Coastal Engineering
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Module - 2
Sediment Characteristics and Longshore Sediment Transport
Lecture - 8
Longshore Sediment Transport (Problems – II)

We will continue with what we have seen in the last class. So, once a suitable value of value for p is selected then that is to define the overall shape of the profile, the value of a the friction co efficient corresponding to the beach slope can easily be obtained.

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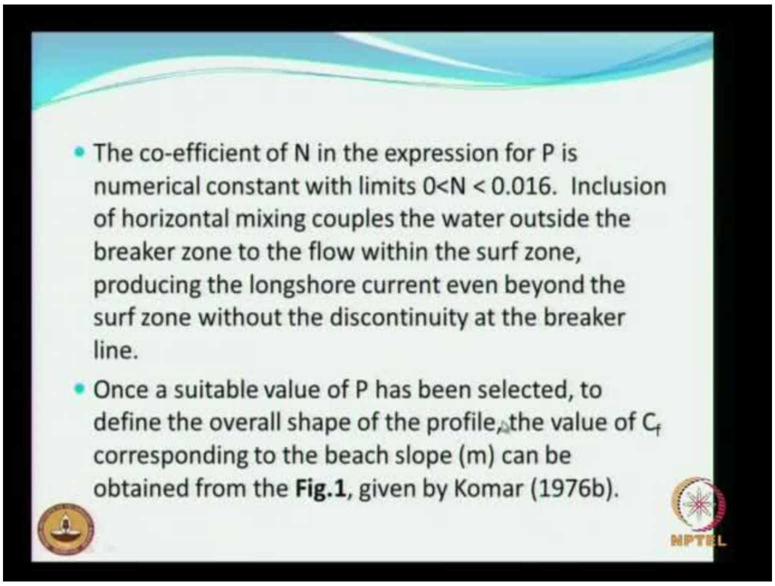

There are several ways of getting this done so you have to again go into the manual costal engineering manual or the show protection manual to look into these aspects, so this is the figure which shows the variation of the long shore currents, that is the, a dimension less long long shore currents as a function of the dimension less distance between the from the shore towards the sea.

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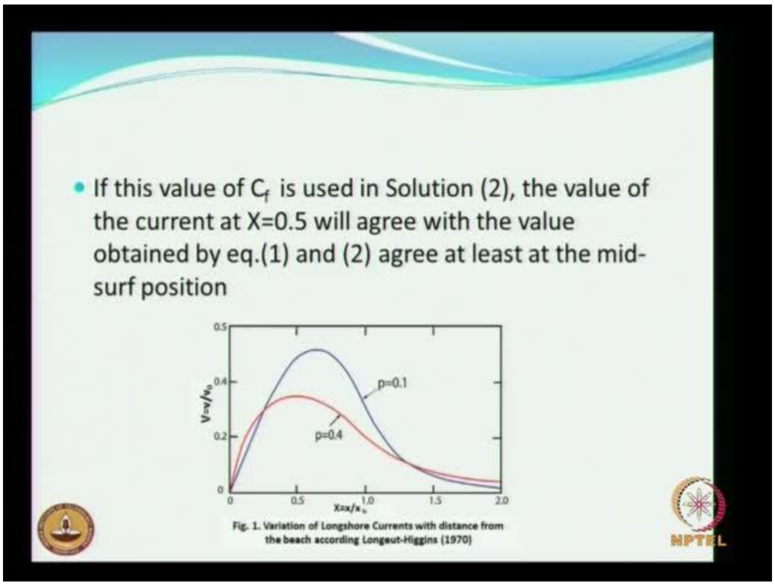

So, you see that there are two values for the capital P, one is 1.1 and the other 1.4 and here you will see when you look at this picture, the if the value of co-efficient that is the friction co-efficient that has been used in the solution to equation two.

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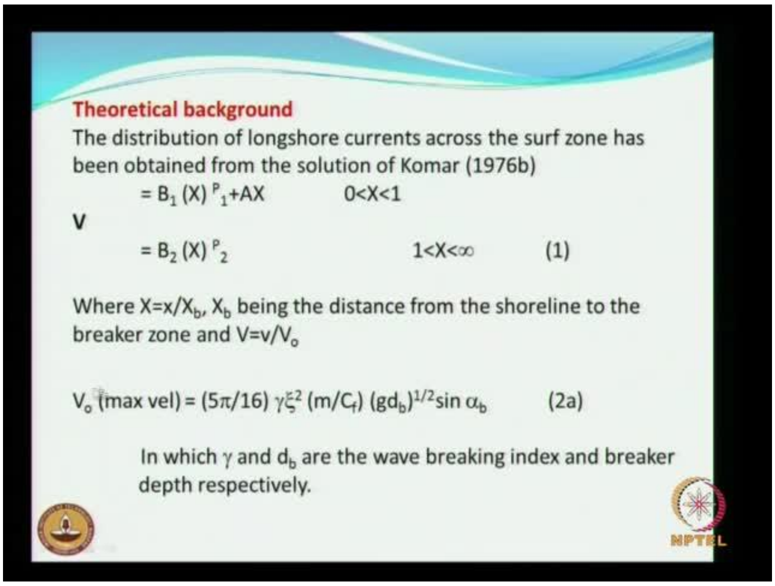

This is the maximum velocity equation two if. So, the the value of the current at x equal to that is what x equal to 0.5 will agree with the value obtained by equation one and two, at least at the mid surf zone. We will come back to the mean velocity maximum velocity etcetera later with

with the help of few more slides I will again explain this later. Now, earlier what we had for a single wave what did we do for a single wave we calculated the PLS parameter and then the PLS parameter is nothing but the driving force, then we sort of equated it to the immerse immerse weight of the sand, remember? IL, PLSIL, etcetera. Please recollect or go through the lectures again or the lecture material.

So, the same way only we are going to do for this, so what we do is, so those are for a representative wave height which may be either the h r m s or the h s or just the the monochromatic wave of wave height. So, the other way of doing this calculation of the sediment transport, once you know that the sand transport is within the surf ground, so we can integrate this whole thing to get the total sediment transport.

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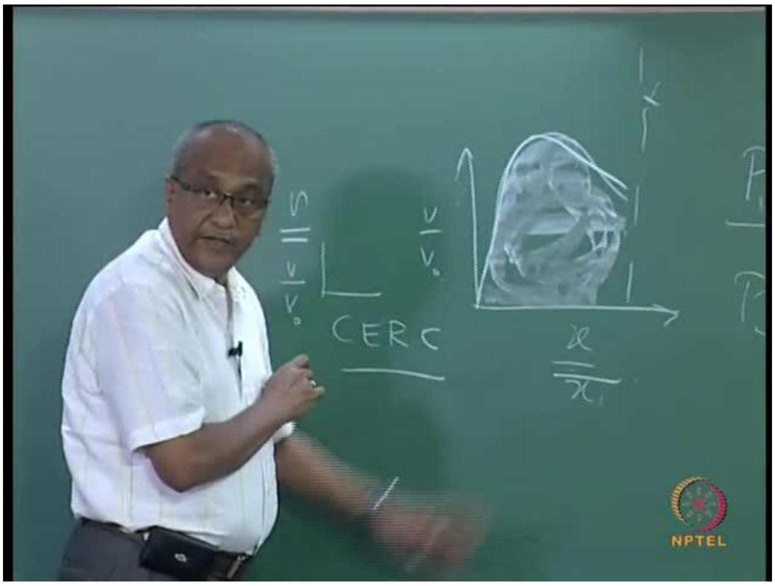

So, once you know the for which you you should know the distribution of sediment transport rate, once you know the sediment transport rate you integrate and get the total sediment transport rate. So, such figure can be drawn for every month for for constant for an average breaker wave angle or wave average breaking average breaking wave characteristics for each of the month. And then try to integrate and get it and then you can try to compare one is by comparing the sediment transport rate by integrating the distribution of the sediments within the surf zone or using the Cerc formula or may be Komar formula, which we are discussing, right.

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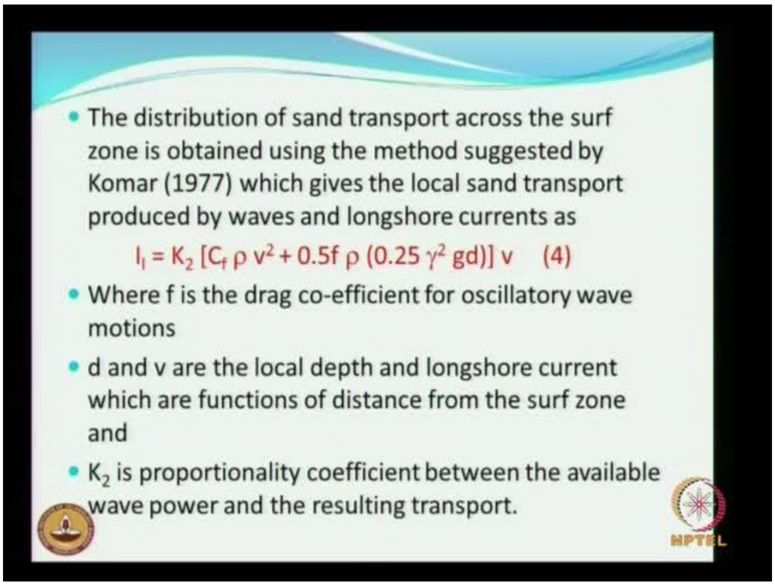

Komar formula also is there so you can use all these three methods and then you can also compare later. I will just show you some of the typical examples where we have used all these formulas for a predicting the sediment transport rate. May be may be one of the coast stretch of the coast along Indian coast, some may be Kerala or Chennai or so the distribution of sediment transport across the surf zone is obtained using the methodology suggested by Komar. What it gives? It gives a local fan transport produced by waves and the long shore currents. So, this is IL is this is what he obtained an expression which is going to be a function of this long shore current velocity which is going to be the trained force.

