Coastal Engineering.
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Module - 2
Sediment Characteristics and Longshore Sediment Transport
Lecture - 7
Longshore Sediment Transport (Problems-1)

We have earlier seen, the problems related to using the energy flux method for determining the sediment transport rate. What I have done here is, you think both the energy flux method, and the leo observation method, and kind of making a comparison. It is not exactly a comparison, may be both simultaneously for a given particular coast on the assumption that the measured velocity and the leo method is available. So, you assume that, and then try to evaluate both the methods. So that is what I have tried to do.

And also, I want to that just highlight the importance of considering the angles, angle of the, I mean the wave direction as well as the orientation of the course. This is very important, and this is where many of the students they make a mistake. And, they land up and once they make a mistake in this direction, you see that the p l s parameter is directly a function of breaking angle. Are you understand? Once you make a mistake, which is very common in assigning the direction of the wave, with respect to the shore normal. If you make any mistake in that, then you are in for trouble, because the estimate can be either an over estimate too much of overestimate or too much of under estimate. So, that is why in order to demonstrate that, I am just, I have taken this problem.

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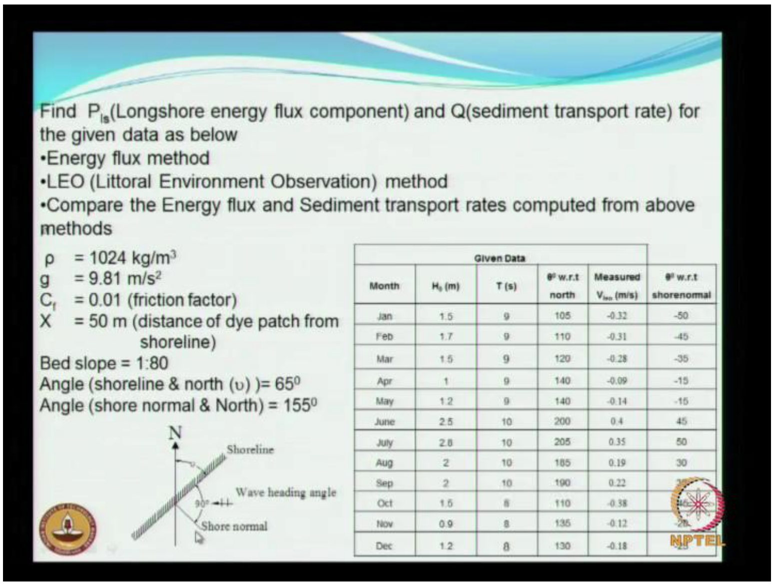

So, all this parameters are given to you. So, for example, deep water wave height is available monthly, monthly mean wave height. Let us take monthly mean wave. But, if you have everyday wave height, then everyday you can calculate the wave height and then take its average. Now, what we have assumed here is, the data is h naught that is deep water wave height is given, the wave period is given, the theta north, with respect to geographic north is also indicated there. And, in addition the measured velocity under the leo observation. That is, you have the di patch movement of the di patch. Please recollect what we have seen under the leo observation method, describing the leo method of, the littoral environment observation method for getting the, for deriving the p l s parameter from measurements.

Now, another assumption that these values are already available for particular course, and then these are indicated may be monthly average or monthly average or maybe it is a representative measurement for a particular month. Very often, it becomes very difficult to continuously measure all this parameters. So, they we very often they consider within fifteen days in a month or may be for ten days within a month, they take the average and then, they say this would, this could be the probable range or probable value of mean value of your leo velocity. That is the moment of di patch again. So, here, the sea bed slope is also given here. Now, the angle between the shore line and the geographic north, so this is the angle, and this is your geographic north, and this is your shore normal.

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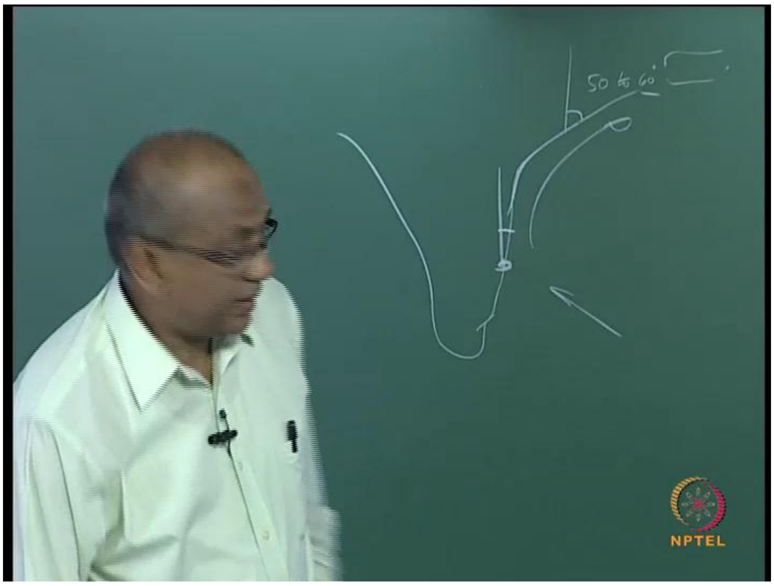

For example, if you look at the Indian coast. So, Indian coast is something like this and then it goes like this. So, you see, always you have the cyclone and then the cyclone gets and this is where you are having the Bay of Bengal. So, something likes this. So, you see that this around Chennai, the here the angle is approximately say 16 degrees to 20 degrees. But, when you go somewhere, further north may be Orissa etcetera, so Orissa, Vishakhapatnam, etcetera, this may be around 50 to 60 degrees. So, this angle has to be considered, and when we have the wave direction, wave direction is always with respect to geographic north.

So, you see that, here x is the distance of the di patch from the shore line, that also indicates given here, 50 meters. So, bed slope is given. The angle between the shore line and geographic north is 65 degrees. The angle between the shore normal, this is the shore normal, and the geographic north will be this much, that is 155. So, when you want to have the wave direction with respect to shore normal, then you consider this angle. This will be 180 minus 155. Is that clear? So, this is what you have to get depending on the angle indicated here, you have to derive the angle with respect to shore normal. So, that is the basic requirement in order to evaluate the sediment transport rate.

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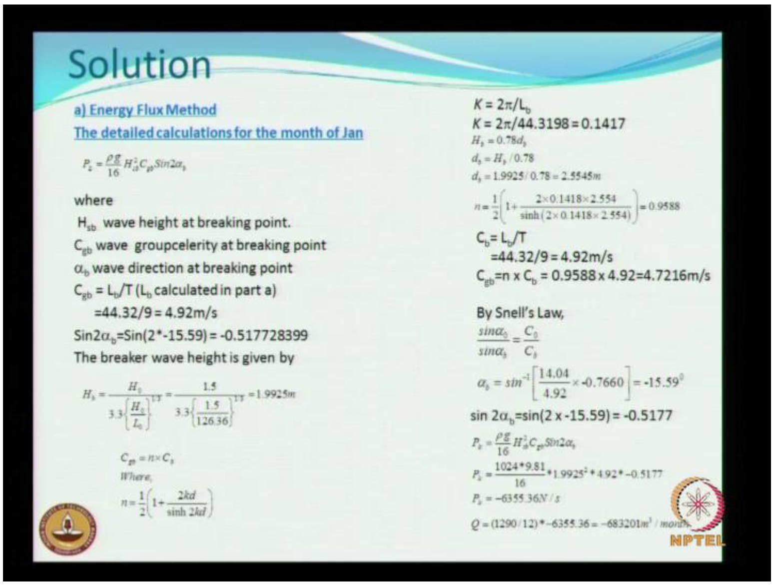

