Coastal Engineering
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Module - 2
Sediment Characteristics and Longshore Sediment Transport
Lecture - 6
Longshore Sediment Transport – II

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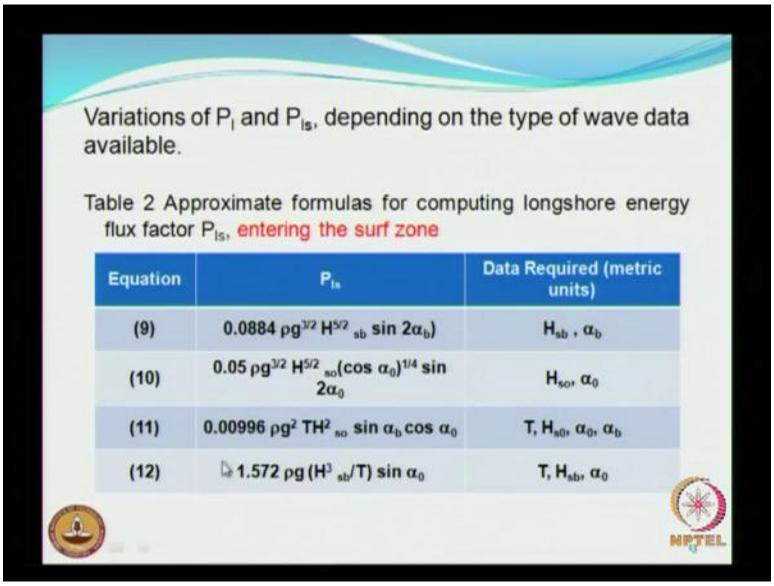

The last class we have seen the sediment transport rate that is Q as proportional to P l s. This p l s parameter can be evaluated using a number of equations you have different options. These options depend on the type of input variables you might have that is input data I will just recall I will, so probably you would be able to remember all this equations.

So, this is, these are some of the equations, which can be used for determining the P l s depending on what kind of data you have in hand. So, depending on that you use the respective equation and then we also said that the, we obtained the immersed weight of the sand and then equated and then arrived at an expression, which is equivalent to P l s.

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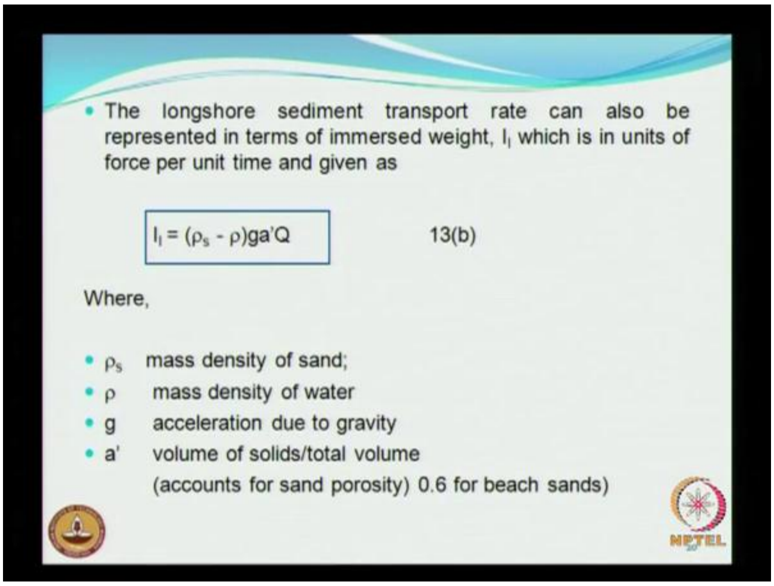

But you have that rho s by rho into g into a dash all these variables we have already seen. So, for example, here a dash is the rho s is the mass mass density of the water sand rho is a mass density of water acceleration gravity is g. Then the volume of a solids to the total volume that is that accounts for the sand porosity usually it is taken as 0.6, which we have already seen in the last class.

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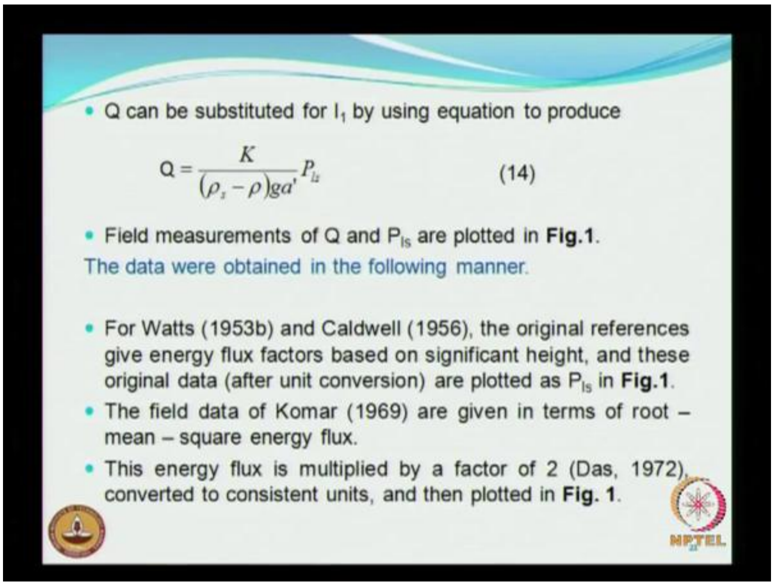

Now, they are trying to arrive at a kind of a relationship between the P l s parameter and your quantity of sediment transport based on field measurements, which we have this also we have seen earlier.