This expression is calling it as local sand transport due to where's that long shore currents. Now, here the different variables are given or mentioned here f is the drag. Co-efficient d and v are the local depth and the long shore current velocity which are the function of the distance from the surf zone. The distribution of v of a function of x we have already seen earlier. So, you remember we were it involved number of parameters like P 1 P 2 etcetera etcetera. One what we have seen yesterday and the k 2 proportionality constant between the available power on the resulting transport which we, which was similar what we have done earlier under the energy flux method.

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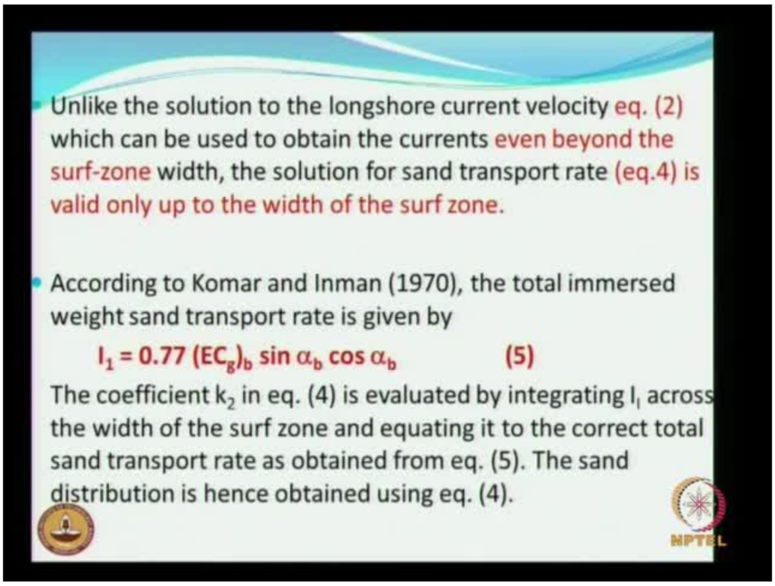

So, unlike the solution to the long shore current velocity, equation two gives the maximum current velocity, maximum current velocity which can be used to obtain currents even beyond the surf width, the solution of the transport rate that is given in the earlier equation, this equation is valid only up to the width of the surf zone because as we have seen the long shore current velocity that is v by v naught, we drew. For example, this was may be, this is the surf surf width for example, this is what we had and then we had here remember yesterday we have seen right and but then I said that this equation can go beyond the beyond the breaker zone right, but here so although the current velocity is there, but the equation four is valid only up to the within the width of the surf zone, you understood?

Because this is where the dominance of the sand takes place and that is why you are trying to equate the power and the sand, in order to get the total quantity by integrating. So, according to Komar and Inman the total immersed weight now can be expressed, this is using the wave characteristics. So, similar more or less similar to what we have done under the energy flux method.

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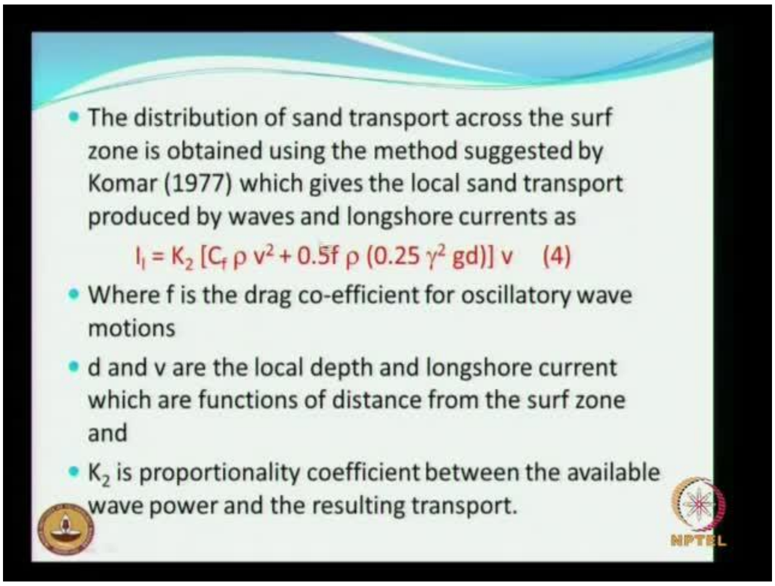

So, now the co-efficient k, so we have one equation for the local sand transport.

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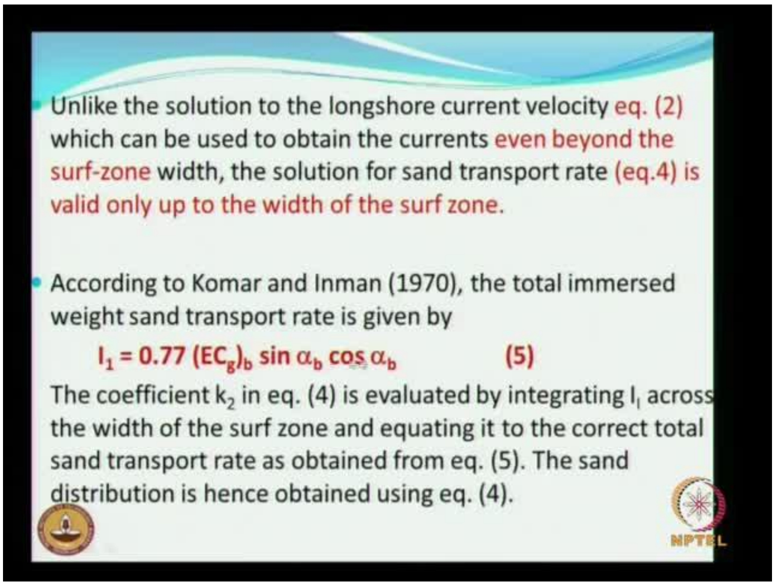

And then this is for the total immersed weight of the sand. So, these two when you equate then you have a co-efficient that needs to be evaluated and that co-efficient is k 2 is integrated, how do you get that k 2? You can get k 2 by integrating here the velocity is going to vary within the surf zone, so you need to integrate that across the surf width and equating it to the total immersed weight. So, you integrate the total integrate the sand distributed in this and this has to be equated to the total immersed weight. You understood this is the total immersed weight. And then once you do that then you get the proportionality constant also so the dense, also you can also with this help with the help of this you can draw the distribution within the surf zone.

What we will do is we will try to use some of these informations, I am not going to go in the complete details, but I will try to demonstrate how you use some of these equations and expressions and in order to arrive at least the long shore current velocity and may be if time permits the sediment transport rate. So, what all we have seen? We have seen maximum velocity then mid surf velocity.

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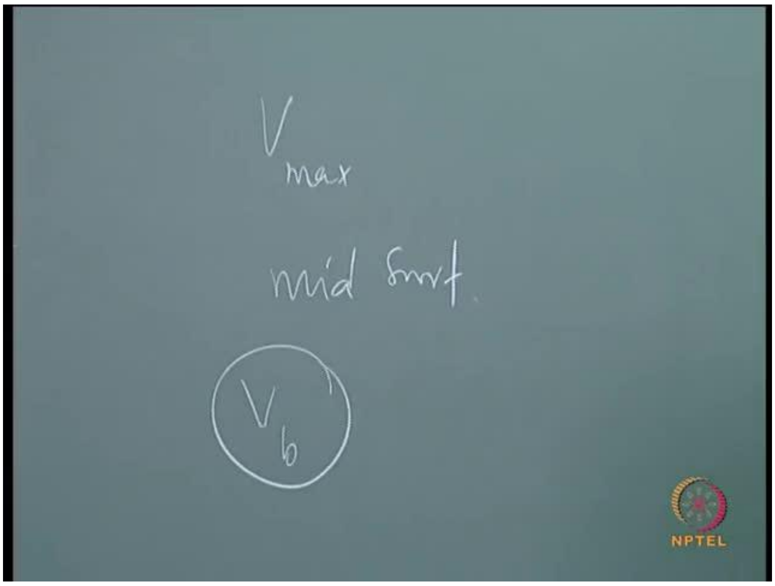

Then now we are having another velocity which is V b, so the radiation stress of Longuett Higgins, he came up with, so all these equations do not get bogged out because of the we are involve because the topic involves so many formulas some of these formulas will be allowed to be brought for the examination, but what I want you to do is look at the problems, the application of the formulas that is much more important. Where do you apply and when do you apply?