Now, energy flux method it is all, I mean, I have coincide the whole thing in one slide in order to have everything there, because already this problem has been explained to some extent, we are just looking into; we are having a course to the same kind of a problem. So, you have the p l s parameter. So, h s b is the wave height at the breaker height, then g g that is the wave group celerity at the breaking, the breakup point alpha b. All this things you must know. So, you can calculate your l b by t calculated in part a, earlier also we have seen this. You know how to calculate this. Because once the breaker height is known, please have a look at the details. Then the breaker angle is also can be calculated. So, breaker angle, you have to assign whether coming from right as negative are coming from left as negative, when you all standing on the shore. So, this is a conversion, this is the kind of co-ordinate axis you should have in mind, before you start doing it. So, you the angle has to be, the direction has to be consistent.

So, usually, normally drift they consider it as positive, southerly drifts, they consider it as negative. But, it is not hard at fascar rule. You can have but, be consistent. So, all so the breaker depth etcetera, so the breaker height is calculated here as given here. So, what you have is, the h not, given is h not. This is only sample calculation which is given here. So, then, you can calculate all this things. So, for each of the method we can calculate. So, this is for the month of January, and then this is for, this is the alpha b for the month of January which is worked out here. So, for the month of January, using all these variables, you can calculate your p l s parameter and then, because, we are dealing with

January month, the actual, I mean the quantity of sediment transport is 1290 into p l s that is for the sediment transport rate per year.

Look at the formula again. But, since we are dealing with the monthly transport, that has to be divided by twelve, that is why you have this twelve, all other parameters, variables etcetera you use the snell's law, and you use the breaker formula. I mean to determine the breaker height. You have a variety of formulas. You can use any of those formulas, depending on the kind of variables you have. Similar to what you have for p l s parameter, the p l s parameter depending on the kind of input data you have, you choose the corresponding formula. Similarly, here also you can use the corresponding formula. Look at the chapter on or the topic on wave deformation for the detail, different methods for estimating the breaker height.

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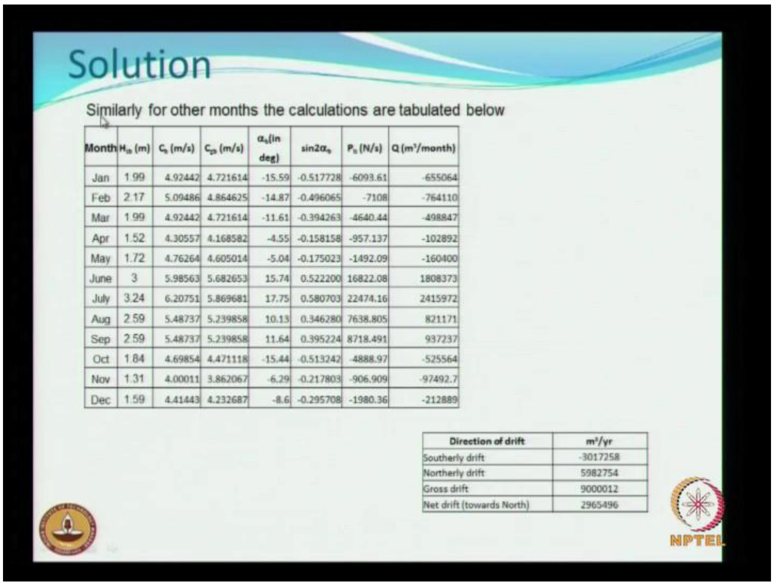

Month	H_{sb} (m)	C_b (m/s)	C_{gb} (m/s)	α_b(in deg)	$\sin 2\alpha_b$	P_{ls} (N/s)	Q (m^3/month)
Jan	1.99	4.92442	4.721614	-15.59	-0.517728	-6093.61	-655064
Feb	2.17	5.09486	4.864625	-14.87	-0.496065	-7108	-764110
Mar	1.99	4.92442	4.721614	-11.61	-0.394263	-4640.44	-498847
Apr	1.52	4.30557	4.168582	-4.55	-0.158158	-957.137	-102892
May	1.72	4.76264	4.605014	-5.04	-0.175023	-1492.09	-160400
June	3	5.98563	5.682653	15.74	0.522200	16822.08	1808373
July	3.24	6.20751	5.869681	17.75	0.580703	22474.16	2415972
Aug	2.59	5.48737	5.239858	10.13	0.346280	7638.805	821171
Sep	2.59	5.48737	5.239858	11.64	0.395224	8718.491	937237
Oct	1.84	4.69854	4.471118	-15.44	-0.513242	-4888.97	-525564
Nov	1.31	4.00011	3.862067	-6.29	-0.217803	-906.909	-97492.7
Dec	1.59	4.41443	4.232687	-8.6	-0.295708	-1980.36	-212889

Direction of drift	m^3/yr
Southerly drift	-3017258
Northerly drift	5982754
Gross drift	9000012
Net drift (towards North)	2965496

So, here you see that, you have similarly, if you can work out for the different months. This is what you will have, as indicated here. So, for every month you calculate and then you get the, so first for what the procedures are? Find out the h s b or the h b, then the celerity at the breaker point, so everything at the breaker point, because that is where the house sediment transport is getting initiated. And then, your alpha b which controls the again the direction of the sediment transport and then that is being reflected here. So, then you calculate your p l s parameter monthly sediment transport. And then, you from which you can calculate your sediment transport as indicated here. So, you add all negative, the ones the magnitudes with the negative sign, so that is going to give you the southerly transport.

And northerly transport here we have assumed that northerly transport is positive, so you add up the all the positive values then you will get the northerly transport. So, the gross sediment is just add it, add the broth without the sign, the absolute addition of absolute value of both the magnitudes will give the gross sediment transport, and the net transport is with this direction. So, this clearly indicates that it is a northerly drift. So, along the east coast of India is usually northern, it is the net drift is northerly direction. So, this is a classical example which we have worked out. This is the second example have I am working out because, very often we have students facing difficulty in evaluating the sediment transport rate.