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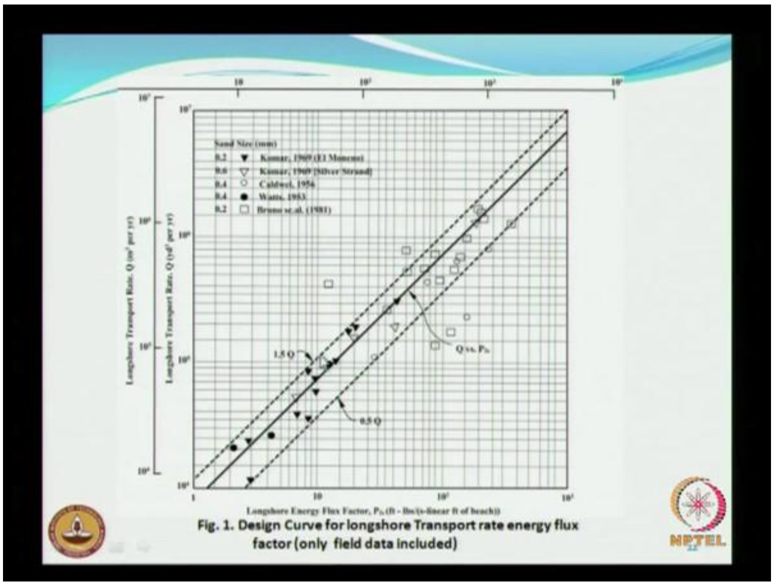

So, you see that you the centerline is Q verses P l s and here this is 0.5 into Q and this is 1.5 Q.

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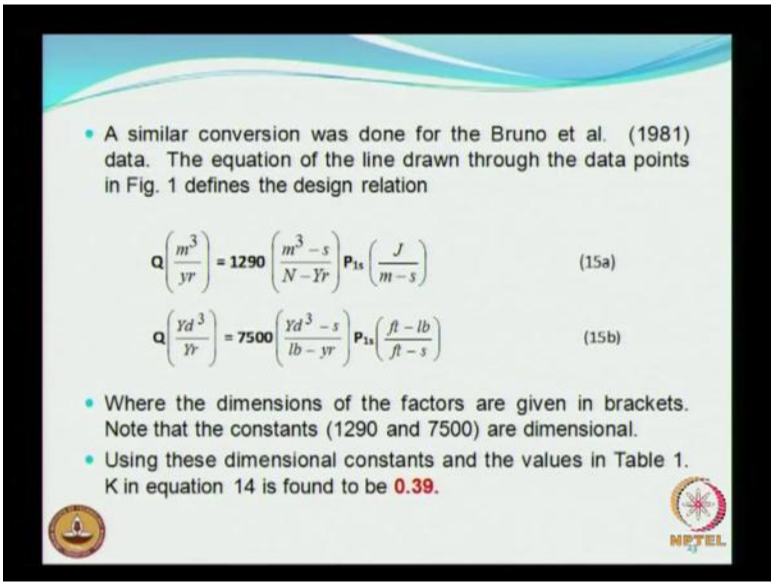

I have already explained that a similar conversion was done by Bruno, a Bruno et al in 1981 and then this defines q is equal to… Usually we use Q per meter cubed. So, this will be going note that this is going to be a dimensional constant and the dimension is and into P l s. So, similarly you have a, an expression for calculating this sediment transport for in terms of yards in f p s. So, the the formula is quiet straight forward, you know say how you have to estimate the P l s and how you have to calculate your… So, you can simply calculate using your calculator you do not need big calculations needed for estimating, but you need to be careful while using this expressions particularly the wave.

Wave direction that kind of wave height etcetera it has to be taken care of alright. For example you can get from this sediment transport per day, per per month all this thing information can be and also you can get the sediment transport season wise. You understand, so suppose if I want to have the monthly sediment transport from January to December. So, this formula you have to take care of divining it by twelve so that you get the monthly sediment transport rate. So, we will work out a problem later after looking at some other aspects we will work out one or two problems on how do we get the sediment transport rate and also remind. I would like to remind you that you need to take always your angle is with respect to geographic north. In deep water I am repeating this because this is a common mistake made by the students.

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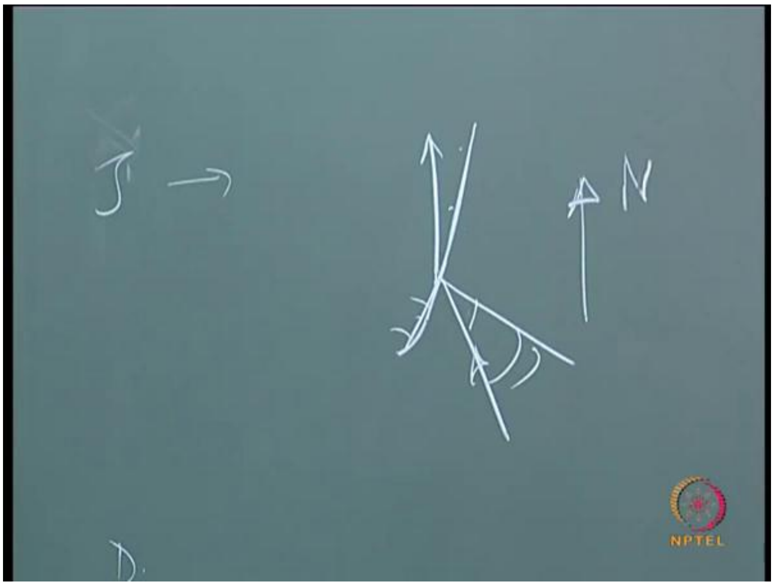

So, theta is always given with respect to north then the angle the course is also inclined at an angle with geographic north. But when we calculate your make the calculations for estimating the sediment transport you calculate the angle is defined as with respect to shore shore normal the wave direction is defined with respect to shore normal. This is very, very important which is the common mistake made by the students. So, the dimensions etcetera are all using these dimensional constants and the values given in table 1 the k in equation 14. Let us see what is this k that is this k in this is the k 14 is found to be approximately 0.4. Therefore, you can that is 13.13 this is the one, so this will work out to I l will be equal to 0.4 or 0.39 to be precise into P l s.