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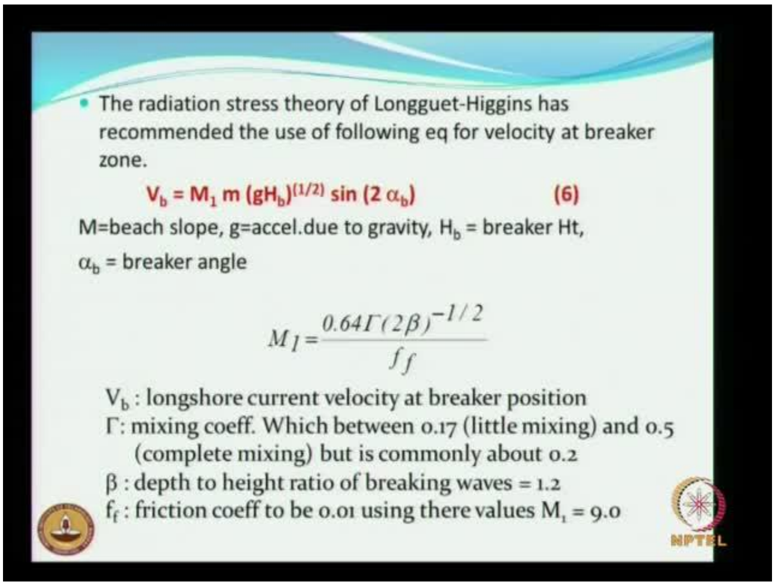

So, here small m, m 1 this should be small m and here m, m 1. m is the beach slope capital M is given as given by the expression there, where this is the mixing co-efficient which we have already, which I have already explained yesterday what is meant by mixing co-efficient and that is going to be between 0.17 to 0.5

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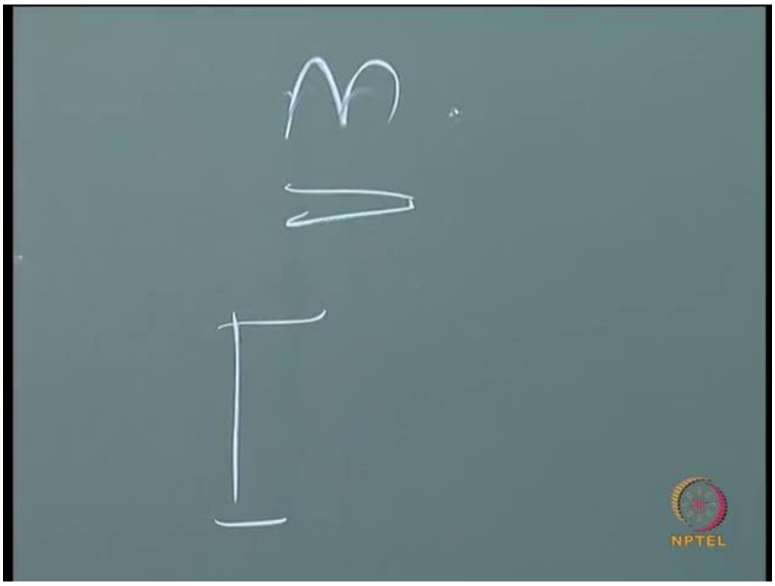

That is 0.17 for little mixing and 0.5 for complete mixing, but the Commonly they use value for about 0.2.

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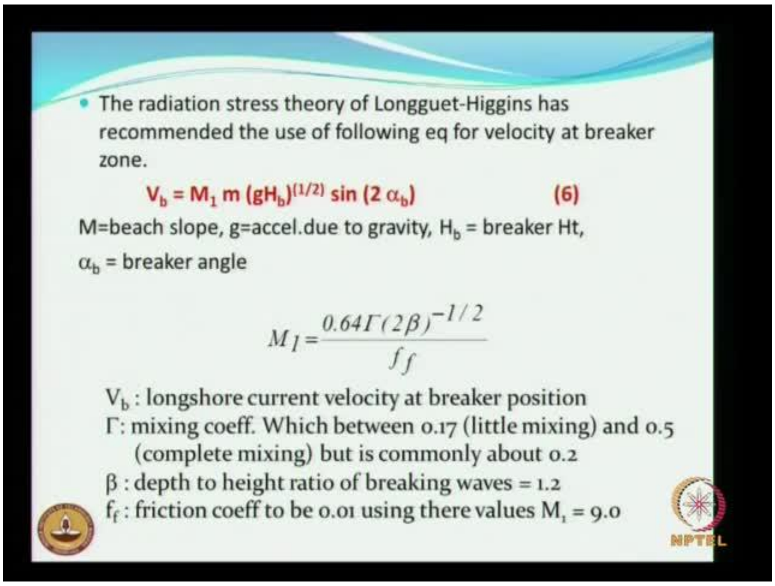

So, you see a number of co-efficient are involved, when you are dealing the sediment transport rate becoming more and more complicated and more. So, we use the word estimates it is not so easy to accurately calculate the sediment transport, whatever is involved in, when in the field of sediment transport, so the other things are the friction factor and friction factor is taken as 0.01 and beta is you know that is that is nothing but the breaker index, that is 1.2.

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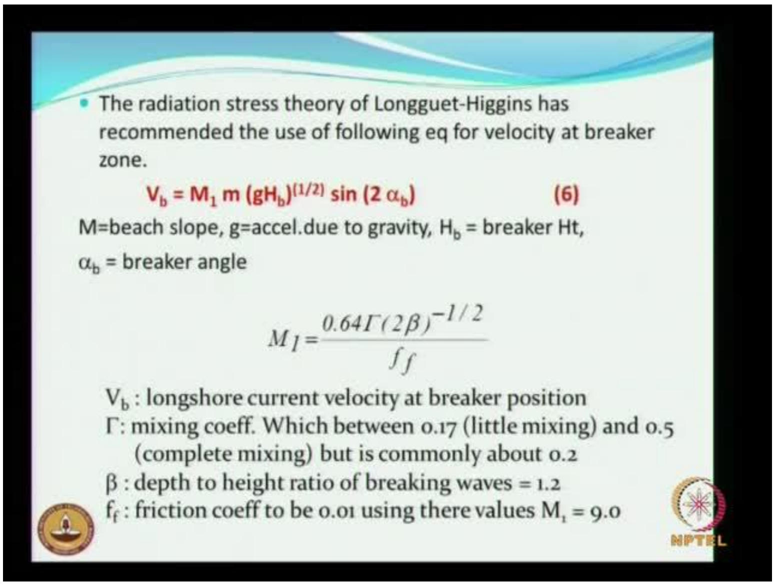

So, applying equation six that is this particular equation, which is the velocity, the long shore current velocity at the breakers breaker line at the breaker line when this was applied to two sets of data. Then it yielded predictions that was that average was about 0.3 of the measured values, you understand? So, then in the, so in part these predicted speeds found to be much lower than V b that is what then that predicted by this equation the measured was less, so that means there is a velocity which is much less than the velocity at the breaker zone is that clear?

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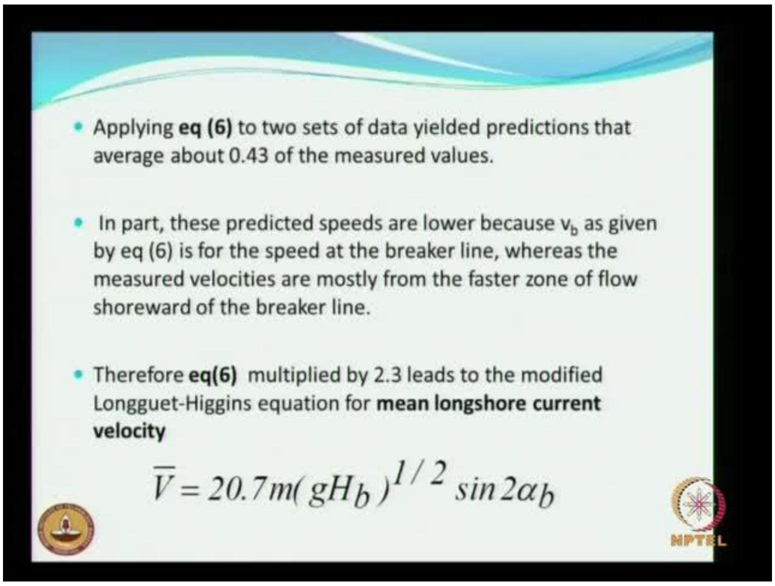

And that could be, so therefore, the equation two was multiplied by a factor of 2.3, this was done by Longguett Higgins equation to get us what is called, what is defined as the mean long shore current velocity. So, we have yet another factor which is V v bar.