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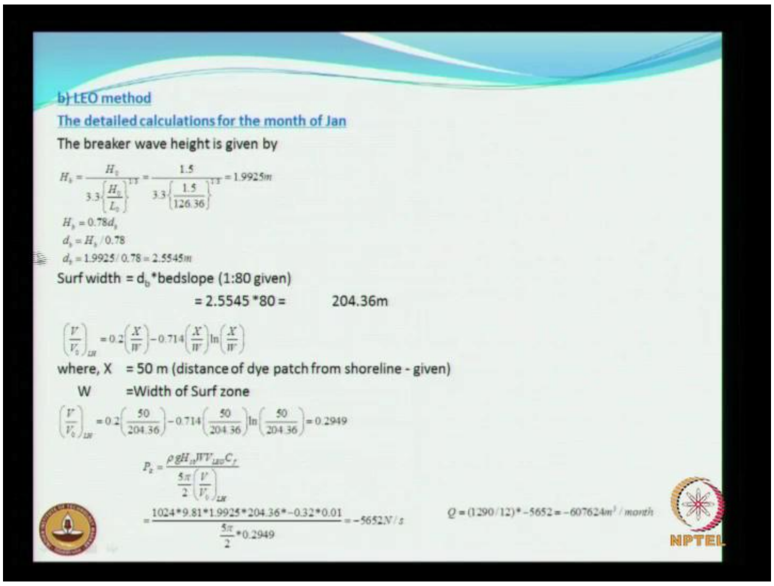

Now, by the leo observations the same you have to calculate the breaker wave height as clearly indicated here using this formula. And once you calculate the breaker wave height, you know that the breaker depth can be easily obtained using the relationship of h b is equal to point 7 8 times the quarter depth. And then, once because here the beach slope is also given, so 1 is to 8 is the input. So, once you know that you can get the surf width parameter. So surf width is approximately 200 meters here. So the surf width is likely to change every month.

Because, the monthly characteristics wave characteristics is going to change, because the depth at which wave is going to break is going to change. And, more or less within a month also it can change. Why within a day also it can change. But, what we are referring to an average estimate. Even within a day it is also an average estimate what you are going to have. So, the surf width is already known, and then w is the width of the surf zone, and x is already given to you as 50 meters, and then use v leo is also given to you in the data. So, you have to obtain this parameter, and this parameter, this is the surf width, and this is the surf width, and 50 is the distance of the di patch.

Using this equation, you will get the value of value of about point 3, and then substituting the po for the p l s parameter. All this variables are already given to you or already have or already been discussed. Then substitute only all those values, and then you will get the cue as shown here and this typically for a month of January.

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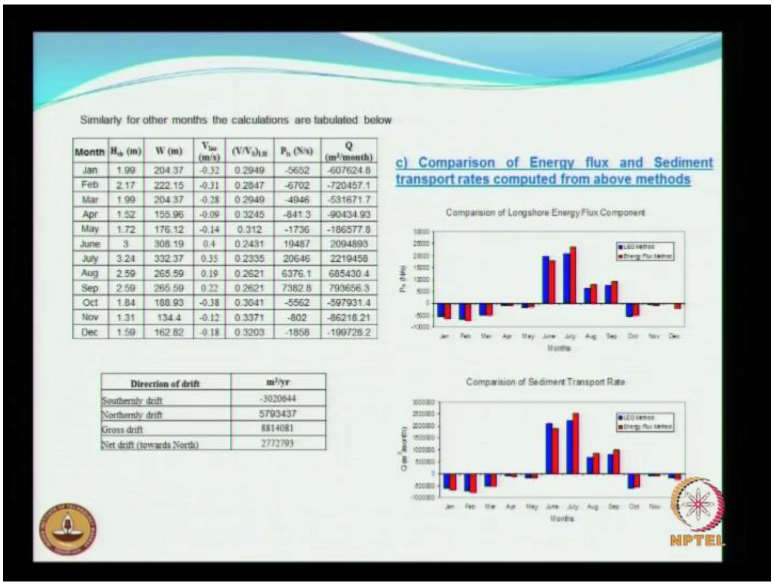

You repeat the calculations as I have stated here. And so, you will get the distribution of the monthly distribution of the sediment transport, and then also the corresponding northerly drift and the southerly drift, the net drift as well as the gross drift. So, as similar to what we have done in the earlier problem, so this problem shows you or demonstrates to you how we can use both the methods for obtaining the. So, the top figure or top figures shows the variations of p l s parameter, just by multiplying by a constant, you are going to get the sediment transport which is shown in the bottom figure. So, as stated earlier, it is not, the purpose is not to compare. But, if you want you can still do that comparison.

So, here I have just simply assumed a value of 50, for the surf width, for the distance from the di patch. I have assumed also the v leo is also assumed .We have not done any measurements. But, suppose in case you are involved in such kind of a measurement and then the measuring exercise has to be sort of compared with some available method, and that is what has been demonstrated with the help of this problem. Is that clear? I think with this I would like to suggest that the sum of these books have been measured, I have been referred and there are semis many other books.

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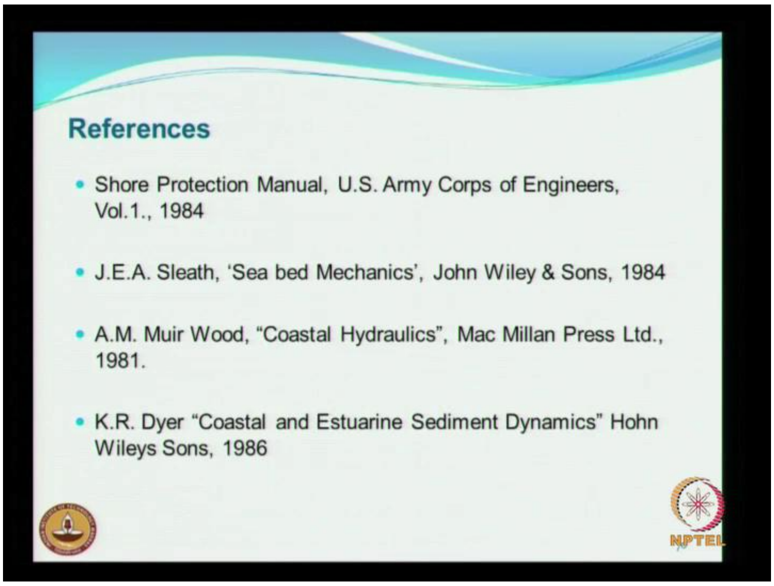

Now, show production manual is the coastal engineering manual, which gives a lot of information and there are few things, which I have not covered in this lecture, particularly when you this is this lecture has given you that if you have given you the information on wave height, wave period, and direction how to evaluate the sediment transportation. Is that very clear?

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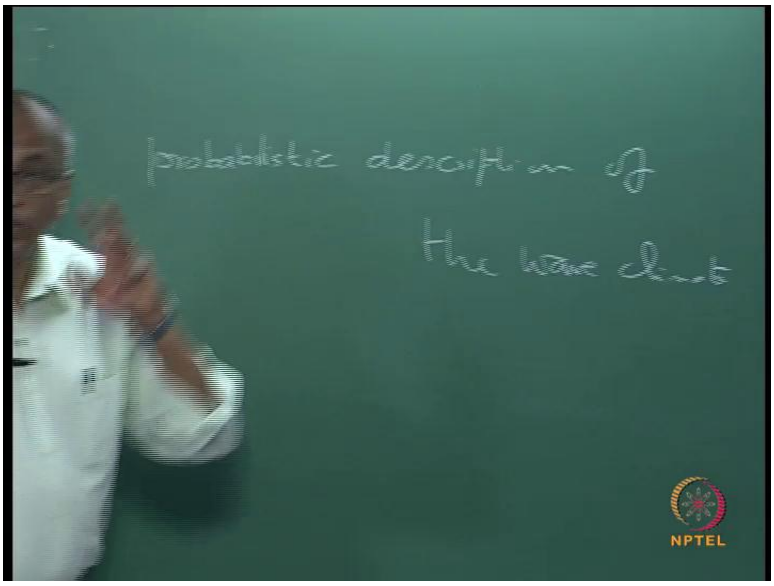

But, when we are dealing with the practical problem, so for example, you want to do it for a coast, first may be some course, may be along the east coast of India. Then you have to take the percentage of, so I have already explained the wave rose diagram right? Wave rose diagram we have already seen so, which gives nothing but, the percentage of occurrence of wave height with a particular direction. What is a percentage of wave height of this much range coming from this direction, coming from this direction, coming from this direction. That is nothing but, the probabilistic description of the wave climate. When you look at the probabilistic description of the wave climate which is usually available for offshore locations, sometime may be for boats etcetera, you might have some information at the breaker zone. They would refer to wave data for the port and they would normally call it as visually observed wave data. As I said earlier, this has to be treated as h s b, straight away h s b.