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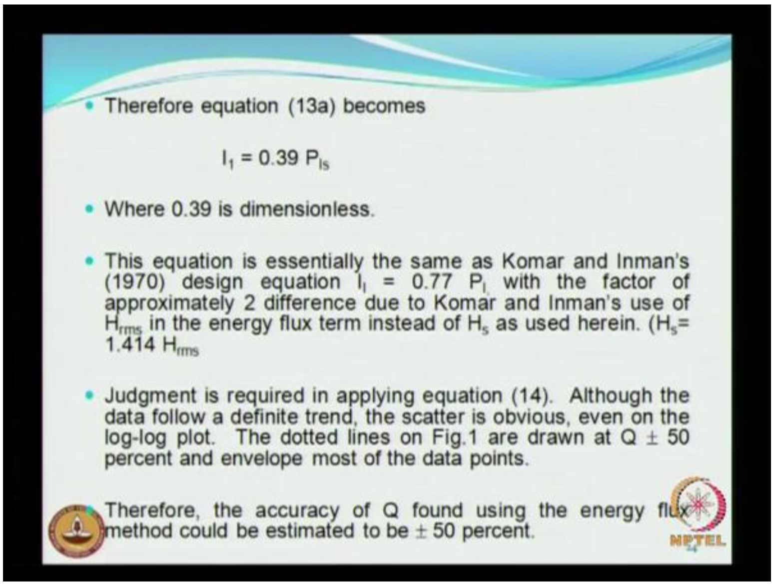

So, in this case a 0.39 is going to be dimensionless, now this equation is essentially the same as that a proposed by Komar and Inman. So, this they they were the guys who were working in this sediment transport they have contributed significantly. So, they came up with I l equal to 0.77 P l, so with a factor of approximately 2, so you can imagine the kind of variation. So, this you have to be very careful because I have seen some people using anywhere between a coefficient, anywhere between 0.3 to 0.77, but please remember that the difference is because this equation of Komar and Inman uses the H r m s.

That is root mean square value of the wave height, that is why you have a set of formulas there you understand table two and table one there are set of formulas depending on I will again show you them those formulas. So, you see the these formulas, so the other table also you have other formulas, so these these table gives, so many equations with which correspond to the type of input data you have from the field. So, you have to use only the respective equation I am repeatedly telling this because this is again a common mistake made by the people. So, here you see the difference because H r m s, H s equal to all of you should know that h s h s or h one third is approximately 1.414 into H r m s the earlier equation with a coefficient of 0.4 0.39 was derived with h s.

So, initially we started with a regular monochromatic wave wherein we used simply h and then we referred it to h s and we also said that it is it can be visually observed wave data know that is also called as h s b or whatever. So, this is for the wave height, but the formula that has been proposed by Komar and Inman has a value I l is equal to 1.14 into H r m s. So, here since we are using that H r m s in this formula the coefficient is, now it has it takes a value of 0.77. So, judgment is required, so this I have already explained here because in the earlier figure that in this figure you see that there can be so much of scatter. You can have deviation of even up to plus of minus 50 percent. So, you have to be very careful in looking at the values the equations etcetera.

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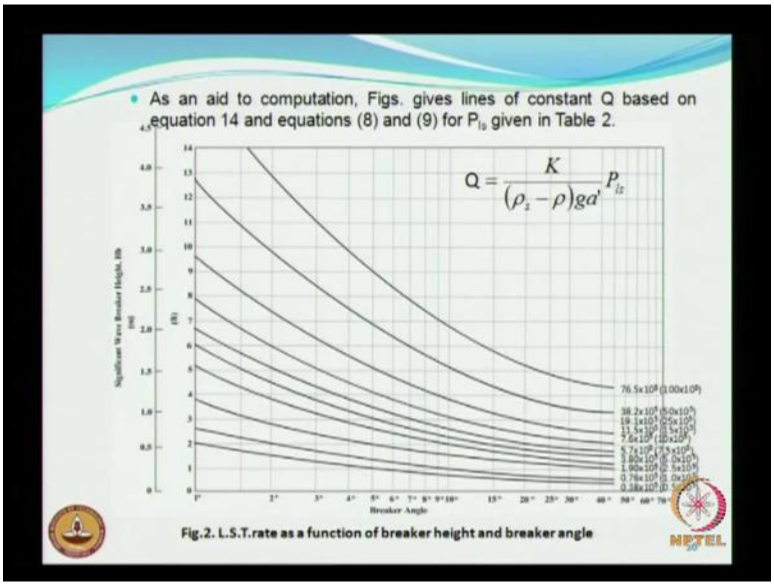

So, the, but this energy flux method is quiet straight forward and very easy to adopt see and as an aid of computation this figure again it is taken from the shore protection manual shore this was called as shore protection earlier. Now, it is renamed as coastal engineering manual how many of you have downloaded this manual manual how many only one no you have to read know no no no it does not because I have downloaded and it was quiet, it was so you have downloaded right. Some of you do not have this and really you are a kind of you want it badly you can talk to me after the class.

So, I can give a I can make some arrangements for you to have the copies then you can just exchange you can talk to my other students this is where because I cannot cover all that is available in the manuals. The books not possible with in this 40 hour of lecture, so I am just giving the overall picture, so as an aid of a computation this line this picture or the nomogram gives the relationship between the breaker wave angle and the breaker significant breaker height and it gives the quantity in as.

So, this is this gives a constant q based on equation 14. Where is equation 14? This is equation 14, which is readily available there on the as a legend. So, using this and equation set 8 and 9 of the P l s in table two. So, if you use that equation and then use this nomogram you are going to buy, if you use those equation you will get the nomogram as indicated here, which will straight away give you the quantity of sediment transport per year is that clear. So, what you need is the breaker angle and you know how to calculate the breaker angle, yes or no? Breaker angle, how do you calculate the breaker angle? How do you calculate the breaker angle? Because now you see that this if you want to use one of the simplest thing is you use this equation you use this nomogram.

What is that you need you need? Only the breaker angle, now and the significant wave height, now assume that someone has given you significant wave height significant wave height normally it is available it is a data. But breaker angle is not a data you have to evaluate the breaker angle. How do you evaluate the breaker angle? Yeah you calculate the breaker, breaker dept breaker dept you calculate, then why do you need the distance, what is that cos theta cos theta or sign theta? Sir, you will get distance between the rays then it will come cos theta. What is that you want, which one you will use because I am not interested in the distance, now yeah then sine theta then corresponding severities. So, then what will happen if you have c naught what you need you you will be needing the wave period, that is also an input which is given to you is that clear.