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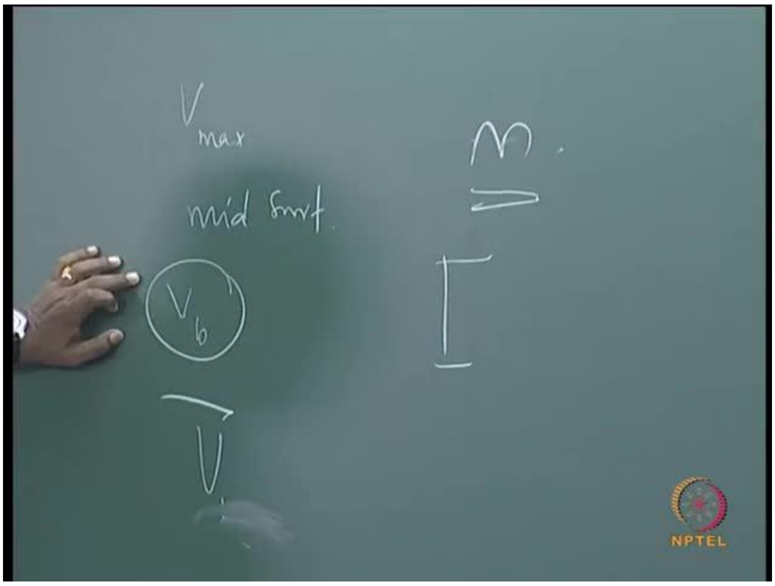

So, we we deal with maximum current velocity, mid surf current velocity, velocity current velocity at the breaker zone, and then we have the mean current velocity within the surf zone. Now, you please re collect how many kinds of velocities we are dealing?

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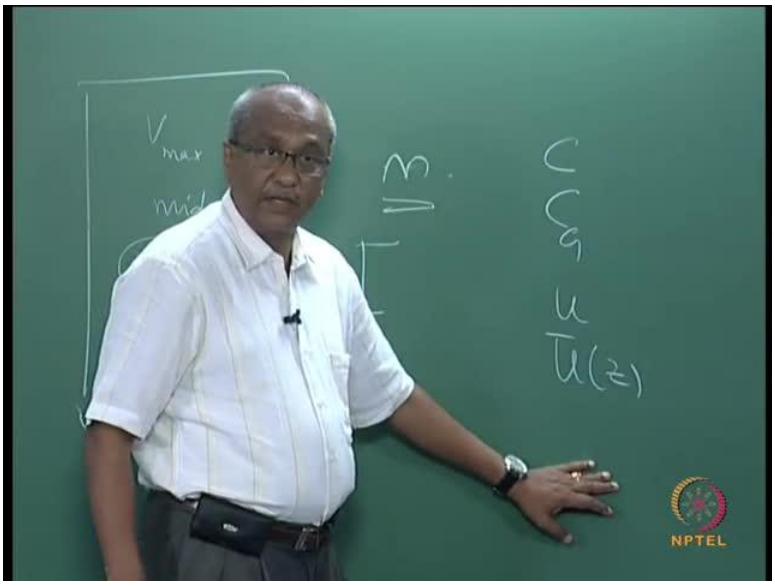

Earlier to ref, so we had celerity, group celerity, orbital velocity, mass transport velocity, in fact we have ripped current velocity which we have not, I have not gone into the details. Now, under the near shore fields you have, so many other kinds of description of the velocities which are being used and the near shore dynamics.

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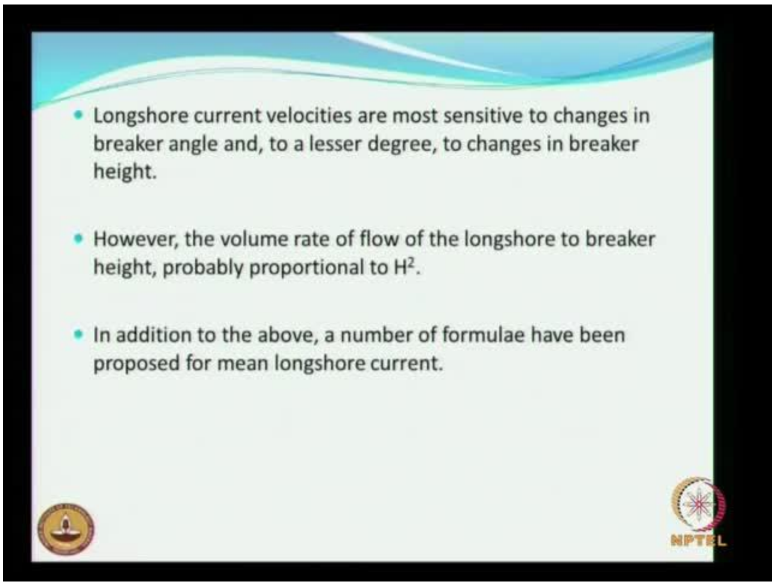

So, long shore current velocity are more sensitive to changes in breaker angle and to a less degree to the changes in the breaker height. So, that is why this you can you can try to work out, you have the expressions for the long shore current velocity. Try to keep your breaker wave height constant keep changing your breaker angle by a certain percentage, may be for 2 or 3 percentage or may be 5 percent and then you do the repeat the same thing by keeping the angle same and then changing the percentage of the wave height. You will see that the change in percentage in the angle will really change ah result in a significant change in the in the long shore current velocity, that is true no, because the long shore current velocity as I have said it is because of the oblique wave, oblique attack of the waves. So, more is the angle greater will be the long shore current velocity.

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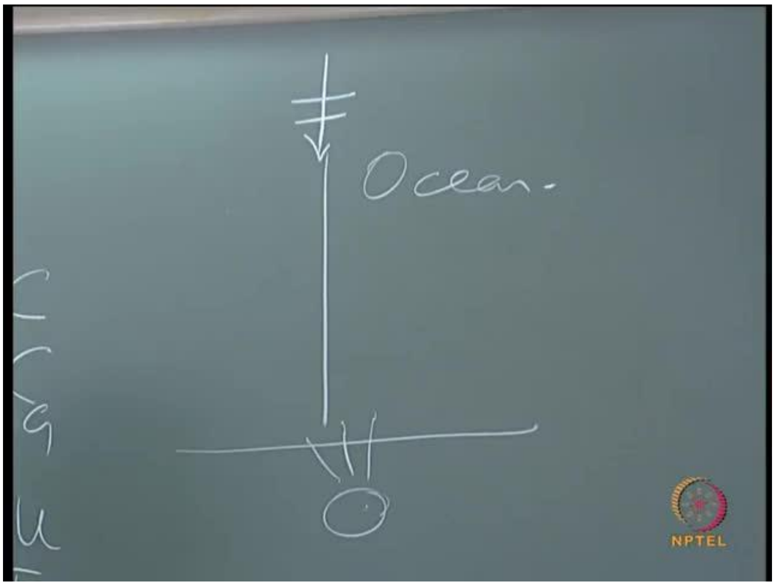

Again to recollect, so when you stand here and look into the ocean, if you see that waves are at that particular at a particular to the location is approaching normal to the shore, that means what does that mean? You do not have much of, you do not have long shore current velocity at all. So, in such a location if you have some kind of a vertical an obstruction normal to the cylinder, normal to the shore line the changes will not be appreciable now.

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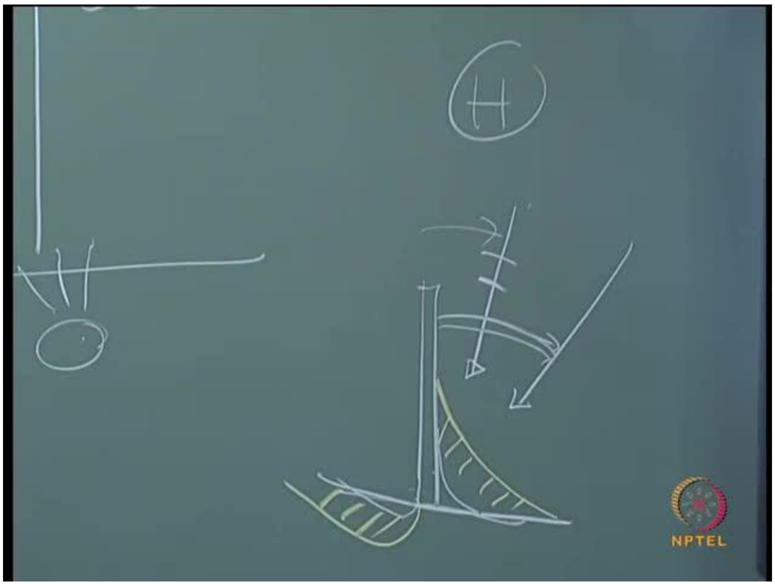

Go to an area where, you have only this much of angle and you have having, so this indicates that there is a long shore current velocity. Now, what is the kind of variation you may have? You may have the deposition or the advancement and you may have, not you may you are bound to have this kind. Is that clear? Suppose if this angle is more, I am keeping your h constant, I am changing only the angle. Now, if the angle is more than the deposition will be more and similarly, the erosion can also be more. So, this is the physical significance of the importance of evaluation of the or know, knowing the having a knowledge on the variation on the long shore current velocity and also the variation in the wave directions, particular in the near shore.