Suppose, if you do not have that kind of data, the other source of data is only the deported data, and this deported data can be from whether charts of the wind data derived from wind. Or it can be visually observed data through ships, ship observed usually observed data. Whatever may be their source of data, if you want to make use of that data, then finally, it boils down to the brio the way you get the data will be in the form of wave rose diagrams. Or in the term of in case, if it is, in the term in the way of wave rose diagrams. This is the way you need to represent your sediment transport rate.

You understand? So, what is a percentage of occurrences of wave direction with this with a particular wave height?

Then, that is going to induce certain percentage of occurrence of sediment transport of a certain magnitude and direction. So, if the wave is in this direction naturally the northerly drift is going to take place, for example, in the month of January. And what is its percentage? No, so, the percentage of occurrence has not been covered in this lecture. But, I suggest you refer to one of this particularly the show protection manual or the coastal engineering manual, to have a better idea about how to deal with percentage. Because, that is going to be also of relevant maximum use for, if you want to design, if you want to plan for any coastal structure for which information on the littoral drift is needed.

So now, what will do is, we will get into another topic which is quite relevant, which is actually the driving force. So, we all know that the sediment transport is distributed within the surf zone. How it is distributed, do we need this information or not? Suppose if you are interested in finding out, for example, if you want to put a kind of a structure normal to the shore, littoral barrier like a groin for example.

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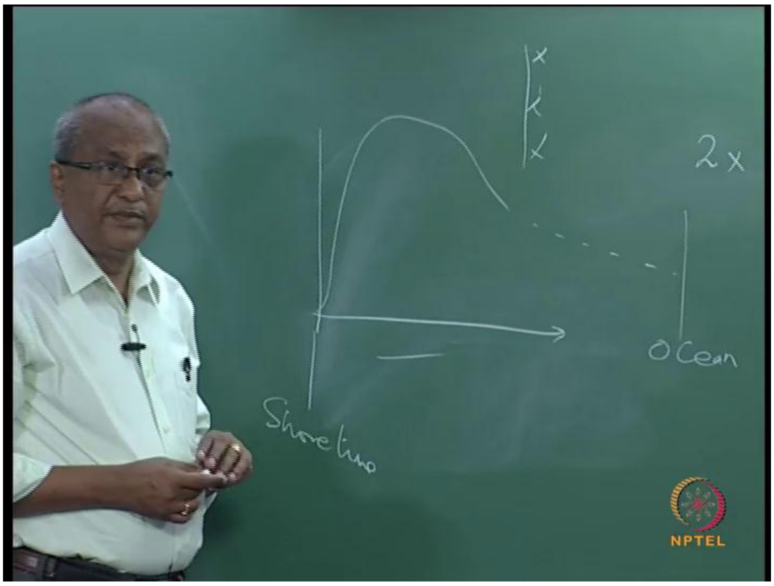

Then this information on how the distribution looks like. So, this is the shore line, and this is towards the ocean. So, the distribution would be something like this. You understand? So, this may be a breaker zone. And although, we have said that, the new shore currents like in particular the cross shore currents and the littoral currents and in the long shore currents are generated due to the waves breaking. Since it is breaking, you have these two currents. Not only that and it exists mostly in the surf zone. It has been proved that, it they are wave induced. They are wave induced, because basically they are generated because of wave breaking. So, when once the waves are breaking this is the shore Line, once the waves are breaking then you expects that the sediment transport will be only within this region? Am I right?

But, there can be sediment transport even beyond the surf width. There can be sediment distribution even beyond the surf width, so that is a maximum of twice the surf width, you can still that is beyond the twice the surf width, you normally do not expect the sand to be moving, due to wave induced currents. So, and also when you want to dredge certain area, the distribution becomes quite important.

Now, there has been a lot of work that has been done in this area. And I will cover only the salient information, and I may not go into the complete theoretical background because I would leave that to the students who are more interested. So, again refer to the coastal engineering manual which is which I can say is the reference book for all information dealing with coastal engineering. So, wave induce long shore currents at the mid surf zone. That is, you, I have said the surf zone, within the surf zone, you have the mid surf zone.

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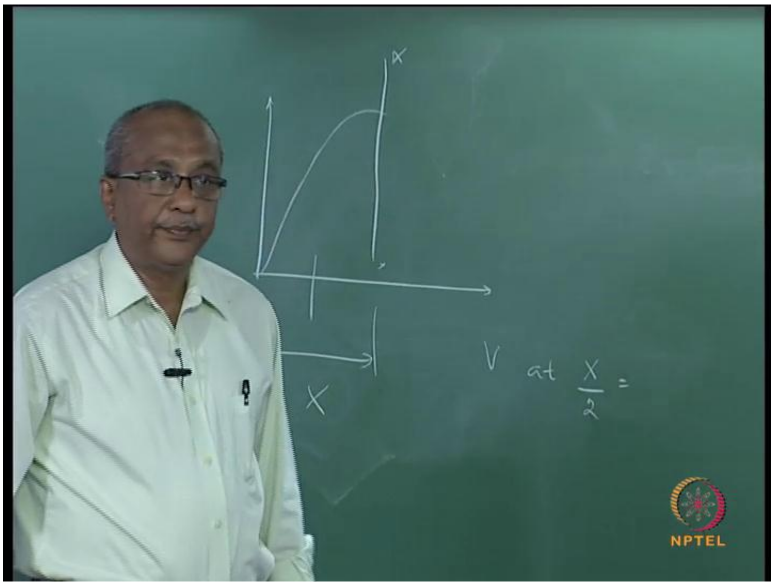

So again, I will draw the same figure, so you will have assumed that this is the kind of current. And, so somewhere, the, this is the breaker zone for example, so mid surf zone is within the, this is the surf zone. So, v is at x by 2.