So, you will calculate your c naught, which is straight forward, which is nothing but 1.56 anyway we will work out the problem, but I just want you to recollect what we have done already. So, my we know once (( )) and you want to have at the breaker dept is that clear. Now, as he says you there are some formulas to calculate the breaker dept once I know the breaker dept can I get the breaker celerity? So, I I know this one I know breaker celerity the theta naught deporter direction is known to you which is going to be a input for you.

Because, now at this this also has to be the input then use this relationship, now you have this one, this one is there this one is there and may be theta one is the one you might need. So, all the other variables are known to you, so you can calculate the breaker angle once you know the breaker angle go into this figure and calculate your sediment transport it is not quite easy. But very often you need to use a lot of your judgment in dealing with problems related to sediment transport that is one important thing, which you have which you which you should have in mind know after this we also have another.

So, there are other methods for calculating the sediment transport rate, so what I have shown. Now, is for a given wave conditions may be significant wave height or H r m s or just H you can calculate the corresponding equations and calculate your sediment transport rate, is that clear? For everyday you can calculate, suppose everyday wave character 6 you have you can calculate the sediment transport everyday is that clear. Suppose if you have, what do you have the other method is that you have waves coming from different directions. So, for example, this is a north south and assumes that our cost is here.

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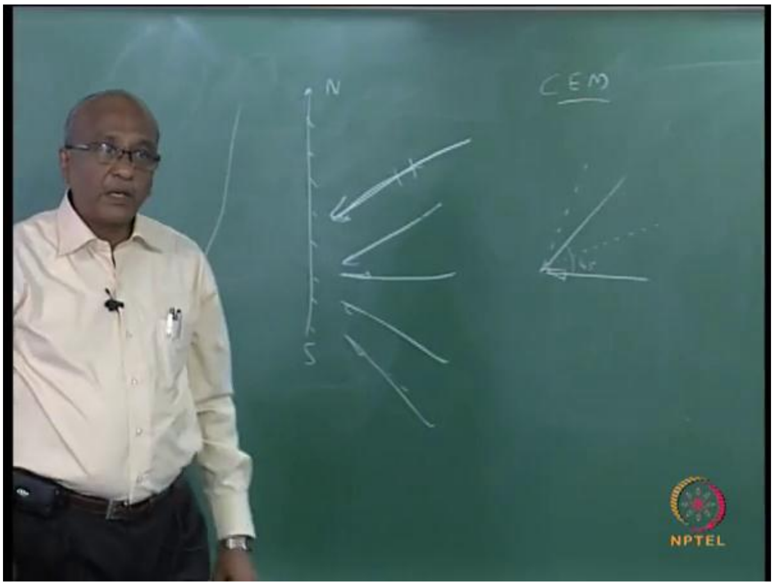

So, waves are coming in this direction canes waves are coming in this direction, this direction, this direction, this direction. So, all through all wave direction all wave directions are possible and each direction will have its own percentage of occurrence. So, considering the percentage of occurrence and how you share the energy between two segments for example, this is the wave direction and this will be split into some amount of energy can be propagating with in a particular sector.

For example, you you would have a wave sector see for example, this is 45 degrees waves are approaching. So, I can divide this into two sectors you understood, so the character six wave character six which is passing from this can be considered to be straight, but any other angle I will say that some amount of 50 percent of this is transferred within this sector and 50 percent is transferred within this sector.

So, this type of evaluating the sediment transport considering the percentage of occurrence of the wave characteristics are clearly explained in again the C E M or the S P M, which I am not going to cover here. But you I suggest strongly suggest you have a look at all this things probably I might include the lecture material. But not here then there are some director measurements, which is very often a bit difficult to measure the sediment transport it is not so easy to measure the sediment transport then compared to the wave forces for example, you want to evaluate the wave forces on a Pi

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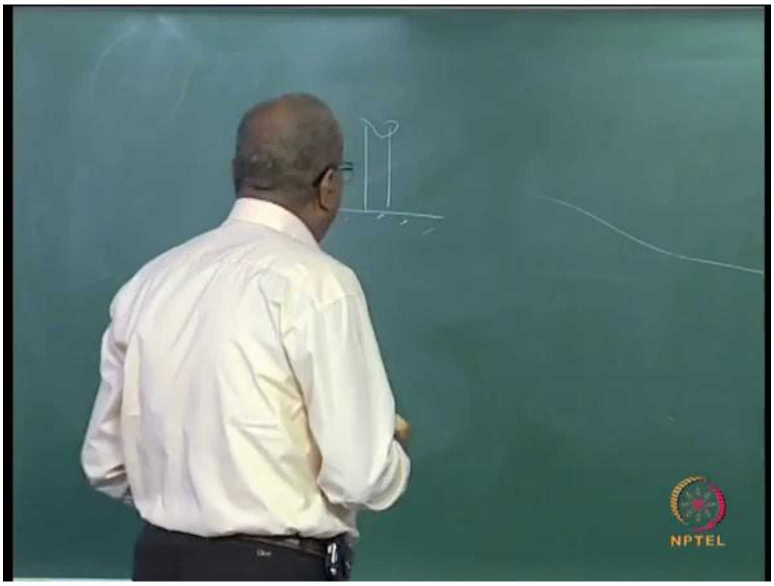

One way is you can straight away calculate a large diameter structure probably u can diffraction resume. You can either calculate numerically or you can do experiments any kind of such parameter such kind of waves structure interaction problem wave structure interaction problem that is not much of a problem. Because we use a particular scale model and then model the whole thing and get the results and reported in a dimensionless form look at my lectures on wave mechanics. But in the case of sediment transport it is rather why we say it is quiet complicated, not because of the calculation calculation of sediment transport as you have seen it is quiet straight forward. But assigning the values for the parameters, which are involved that is bit some sometimes its big complicated or questionable and more.

So, is when you want to simulate a kind of a field the problem concerning sediment transport in the lab it becomes very difficult I will not say impossible, but using any kind of a scale its difficult. But for the simple reasons if you have a a rigid bed this is also very important when you want to re simulate a rigid bed it is, what do you mean by semi rigid bed? How does your flumes look like? What about the bed are you simulating the sand? We do not simulate the sand bed and what is the basic assumption in the small amplitude wave theory the bed is horizontal impermeable.

