you.