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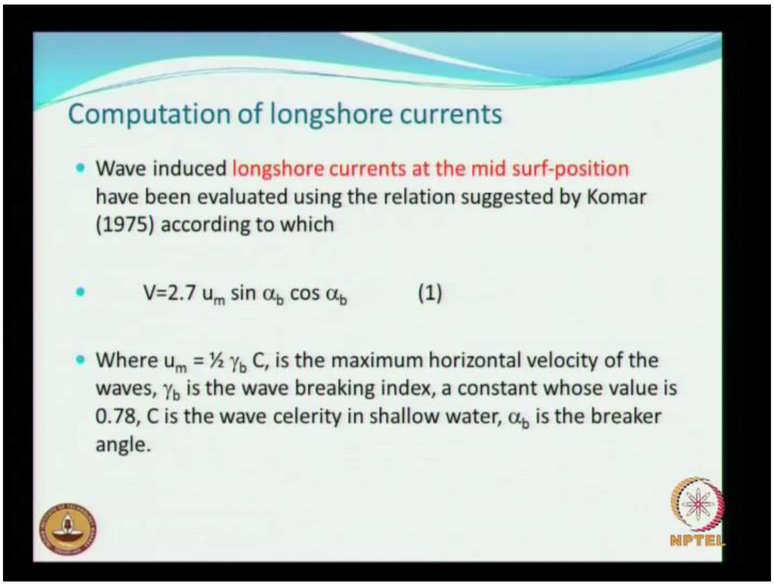

So mid surf velocity is given by, as per suggested by Komar 1975. You go to the net, and type Komar you will get all his articles, all those articles which are very very interesting. So, this is given by 2 point 7 into u max sign alpha into cos alpha b. And here, u max is nothing but, half into comma b into celerity, because it is in the shallow water. So, you can and gamma b is nothing but, is a constant value of about point 7 8. That is nothing but the breaker index, which we have already seen.

So and C is the wave celerity in the shallow water, alpha b is the breaker angle. So, you want to calculate the mid surf velocity, the formula is there, is quite straight forward to. So, the only thing you need to calculate is the breaker angle from the deep water wave angle using Snell's law. That is the only thing, once you calculate that, then it is just having a calculator to calculate the velocity at the mid surf zone.

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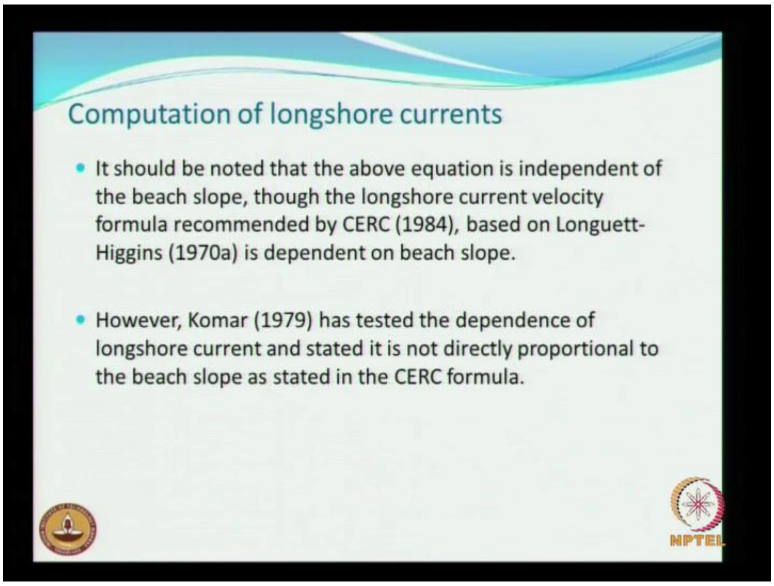

So, computation of long shore currents it should be noted that the above equation is independent of the beach slope. So, you look at this beach slope, does not come into the picture at all, although beach slope is not coming directly here, but, based on beach slope only, your breaker depth also is taking taken care. Actually this point 7 8 times water depth is an empirical relationship. You go back and look at the, have a look at the topic on wave deformation on breaking, wherein one particular formula is by dean and dal rimple, which is illustrated in dean and dal rimple book, where in we consider the beach slope as well as the wave direction. When you use that formula, in order to get the breaker index, you will see that it is going to be differing by about a point. It may be around point 8 instead of point 7 8. There may not be much huge difference.

Though, the long shores are here, it should be noted that the above equation is independent of the beach slope, though the long shore current formula recommended by c e r c based on Longuett-Higgins is dependent on the beach slope. So, komar has tested the dependence of the long shore current, and it was stated that it is not directly proportional to the beach slope as stated in the c e r c formula. These are the some of the running commentary which you should have in mind. So, if you are really interested in this topic further you have to go into the details. And, there are a variety of other formulas, or other long shore currents or the velocity definition as given here.

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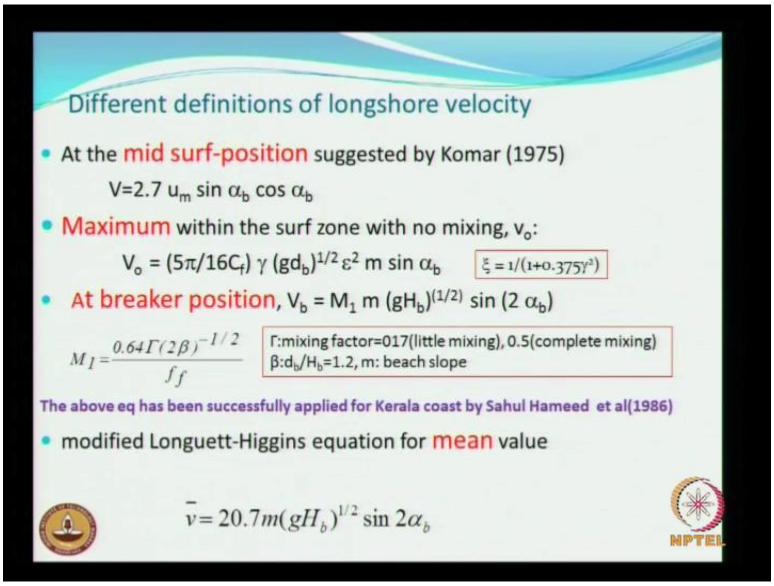

What is happening within the surf zone? Within the surf zone, you can have mid surf velocity which we have just now seen as suggested by komar, the maximum velocity, long shore current velocity, within the surf zone, with no mixing, with no mixing. I will come back to that mixing later. Here you look at this parameter c f is friction coefficient; we will be using all this formulas to calculate the velocities for a typical data at the end. So, those things will be quite clear. So, I suggest after the lecture, you just go through the presentation, so I am sure that it should be clear. And in case you have still any doubts, you please come back to me or refer to coastal engineering manual or the shore protection manual for details.

So, d b is given, and then this epsilon here indicates that is, this something like a correction factor .this this includes the friction the breaker index as shown here, and all other parameters are already known to you. So, this is the maximum current velocity within the surf zone. The other formula is the velocity for at the breaker position. So, at the breaker position, you see that, you have an m 1 then, the m is the beach slope, and the other parameters are given. Only m, and is indicated here as shown here. This is kind of a friction factor, and then you have a mixing little mixing, complete mixing. See, little mixing or complete mixing is something like you have a when the waves are breaking; you have a lot of turning action going on. You will have a very good mixing or you may not have.

So, this basically depends on the sand particles size, at that particular location plus the beach slope, as well as the wave characteristic. Why beach slope and wave characteristics have come into picture? Because mixing also depends on the type of wave breakers .Type, if it is spilling, you may not have much of a if you have spilling type of breakers, you cannot expect much of mixing.

But it is going to be plunging. You see, that there’s a lot of turbulence that is going to occur at the breaker zone. And then when you have lot of turbulence taking place, then you have very good mixing. So but, breakers a type of breakers basically depend on what? Tan beta divided by wave steepness, recollects my lecture on wave breakers types of wave breakers. So, tan beta is basically beach slope and then the square root of h not by l not. That is di pot wave steepness or wave steepness of the breaker zone. So, this depends on, so this will take care, this will depend on the side conditions, whether you have mixing or no not much of mixing. So, you can either use this is point 1 7, this is point 1 7 and this is point 5, you can use depending on the on the kind site conditions.