So, we have, so much of it is, so convenient comfortable for us to use that assumption, but can you use at same kind of an assumption in a problem related to sediment transport it is not possible. Because the main governing things is the type of a sand that needs to be modeled how do you model if you model a scale if you model a structure you have to model the scale down the wave height wave period wave water depth also the grain size you understood. So, that is why it is very difficult to model the, so we so we call that if you want to model also this then we call it as mobile bed modeling the bed is also mobile, so mobile bed modeling.

All the people have done some results, so you can search for mobile bed modeling under coastal engineering probably you will get some information in which Google there are several other suggestions or I mean way to calculate their sediment transport. One widely adopted is which was adapted earlier, this is apart from the satellite image etcetera you know you can use g i as satellite images all those things have come in a big way in order to assist the variations in the shore line’s etcetera.

Now, shore line positions or oscillations of shore line this is a littoral environmental observation this is very popular because this is quiet straight forward, which is used for getting some information about the P l s parameter. As well as once you get the p l s parameter you can straight away calculate your sediment transport quiet straight forward. So, the formula shore is like this the equation giving the long flux factor with LEO data variables I will come back to that LEO variable data later.

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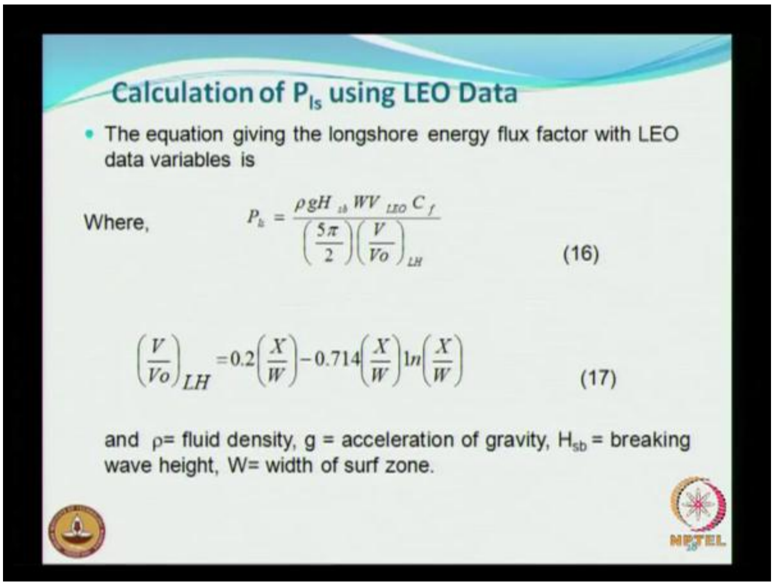

So, here we see the, a equation where in you have a all this this is H s b you know w w v w v v LEO sorry. Then C f and V divided by V naught into L H suffix L s, so rho all these variables are defined here v is the surf zone surf width and this this is given as this parameter this this ratio is given by this this is the surf width and then X. I will come back to X later because X is based on the methodology and we will work out a problem using this method.

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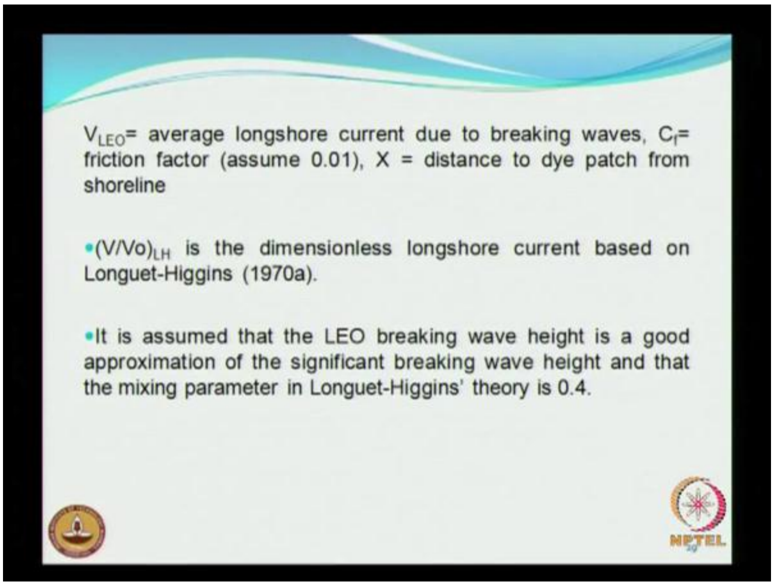

So, here the V LEO is nothing but the average longshore current velocity due to breaking waves longshore current is what longshore current is it has been proved that they are wave induced currents. These wave induced currents are due to the waves breaking I have told you number of times C f is the fiction factor, which is assumed to be 0.1 and then X is you from the shoreline see from the shoreline you dispatch some amount of dye patch. So, this is going to be your X whereas w is nothing but the width of the surf zone if you want you can maintain X constant, but surf with can vary from month to month or it may also be constant for may be two months or three months depends on location to location season wise all those things. Now, this V by V V l X that is given by (( )).

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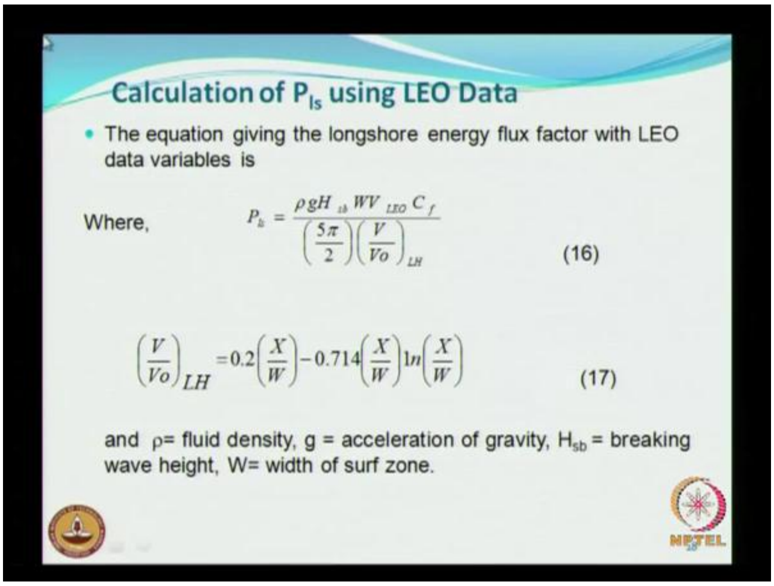

This equation is given by (( )), so once you know the surf width and the distance up to where you have dropped your dye patch you can get all this information and then you can derive the you can calculate your… So, what they do is I need to just spend some time here see there are different ways of doing a costal engineering survey.