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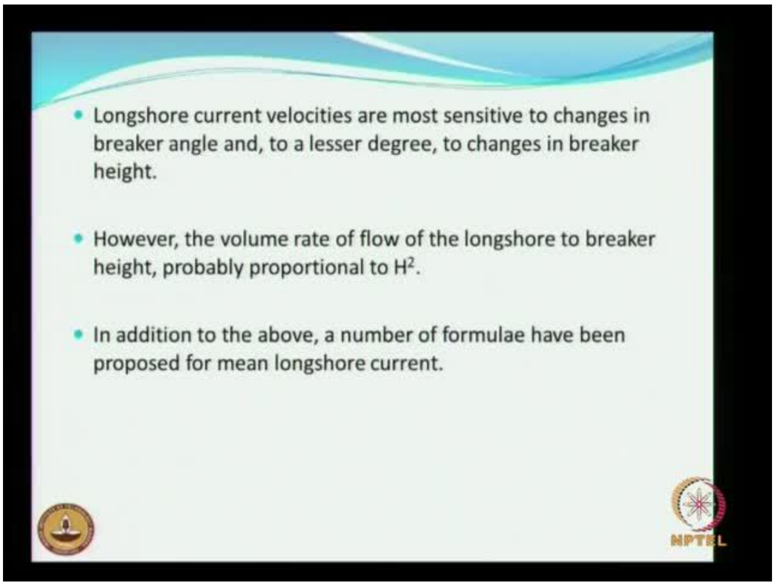

So the, however the volumetric rate of flow of the long shore to the breaker height is proportional to h square, that is what it says the formulas everything. So, I I am sure that is understood right? Finally in addition to the above, we have a number of formulae that has been prop, proposed for the mean long shore current velocity. So, what we could cover here is only a handful of what is suppose to be known to coastal engineers. If you are taking this as field of specialization for your future, I suggest you read number of books references that are given in the lecture material. Now, we will having gained some knowledge, I hope things are clear? We will just go on to some of the problems related to long shore current velocity.

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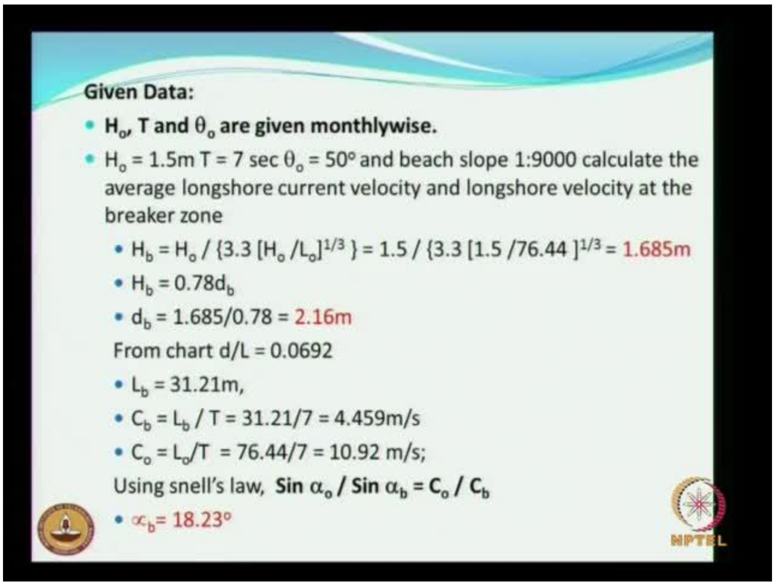

So, here we are given the data month wise, so may be your wave height de porter wave height 1.5 meters, wave period is 7 seconds, deporter wave direction is 50 degrees then the beach slope is 1 in 9000, calculate the average long shore current velocity and the long shore velocity at the breaker zone. So, the procedure is slope is also given so if you want you can use this equation which which relates the deporter wave characteristics in order to obtain the value for breaker wave height. All this data this formulas are discussed in the chapter on wave deformation and then this will yield you a value of 10.685 meters for the beaker wave height, and then there after you get the d b that is the wave breaker depth as 2.16 meters.

Then get into the wave tables and then derive the value of the d by l corresponding to the d by l naught and this will be d by l for this particular d b and then u will get wave length at the zo, in the zone of wave breaking. Is that clear? Is that clear? Clear? Then once that is known, you can calculate the breaker velocity, using the Snell’s law you can get the breaker angle all this things have already been seen earlier.

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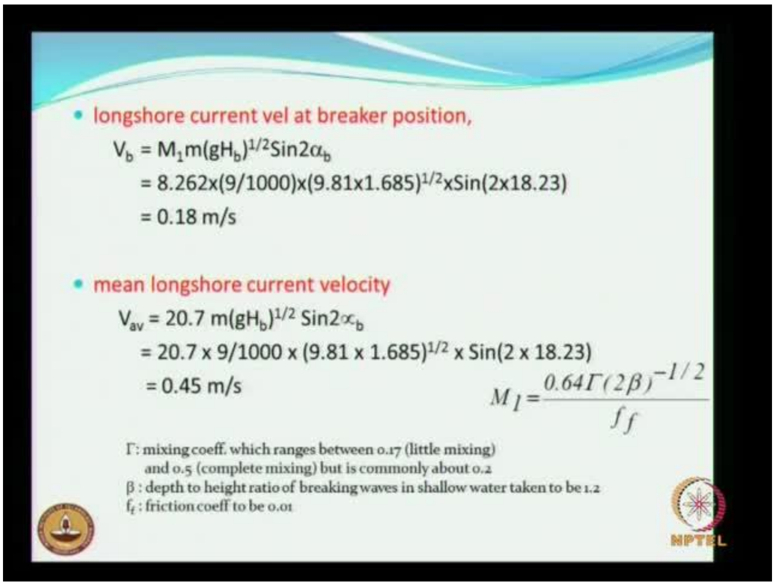

Now long shore current velocity at the breaker zone is given as shown here, so where M 1 is m is the beach slope which is 9 by 1000 then M 1 is given by this, so you can use the factor at 0.2 for the mixing parameter and all other parameters are known beta is 1.2 friction co-efficient friction co-efficient is taken as 0.01 and hence you can calculate this because the breaker angle has been evaluated. breaker height is given and then this is the order of the velocity at the breaker zone. Is that clear? Then comes the long shore, mean long shore current velocity has derived by Longguett Higgins and using the radiation stress theory.

So, this is the simple equation which can be straight away used because M is the beach slope and all other parameters are known and now this is what is you get that is the mean long shore current velocity. So, the long shore current velocity can vary something like this. So, that is only a sample calculation which I have presented.

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Mon	H_o	T	θ_o	H_b	d_b	L_b	C_b	C_o	α_b	M1	V_b	V_{av}
Jan	1.5	7	50	1.68	2.16	31.21	4.459	10.92	18.23	8.262	0.18	0.45
Feb	1.7	7	45	1.83	2.35	32.91	4.701	10.92	17.72	8.262	.183	0.45
Mar	1.5	7	35	1.68	2.16	31.21	4.459	10.92	13.55	8.262	.138	0.34
Apr	1	7	15	1.28	1.649	27.48	3.926	10.92	5.34	8.262	.049	0.12
May	1.2	7	15	1.45	1.859	29.14	4.162	10.92	5.66	8.262	.055	0.13
Jun	2.5	7	-45	2.36	3.037	36.63	5.232	10.92	-19.8	8.262	-.228	-0.57
Jul	2.8	7	-50	2.55	3.275	37.91	5.415	10.92	-22.33	8.262	-.262	-0.65
Aug	2	7	-30	2.01	2.586	33.98	4.845	10.92	-12.82	8.262	-.143	-0.40
Sep	2	7	-35	2.01	2.586	33.98	4.845	10.92	-14.74	8.262	-.163	-0.45
Oct	1.5	7	45	1.68	2.16	31.21	4.459	10.92	16.78	8.262	.167	0.17
Nov	0.9	7	20	1.197	1.535	26.64	3.805	10.92	6.844	8.262	.06	0.20
Dec	1.2	7	25	1.45	1.859	29.14	4.162	10.92	9.269	8.262	.089	0.22

Now, this figure this table shows that the every month January to December for a particular particular location. So, all these H naught T and theta naught is suppose to be input data available data for which you are suppose to calculate all these where these two parameters that is the velocity at the breaker zone and the average velocity. So, you calculate the same procedure you, so this shows the variation of the breaker wave height, this shows the variation of the breaker depth for different months, the breaker wave length, then the breaker celerity, de porter celerity, breaker angle and M 1 this is going to be a constant in this case in fact M 1 can change also because beach slope cannot be always same also, we are we are assuming that it is as same. So, we have got the that 8.262 and then the variation of the both velocities are given here, which incorporates the direction of the velocity also.

The velocity at the breaker zone as well as the average velocity, is that clear? Now, the calculation of PLS parameter which is a very important parameter, because that is once only after you calculate the PLS parameter can you really get the, I mean quantity of sediment transport rate. So, for the calculation of PLS parameter, there are several formulas which we use in the wave deformation.