This above equation has been applied successfully for the Kerala coast by the Sahul Hameed et al in 86. And there are a number of studies reported using some of these formulas for determining the current velocities along Chennai coast, Paradeep cort coast, Visakhapatnam coast, most of the coast along the along India. So, you have lot of literature available for such studies. So, then within the surf zone, you have also the mean velocity, that is given by, as v bar and so also given by Longuett-Higgins and this is given here.

Now, you see there are four different types of formula and four different kinds of velocities used for describing the long shore current velocities within the surf zone. One is mid surf zone mid surf velocity, the next is the maximum velocity, so it is at the breaker location at the breaker point and finally, you have the mean velocity. So, please remember, although, you have so many formulas, I would ask you can use any of this formula for either it might be difficult for you to remember all these formulas. So, we will decide whether you will be allowed to bring some of these formulas for your examination or otherwise. We will take a decision later. But, what is more important is, not just the formulas you should understand, when it is breaker velocity you should know where the breaker velocity is taking place. So, the application of formula is much more important than the formula itself. Are there any doubts?

Now, we will look into the distribution of long Shore currents and sediment transport rates across the surf zone. This involves a number of formulae. I do not want you students to remember all these formulas, but, certainly you need to know how all these formulas can be adapted for a given site for given data values. So, there is some theoretical background for the distribution of the long shore currents, within the surf zone has been obtained from the solution of komar.

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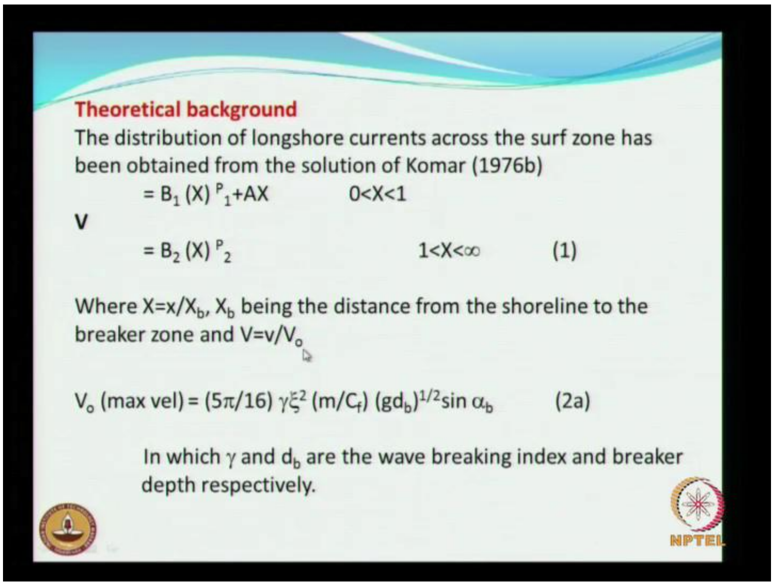

There are number of articles by komar, number of publications. So, if you are again interested, you can download all this you can almost of this publication are available in the net. So, if you are interested you can download, and read it by yourself. So, there are we will be dealing with a number of constants. And, how are these constants evaluated.

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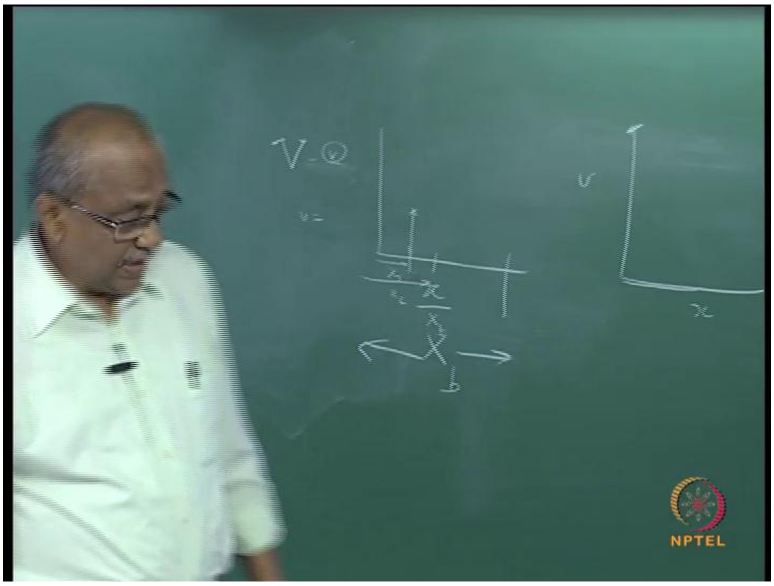

These constants are functions of a number of parameters within that represents the neo shore environment. So the first one is, v by capital V, capital V is v small divided by v not. That V is the velocity at any location. So, suppose if this is x, which is the surf width. So, let me call this as x b. Now, this is now capital v is equal to small v divided by v not. That is what is indicated. What it means is, it is nothing but, this x b now this on the x axis it is x divided by x b. x b is the surf width. You know this value, before you get started with distribution of the current velocity. So, x b is fixed for a particular month say, of for a particular day. So, surf width is fixed and I get x at the every location. So, this will be x 1, somewhere here will be x 2, etcetera up to x n. For each of these x values, I will have the velocity that is calculated. This velocity I have to calculate. Is that clear?

But, this is already calculated which is going to be a constant, that is nothing but, here v not which is the maximum velocity. What we are trying to do is, instead of simply presenting v by small x, we are just dimensionalising it with maximum velocity and the surf width. If you want you can also dimensionalise it with instead of this one you can also present the other way divided by b b. No, that is if you want to present. But, this formula is valid for this kind of representation. Is that clear? So, this maximum velocity the parameters involved in maximum velocity is already been explained to you.

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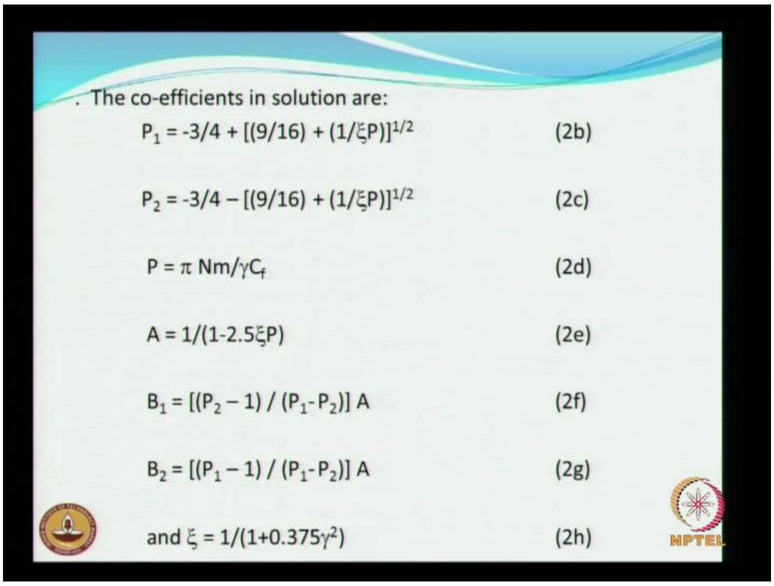

So now, you look at the values, I mean the variables.