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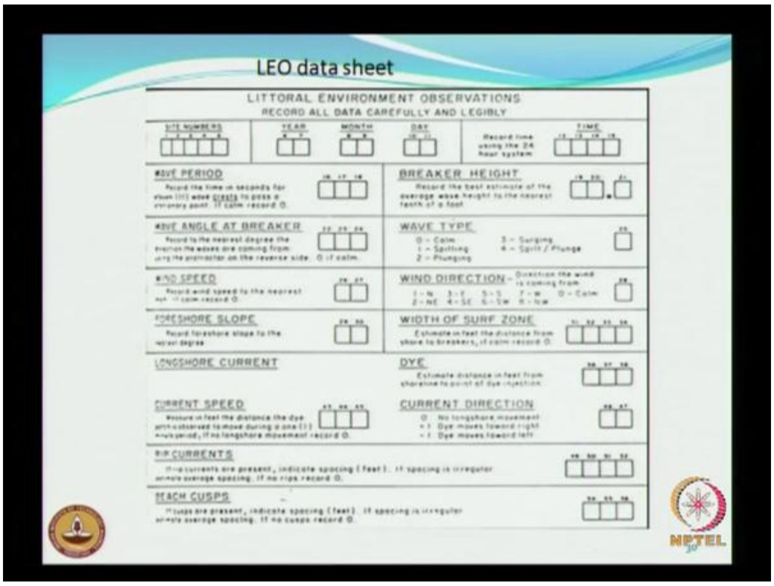

It depends on the type of problem, but somehow for many projects it is not standardized, so for here you see that this is a data sheet littoral environment observation. So, you see that data this site number is there year is there month is there day time all this all are on top and then you see other parameters that is wave period what is a wave period on that particular day for that particular site. So, it contains breaker type breaker height whether breaker type where wave type is whether it is spilling because this is very easy see the for example, wave breaker type it is not quiet straight easy because you know the definitions of the different kinds of breaking of waves.

So, then it also contains the wind speed the wave wind direction width of the surface zone the dye patch how much distance the estimate the distance from the shore line up to the dye patch all these information can be you can also measure the current velocity when the dry patch is moving you can you know you take two reference points. You can calculate the, you can measure the movement of the base on the movement of the dry patch you can measure its velocity.

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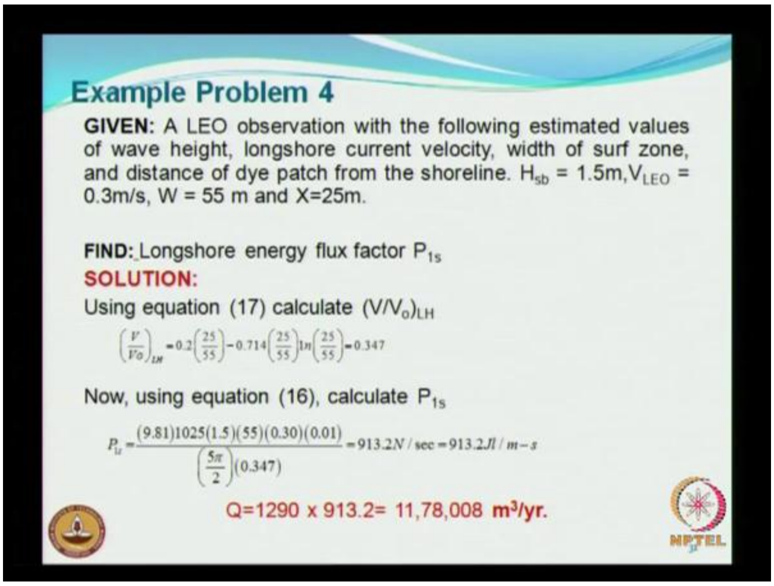

So, all these things are given in an kind of a data sheet which is called as LEO data sheet littoral environment observation data sheet. Now, what I have done is I have just used I have just given a problem here a LEO observation with following estimates are given what are what are the things H s b is 1.5 meters V LEO, which has been measured based on the by traversing the dye patch is 0.3 meter per second then width of the surf zone happens to be 55 meters and X equal to 25 meters.

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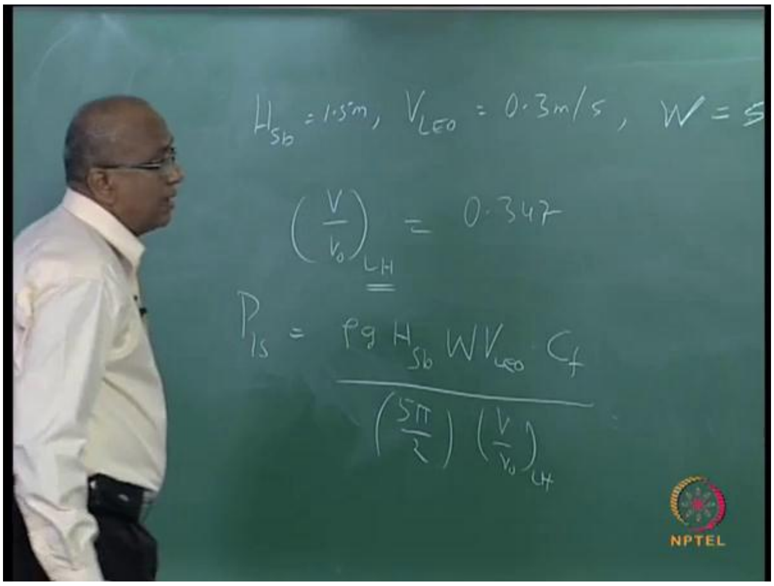

So, you from this you can easily calculate your V by V l H V this is l H stands for (( )). So, he is the one who has proposed this equation or expression where in using that because all these variables are known to you these are all these are all constants and only this 25 and 55 is going to change and then that is going to be around 0.347 is that clear. Now, then you use the equation what is the equation this is P l s equal to rho g H s b V LEO into C of dived by 5 by… So, that is the equation, which when substituted here this I have substituted this I have substituted 1.5. This is 55 then V LEO is how much V LEO is 0.3 and C f is 0.1.01 and then this is what we have calculated as 3.34. So, you have a the final value, which is given there on the right hand side and that you need to multiply it by 1200 and 90 is that clear.