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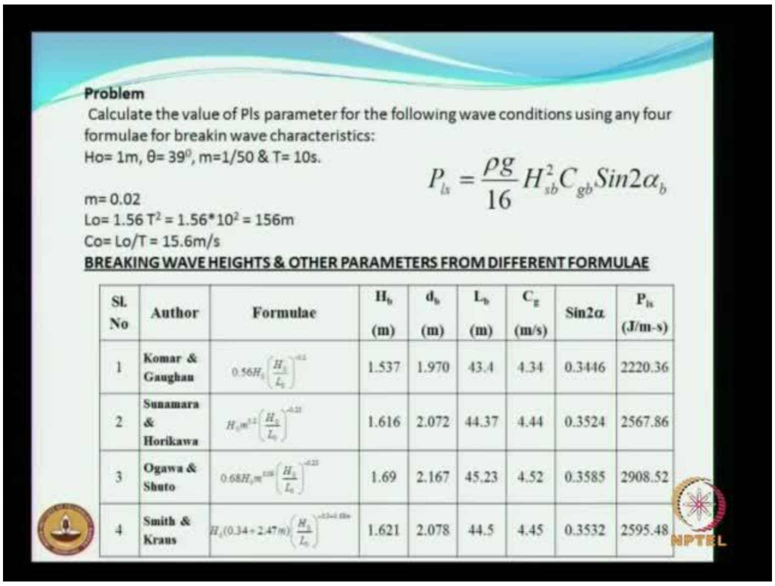

As we have seen under the chapter wave deformation for the, for getting the wave breaking wave characteristics because the breaking breaking wave characteristics are the characteristics which are going to control your variation of the PLS, there by controlling the quantity of sediment transport. So, here you have what I have listed are the formulas given by different authors and then these are the different formulas, so you can sit and do the calculation by yourself. So, you you use the beach slope. Beach slope here is we have taken as 1 is 1 in 50 and then you calculate all those parameters that are needed for calculating your PLS.

So, for calculating your PLS you need the H b and your C b and this is going to vary with the type of formula the kind which is the formula which we are going to use. So, look at the variation of the breaker, so look at the variation of the breaker wave height breaker wave height is going to be controlled the this way and the breaker depth variation is given here, so you have variation of about 10.97 or close to 2 to 2 to 2.2 So, that is the kind of variation you can anticipate, when you are trying to use different kinds of formulas, is that clear? But so this gives clear clear view about the formula that can be used. Finally, having looked into the two problems on long shore current velocity, we will just move on to those are all velocity, current velocities for a particular month, may be the average average of average of the velocity at the breaking, average of the average velocity monthly average.

Now, what we are trying to do is we are trying to understand how the distribution of long shore current velocity could can would look like? So, as I have told you, I told you the principle once you get the distribution of the long shore current velocity you can integrate and get the total sediment transport rate. That is you have to equate it to the immersed volume of the total total immersed of volume of the sand that is what we have already seen.

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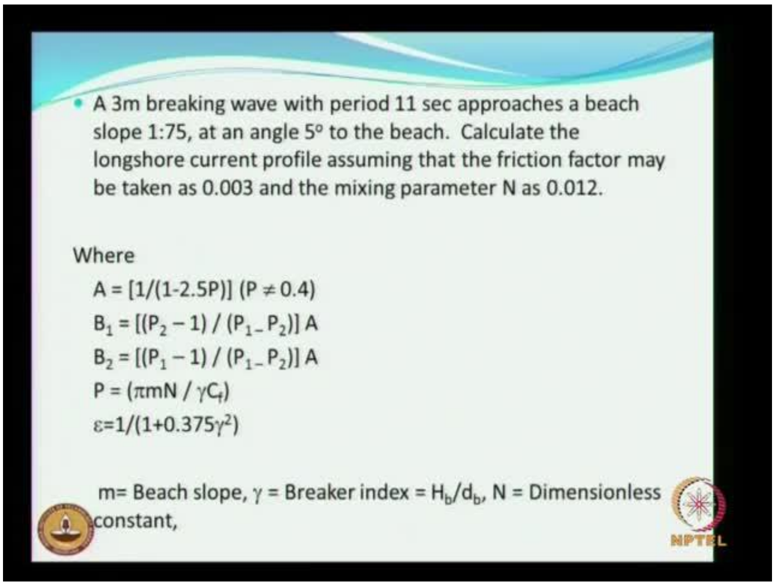

Now, so if it is not so clear please look into the lecture material and also the the file which you are, which is available to you that is the p d f files, so that things are more clear. So, here 3 meter wave breaking wave with a wave period of about 11, if of 11 seconds approaches a beach. Beach slope is given as 1 is to 75 and at an angle. So, the breaker angle itself is given here that is 5 degrees, so 5 degrees are nothing but it is a breaker, breaker angle because its mentioned as breaking wave height, breaking wave. So, calculate the long shore current velocity assuming that the friction factor may be taken as around 0.003 and the mixing parameter has 0.012, if these values are given you can estimate all these parameters. So, the these are some of the formulas which we need to have

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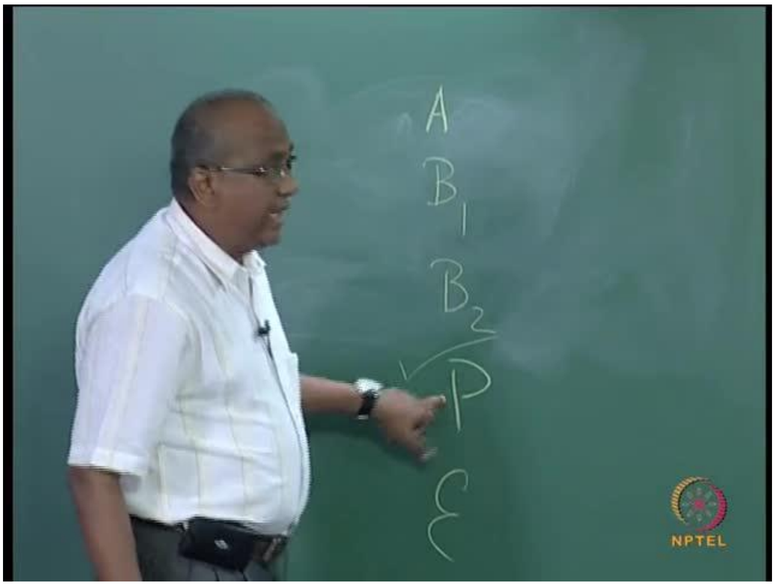

So, we have the parameter A then B 1, B 2 capital P and this one, so what are all the thing? What, which we need to calculate first? As I have said earlier is that is right.

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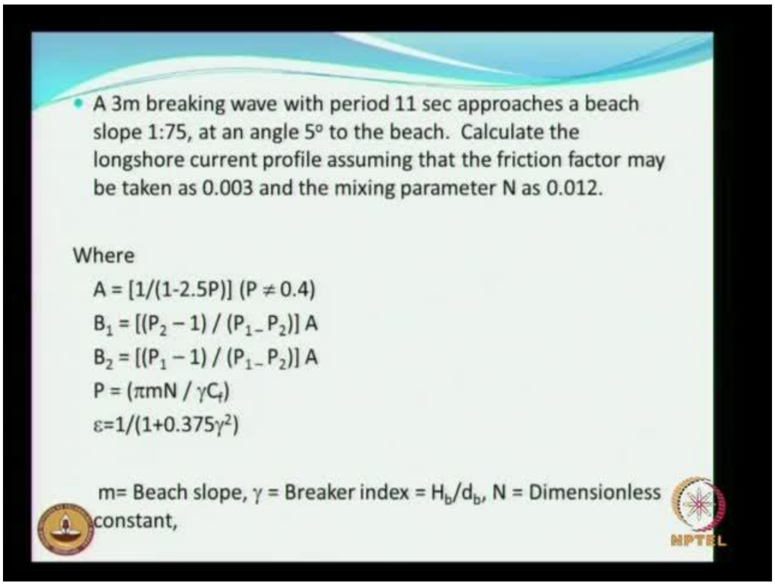

You have to calculate P P is pi into m that this N is already given to you as 0.012 so you and so gamma is nothing but the breaker index and then you can calculate C f is also given, so you can calculate P. Now P is how much?

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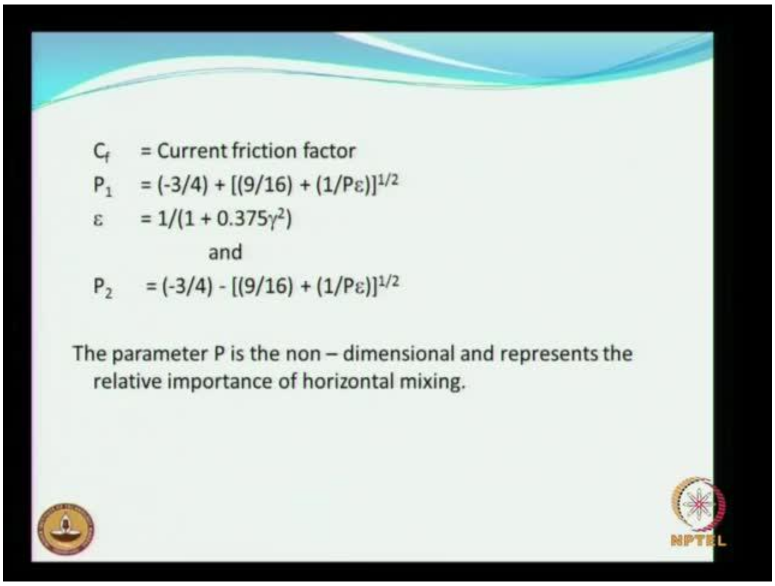

P works out to you have a other parameters like here P 1, all these parameters need to be worked out. So, first we will have the breaker index, so breaker index can be worked out as soon here.