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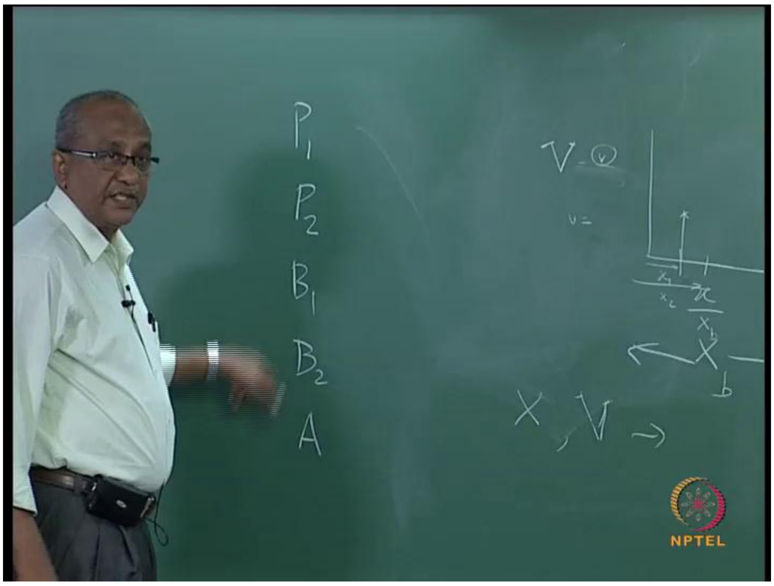

We have variables p 1 p 2 b 1 b 2. And then, we also have A. But, the capital x and capital v is going to be varying. x is going to be varying, and you are going to compute capital v. Once you do that, you are getting the distribution. Is that clear? Now, all these parameters need to be calculated these constants. How do you calculate all these constants? That is what is given here. So, all the formulas are given here, wherein pi p is equal to pi into this one, this is beach slope, and the break current, this is co-efficient and this is something to do with mixing which we will be looking into in detail later, and all other things are known. And once you calculate your p then you can calculate p 1 p 2.

The main thing you need to calculate immediately is, the first step is to calculate capital p. Capital p is the one which connects your beach slope and the breaker index. Once you calculate this, see this is not very tedious; the only thing is you have to use the formulas carefully. Once this is done, then use this to calculate p 1 and p 2. Now, once you calculate this, the next thing would be to calculate epsilon. Is that clear? Once you calculate p and epsilon, you can calculate all other parameters, because p 1 is straight away got here p 2 and a b 1 is, once you calculate p 1 and p 2, then you and as well as a you can calculate b 1 and b 2.

Once that is done, you can substitute in the equation to get here capital v and capital v not capital v, that is v by v not, and that is the area within the surf zone. And this is one slightly beyond the surf zone. Beyond the surf zone, if you use this you will see that the beyond the surf zone, the value will keep on decreasing. So, how does it vary we will see.

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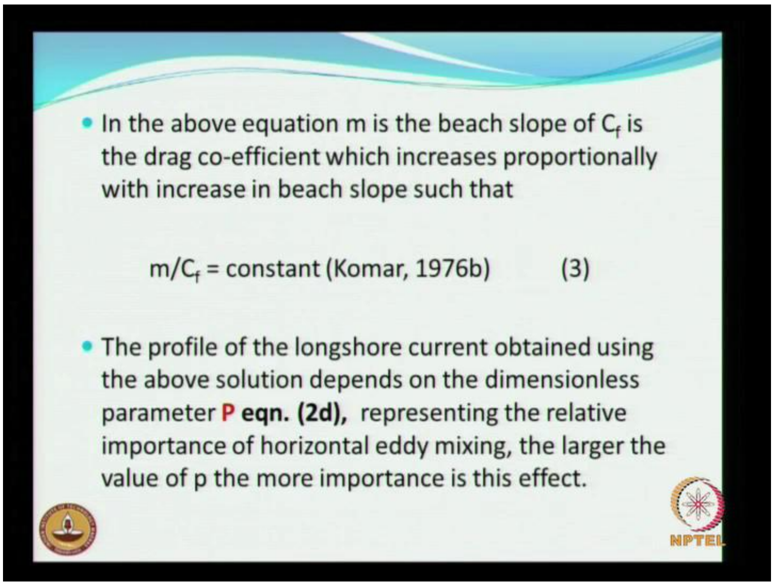

So, I am coming to that. So, in the above equation, I will explain when I am dealing with the problem. So, in the above equation m is the beach slope, and c f is the drag co-efficient, which increases proportionally with an increase in the beach slope. So, but, Komar has stated that, beach slope the ratio of the beach slope to the friction coefficient is a constant. So, I will not go into the details of these things the profile of the long shore current obtained using the above solutions, depends on the dimensional parameters capital p that is this one. That is, in equation representing the relative importance of horizontal eddy mixing and the larger the value of p, more important is its affect.

So now, so here, this is the beach slope and this the friction factor. So, the p is going to control the kind of sediment transport distribution that is likely to take place within the surf zone. That is it is in some way or other controlling the accent of mixing. That is supposed to take place within the surf zone. So I suggest, if you are interested you can just look at some of the parameter study if you want do some kind of parametric study you can still do that. the coefficient n in the expression for p, that is what you were asking just now, is a numerical constant varying between 0 to point 0 1 6.

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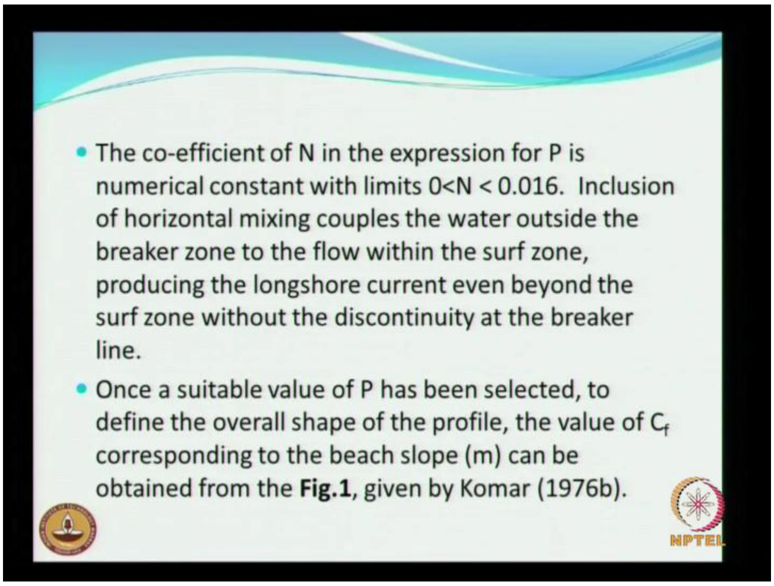

Inclusion of horizontal mixing couples the water outside the breaker zone to the flow within the surf zone, producing long shore current even beyond the surf zone without discontinuity at the breaker line. This is what I explained the just now in the beginning. That is although the currents long shore currents are thought to be due to the ways breaking, only when the waves break at the breaker zone, you have and also the oblique angle attack. Oblique, I mean oblique wave angle attack, oblique waves. Only if the waves are approaching with an angle to the shore normal, you will have the long shore current velocity which we have already seen.