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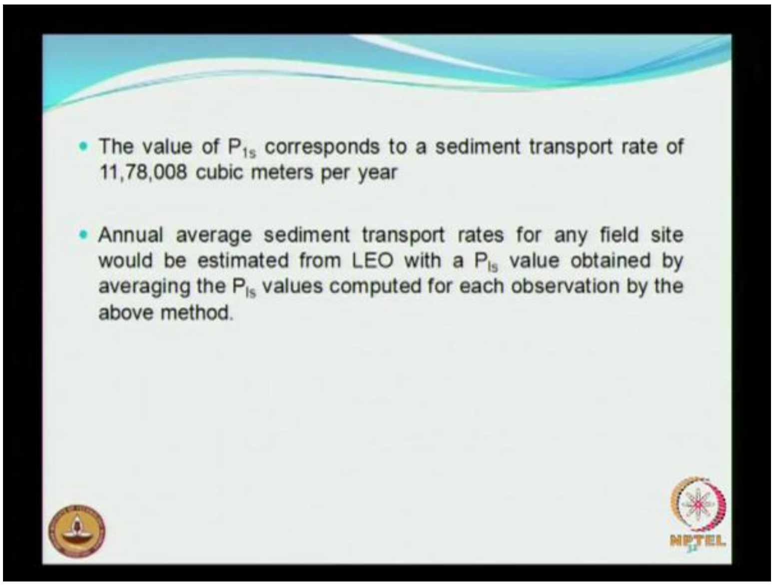

That is going to be your equal I mean value for your sediment transport is that clear. So, the value of P l s corresponding to a sediment transport of this much is given there then annual transport rates for any field site would be estimated from LEO with a P l s obtained from by averaging the P l s values computed for each observation by the above method. So, for each observation you can calculate all these things and put everything together and give come out with the final rate.

So, and also with this expression you can get this daily sediment transport monthly sediment transport all those parameters you can easily obtain, any doubts? No doubts? Now, empirical (( )) of gross transport rate what is this grass transport irrespective of the direction. So, longshore sediment transport rate depends partly on breaker height since breaker height increases more energy is delivered to the surf zone, because surf zone is the area zone of active sediment transport at the same time as breaker height increases breaker position moves off shore.

So, when the breaker height increases it moves off shore, so that the the area over which the sediment can move that is the basically the surf rate will widen. So, that is what happens along the east coast along the east coast during the months of June to August your breaker height will increase and once it is increases the surf width surf width increases it goes up to about even 400 meters. During other other months of the years it can be around 75 meters or may be even 50 as low as 25 meters. Also if it is really a very calm area calm zone it will be only just 25 meters.

So, along the east coast it can go even up to about 300 meters is that clear. So, this again is taken from the coastal engineering manual.

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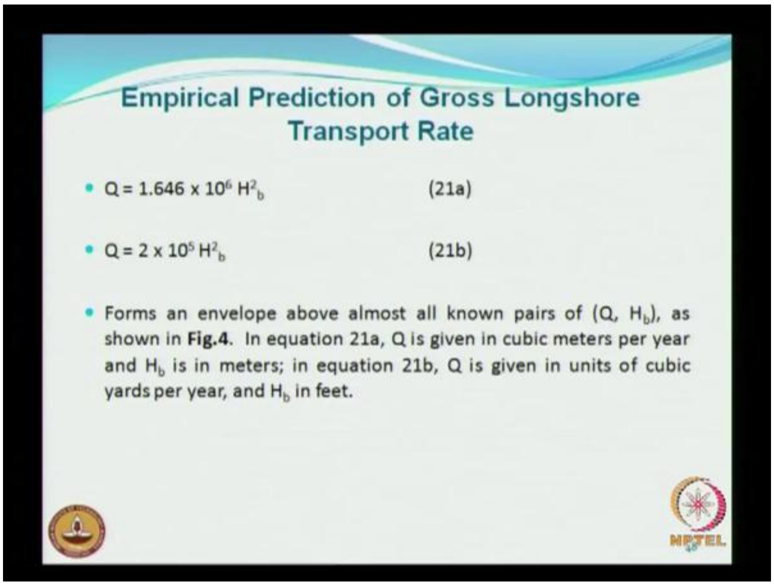

So, the empirical relationship prediction for the cross sediment transport you have a equations as given here for the two things and then you can refer to again your short protection manual for other details. At least I am just giving you the some of these information's are available, but you basically know how to calculate the sediment transport, do you know how to calculate the sediment transport rate? Yes once you know the wave characteristics you can calculate your sediment transport rate once you know the sediment transport rate that will all automatically take care of the direction.

So, if you include the direction you are going to get the net sediment transport if do not if you consider only the absolute values that is going to give you the gross sediment transport. So, this is only an additional provision information for you but we will use only the equations or the methodology that is usual normally used for calculation of the sediment transport and then come arrive at the net and the gross sediment transport rate.