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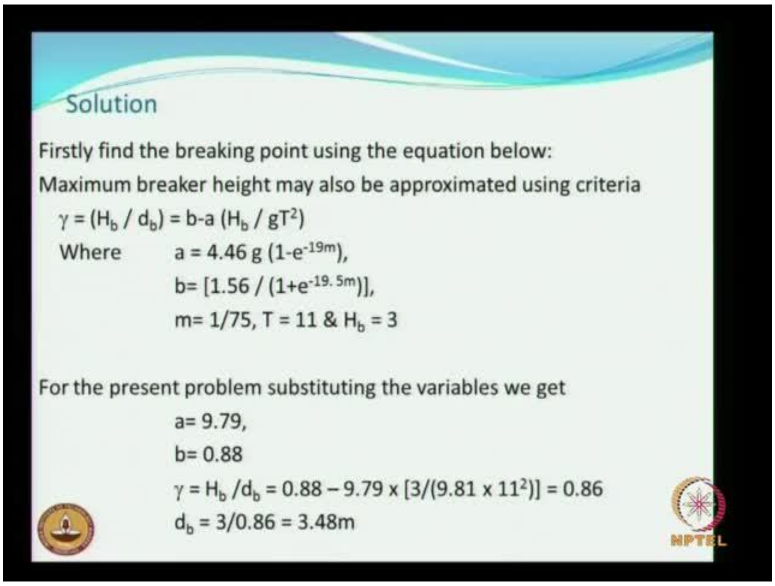

That is here for the present problem, so this is one of the method to use to get the breaker index. This is the in terms of beach slope beach slope is given to you hence you use these, this method. So, beach slope is 1 by 75 wave period is given, wave breaking wave height is given, so you use this to get the constance a and b as we have got point 9.79 and 0.8 for a and b respectively, and then b can be the gamma, can be obtained as as per this formula given here and then that is going to be approximately 0.86, is that clear? See although we use point a 0.78 sometimes it depends, it varies anywhere between 0.78 and 0.8 to 0.86 etcetera 8 6 in in fact its slightly on the higher side.

So, it is usually varies between 0.78 and 8 8 point 0.8 8 2. So, now you have once you have got your breaker index then you can straight away get your breaker depth because breaker height is already known. So, your breaker depth is equal to breaker depth is 3.48 and breaker height is already given so no problem.

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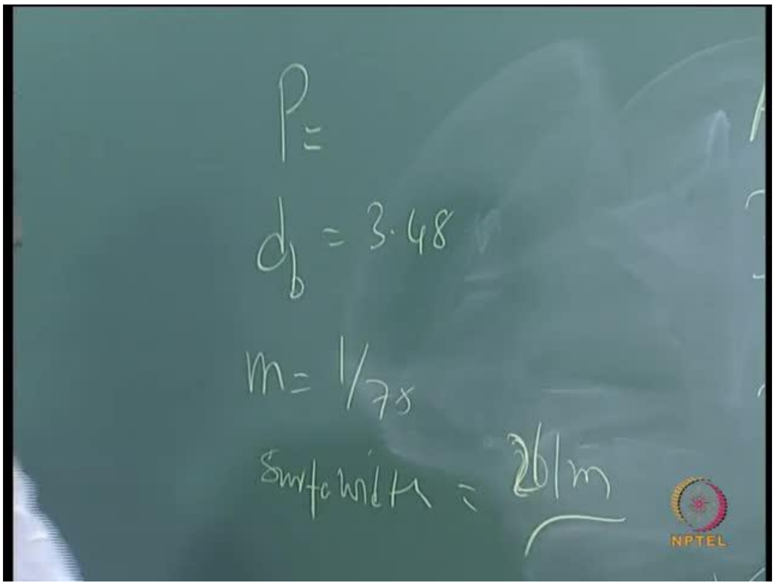

So slope is, m is slope is 1 is to 75, so you can get your what is that? That is the surf width, am I right? Are you following? So surf width is around 261 meters. Now, what is the epsilon. Epsilon is going to be I will just run for, back and forth so that things are clear for you.

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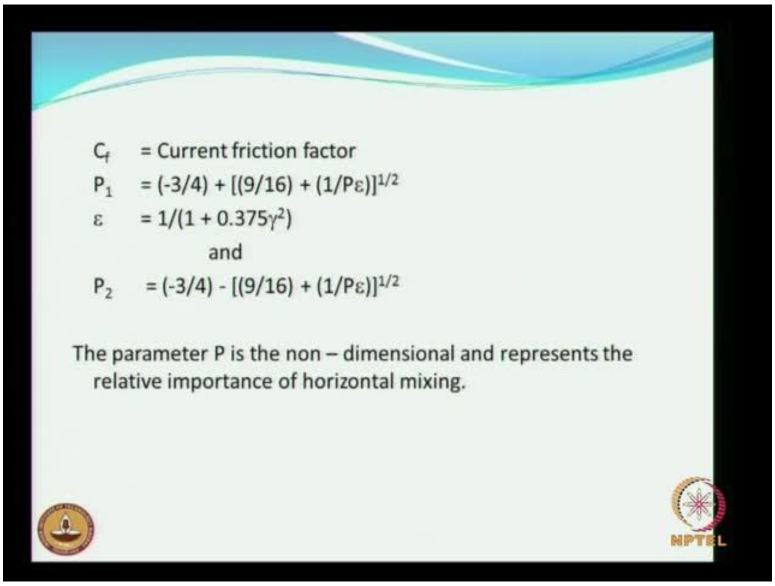

So, here Epsilon will be equal to 1 divided, so in this equation this is already evaluated, this is already evaluated so just you need to use this equation and then that would give you epsilon equal to 0.785.

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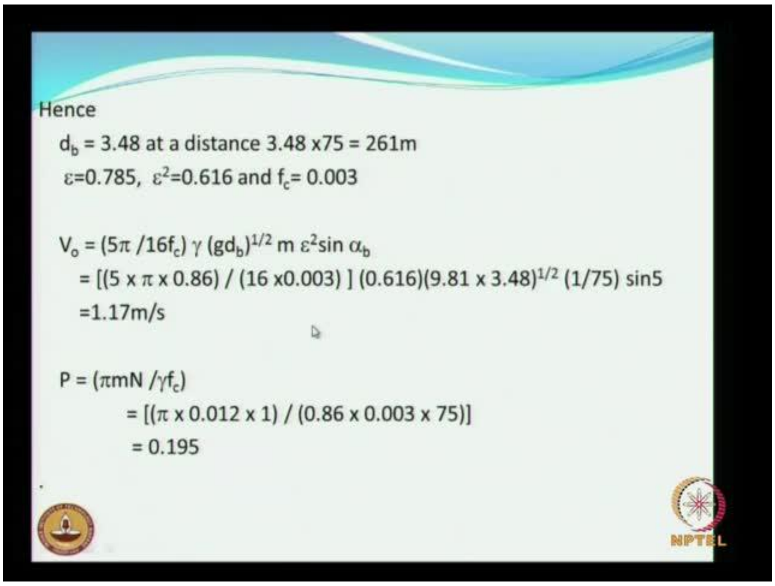

And epsilon square that does not matter and f c is also given to you, no problem. So, straight away you have to use your maximum velocity. How do you calculate the maximum velocity? This is the equation we have already one problem similar to this, in the first problem today was based on this. So, use all these things all these variables are already given to you, already known so you get v naught is equal to 1.17 meter per second. Now, the next task is you get the P value. P value is pi m is known to you, so that is m is equal to 1 by 75 your n is 0.012 and then gamma is the breaker index and f c is equal to 0.003 is that clear? So, this is going to work out as 0.195 is that clear? So, next you have all these equations. You have evaluated this one is clear this one is clear, now the rest is going to be quite straight forward.