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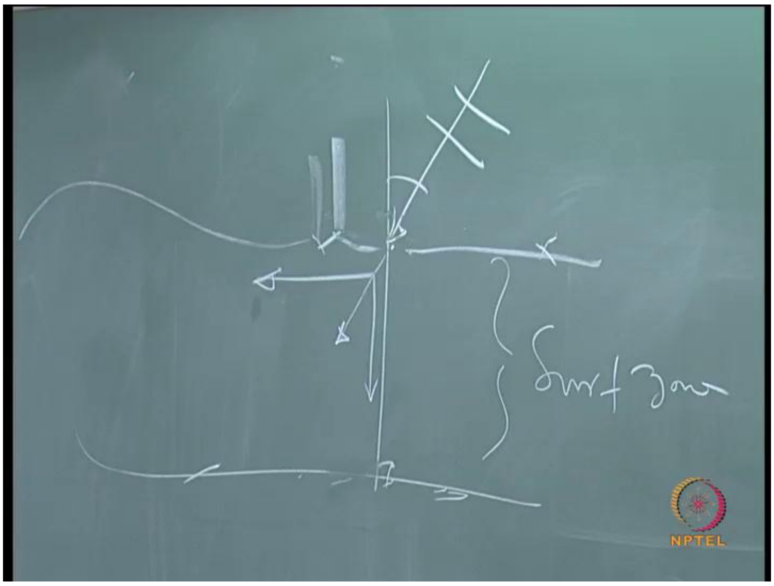

So, you need to have, so you have the shore line, you have the, so the waves will be coming in this direction. This is the shore normal, so this is the angle, only when it is breaking somewhere here, you will have a component. The component of this is, in this direction and you will have another component in this direction. And this component is called as the long shore current velocity which we have already seen. So, we will be under the impression that the long shore current velocity is concentrated only within the surf zone. That is not exactly true. You also can have the current velocity slightly outside the surf zone. And, that is what it explains.

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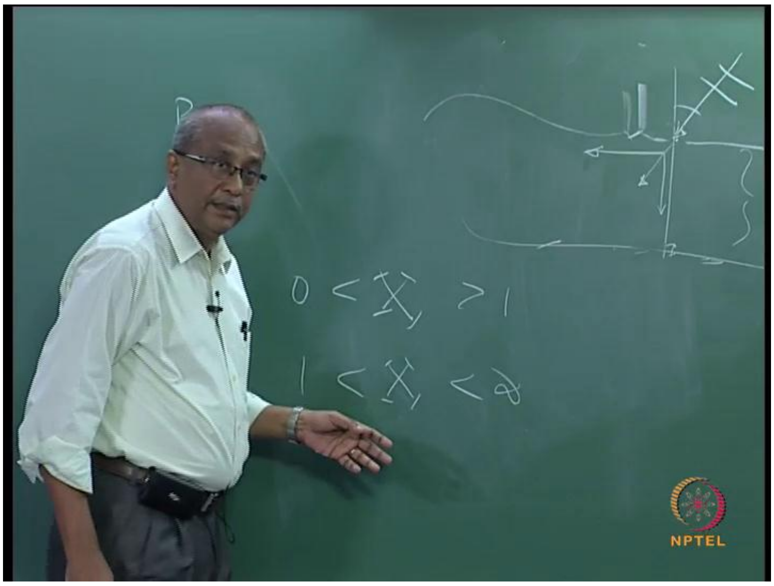

And now, when you look at the distribution the formula for the distribution long shore current velocity, you saw that there was one, this extends up to this up to 1 and 0, you had one formula and from 1 to infinity. So, if it is greater than 1, you will see that the long shore current velocity will reduce drastically, but there will still be some amount of long shore current velocity, the magnitude will be there. Once the suitable value of p has been selected to define the overall shape of the profile that is the beach profile, because p basically takes care of the beach profile you understand.

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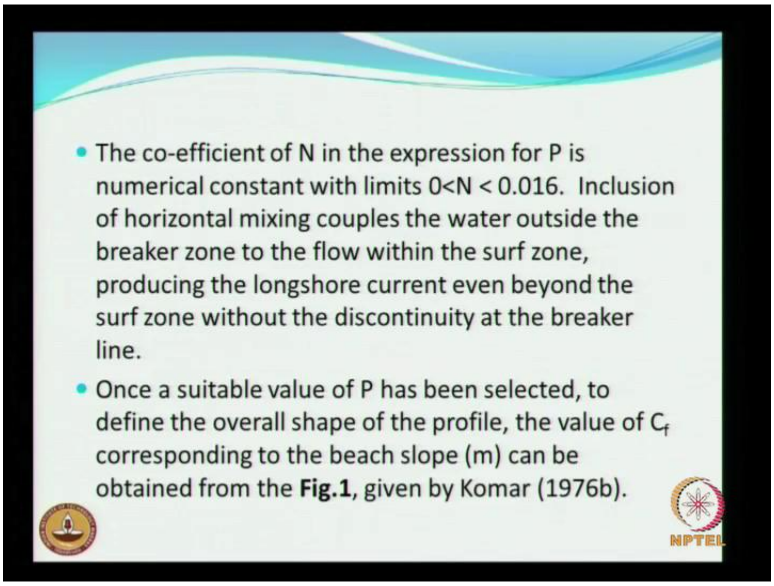

So once you select the overall shape of the profile the value of c f corresponding to the beach slope can be obtained, so this I would suggest.

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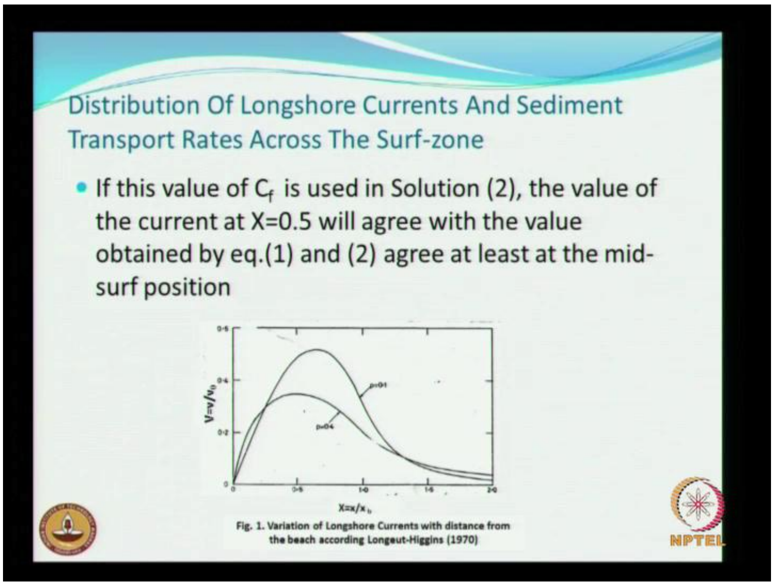

You refer to this information, some of this information is available, I am not going to go into the details of this. So, I will stop here, and then proceed with other things. Are there any doubts till now? So, I think I will stop here. So, that next class, we will just again look at the other aspects. And also, we will work out a problem on the long shore current velocity distribution, and with that we will move on to other chapters.