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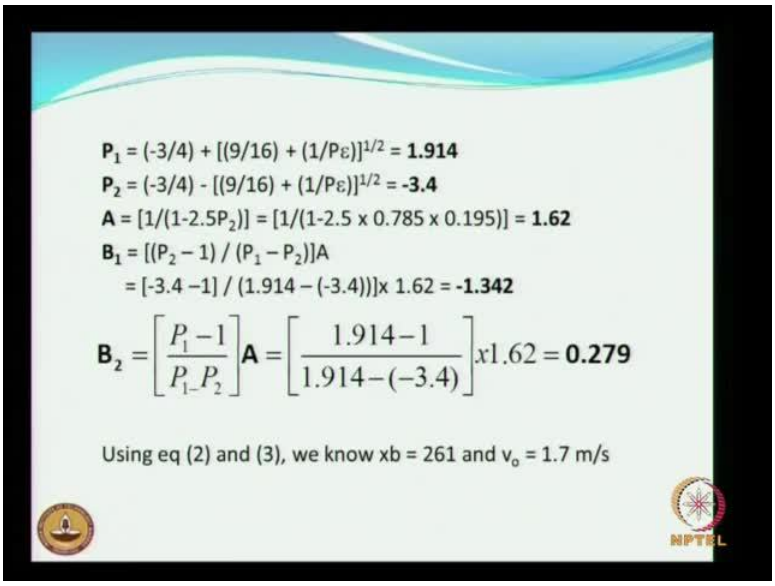

So, once you have the P and epsilon then P 1 will be equal to that expression which is going to give you 0.914 and P 2 is going to be minus 3.4 and capital A is once you calculate the P 2 you can calculate a that is going to be 1.62 and then your next you have B 1 and B 2. So, you have already have evaluated the x B, that is the surf width as well as your velocity. What else you want? What else you want? So you have an expression which can be straight away used, by using all these the values for all the different co-efficient. So, what I do is I take a capital X from 0.12 to run all the way to 1 and half times the surf width. X by XBb equal to 1 is exactly at the surf width, right. So, that is what I have done here.

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$X = x/x_b$ (1)	Dist from Shore (m) (2) = (1) * x_b	v/v_o (3)	Longshore velocity V = Col (3) * v_o m/sec
0.1	26.1	0.156	0.167
0.2	52.2	0.268	0.30
0.3	78.3	0.349	0.40
0.4	104.4	0.402	0.42
0.5	130.5	0.431	0.45
0.6	156.6	0.437	0.46
0.7	182.7	0.422	0.44
0.8	208.8	0.387	0.41
0.9	234.9	0.332	0.34
1.0	261.0	0.260	0.27
1.1	287.1	0.193	0.20
1.2	313.2	0.147	0.15
1.3	339.3	0.114	0.11
1.4	365.4	0.091	0.09
1.5	391.5	0.073	0.07

So, then this is from the shore is given here so it is not from 21 26 meters going all the way to around 400 meters here, for this particular problem. Then V by V naught you can calculate using this particular expression, so I would just…

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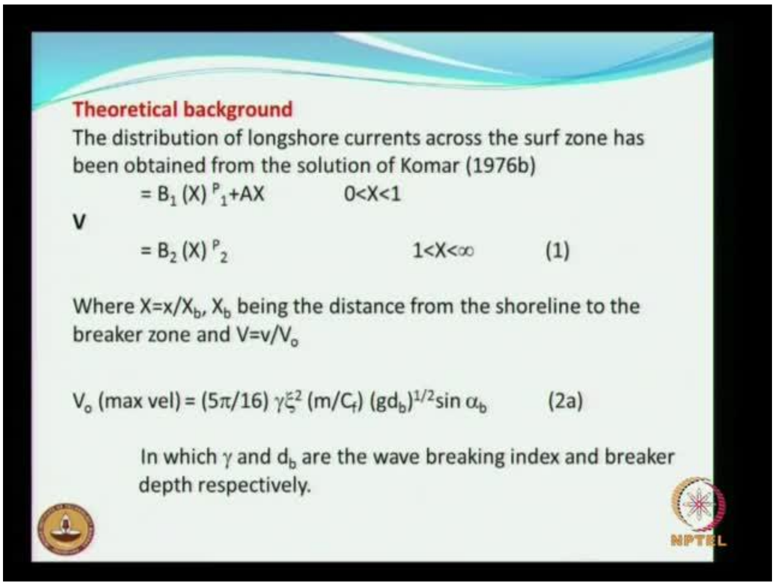

So, this is the equation. This is the equation we are trying to people who have not attended last class, please look into it. So, this was the equation, it is quite straight forward, so this is the equation where you have the top one as the, a expression for calculating the sand long shore current velocity within the surf zone and after the beyond the surf zone you use the, this expression. So, this is within the surf zone and this is outside the surf zone, is that clear?

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$X = x/x_b$ (1)	Dist from Shore (m) $(2) = (1) * x_b$	v/v_o (3)	Longshore velocity $V = Col(3) * v_o$ m/sec
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So, use this accordingly and then you will get the variation of the current velocity as given here. So, long shore current velocity, so this is the dimensionless velocity and the last column you are going to have the long shore current velocity within the surf zone. So, what you see is it increases and then close to the mid surf, it is a going to be about 0.5 you see that its around 0.45which is going to be the close to the maximum velocity and you can also find out what is the average velocity in this case.

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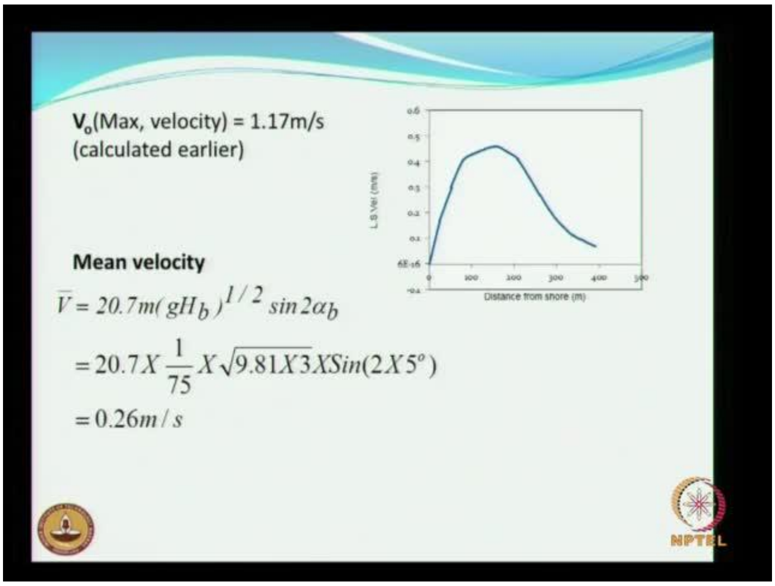

So, the mean velocity in this case would be approximately 0.26 meters per second and this is going to be your distance from the shore to the long shore current velocity within the surf zone. So, it varies from about up to about 0.5 meters or up to about 0.46 meters per second for this particular problem and then it extends up to about, so what what was the surf width? Surf width was 260 meters right, so you see that beyond the surf width also you can have certain amount of long shore current velocity as you can see this. You still have certain amount of velocity being generated beyond the surf zone, is that clear? Any of you have any doubts? So, with this we have completed the long shore current velocity and long shore sediment transport, any of you have any doubts?

Sir, what is they meant by immersed weight of sand?

That is what is the total weight? That is immersed when it is immersed in the water sea water.

(( )) That is moving as well as that is depositing.

That is also a depositing so when you look at the sediment transport rate not only the calculation the measurement is even more complicated. So, when you want to measure the sediment transport rate in the field it is quite difficult. Then how do you some kind of its units on the sediment transport, right? One way is to have a trap to have a trap which may not be accurate, but it still gives a guideline its serves as a guideline. You have a sand trap take a sand trap it is not so easy and all these things are estimates again. So, when the sand is being collected over may be 3 months or 4 months or 5 months take the quantity of sand which has got filled up with the sand trap within the sand trap, and that will give you to certain extent. What is the kind of sand transport which is taking place in the region?

That is one way of doing it the other way is to look at the approach Streusels, approach channels. If there are some major ports, approach channels they have to keep on dredging in order to maintain certain depth for the vehicles for the vessels. So, using the dredging records you can have an idea concerning the quantity of sediments moving in that location. Then the other other way of looking at is satellite imageries. Now, satellite images has come out recently, so you can use these imageries spread over few years. Superpose all those plats, all those imageries one on over each each of these imageries, and that will give a, give you some idea concerning what could be the sand transport. Is that clear? So, these are all some of the ways of measuring the, measuring.

It is not accurate similarly, as I said earlier when you want to do some experiments with understanding the movement of sand in the coastal zone particularly in the coastal zone again it becomes very complicated because modeling poses a big challenge. Earlier most of the projects were based on physical modeling. And once you see, when once the rapid growth in the computers took place then people started resorting to numerical models. This is what I have told in the last class also. It is quite a big challenge particularly this area there are lots of co- efficient a host of parameters which we need to take care of and it is not so easy. Any way the problems which we have worked out gives you a kind of a feeling to the nature of the problem, the magnitude associated with the problem, so what could be the quantity of sand that can move?

As I said please remember along the east coast of India we can have the quantity of sand that is moving towards north is to the tune of about 0.8 to one million meter cube per year, that is a huge sand quantity of sand, huge quantity of sand that is moving its quite a big challenge handling this sand movement. So, I am sure that now with with the lecture on all the other aspects now the we have seen some of the case studies earlier, along the, particularly along the Indian coast. Now, based on that all those case studies, now we have also looked into the mathematical aspect of getting all those variables that is going to control the physical phenomenon that is going to take place.

Now, you should try to link these two. I am sure now you have the answer why we have to study all these things? Where do you apply all these things? Do not be worried about few big long formulas, long formulas can always so as I said earlier you can bring the formulas there's no problem what matters is using the current co-efficient for the correct correct proportionality constant, there are so many proportionality constant, that is very important. So, any other question you have? I think I can stop here, unless you have any questions.