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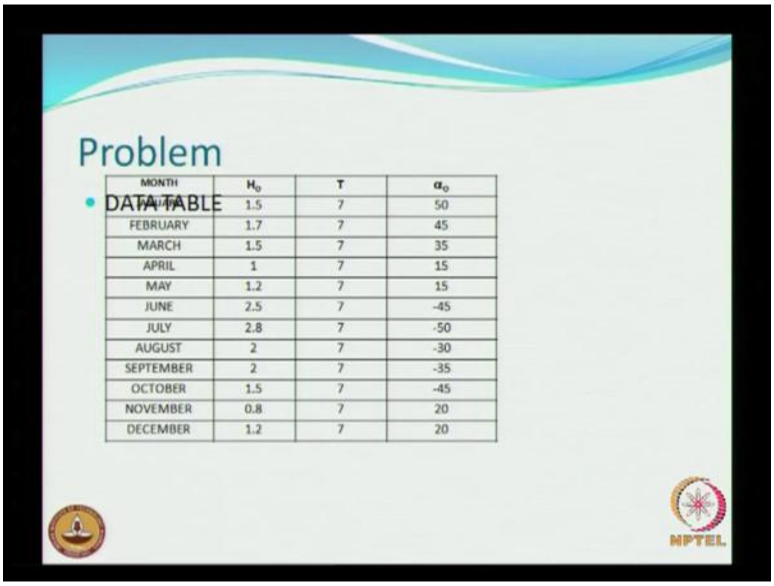

MONTH	H_o	T	α_o
[illegible]	1.5	7	50
FEBRUARY	1.7	7	45
MARCH	1.5	7	35
APRIL	1	7	15
MAY	1.2	7	15
JUNE	2.5	7	-45
JULY	2.8	7	-50
AUGUST	2	7	-30
SEPTEMBER	2	7	-35
OCTOBER	1.5	7	-45
NOVEMBER	0.8	7	20
DECEMBER	1.2	7	20

So, here the problem we are considering a a problem here where in you have a January to December the mean wave height the wave period and alpha naught assume that this information is given to you and you also have positive and negative.

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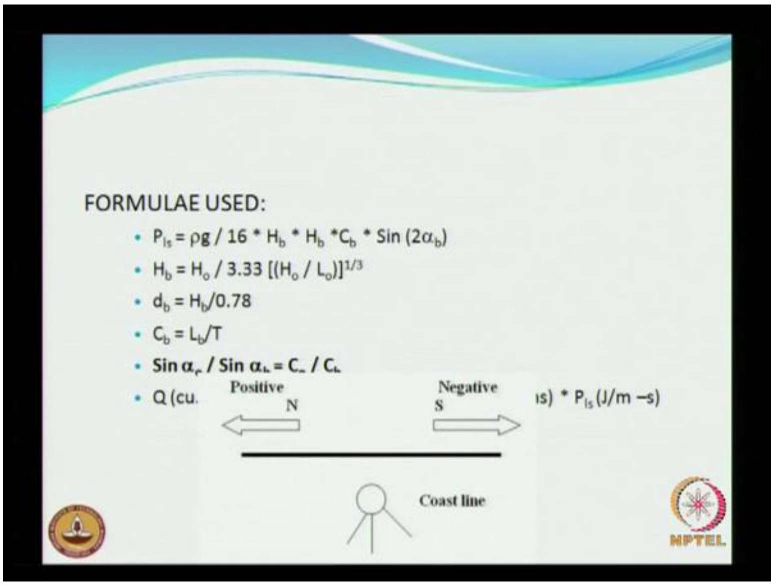

Now, I calculate the formula (( )) calculate the sediment transport rate, now this is negative and this is positive. So, P l s parameter is given, now I have H P is equal to because what what are the data available to you, the data available to you are H naught and H naught and L naught. So, then I can use the first expression there are, so many expressions suppose the b b slope is also given, so you use the corresponding expression for getting the a break way height. We have seen several formulas for getting the breaking wave characteristics under wave deformation lecture material under this topic we have discussed.

So, many formulas, now you have wave height and wave deporter wave height. So, you can calculate all these things, so you can calculate your once you can calculate this you can also calculate your D b, am I right, that is breaker depth once you know the breaker depth this is what we discussed just now sometime back. Now, let us look into a problem concerning the estimation of sediment transport. So, here in we are interested in finding out the monthly sediment transport rate remember here this in this example we have not considered the angle of co the inclination of the coast all those things. So, you are straight away given the deporter wave direction the wave period and the de porter wave height for the different months.

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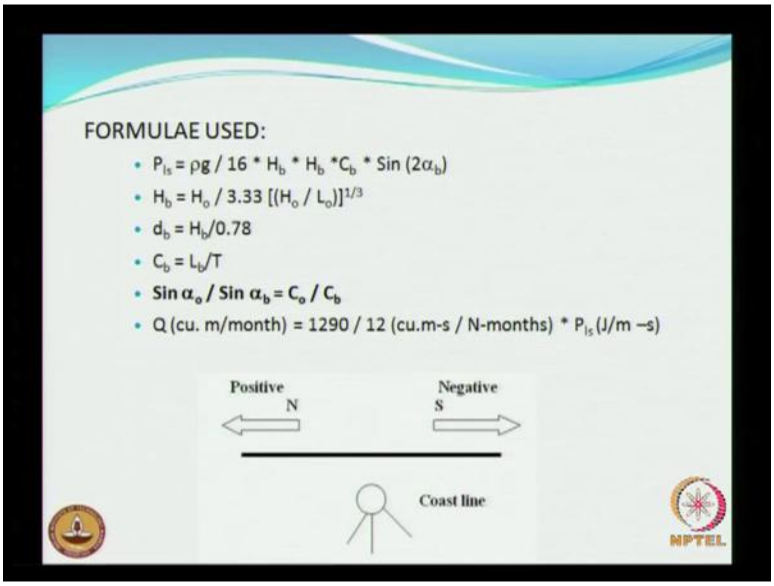

So, the formula available for you is your P l s parameter, which is given here, now H p can be calculated as shown here remember we have several formulas for estimating the breaker breaker wave characteristics. I would not say breaker dept alone breaker wave characteristics and for which you need to also look at my lecture material on wave deformation. So, once you know the breaker height you can calculate your breaker depth why breaker dept is needed breaker dept is needed to calculate the breaking celerity why breaking celerity is needed to use this Snell’s law for breaker angle.

Because breaker angle is the parameter, which is really controlling the direction as well as the quantity of sediment transport, now this is the equation which we use for predicting the breaker angle. Here you have the quantity of sediment transport every month divide by 12, I will get n months is that clear. Now, I am using negative sign for Southerly transport and Northernly transport positive for the Northerly transport assume that this is the cost line. I am looking into the ocean from this side.

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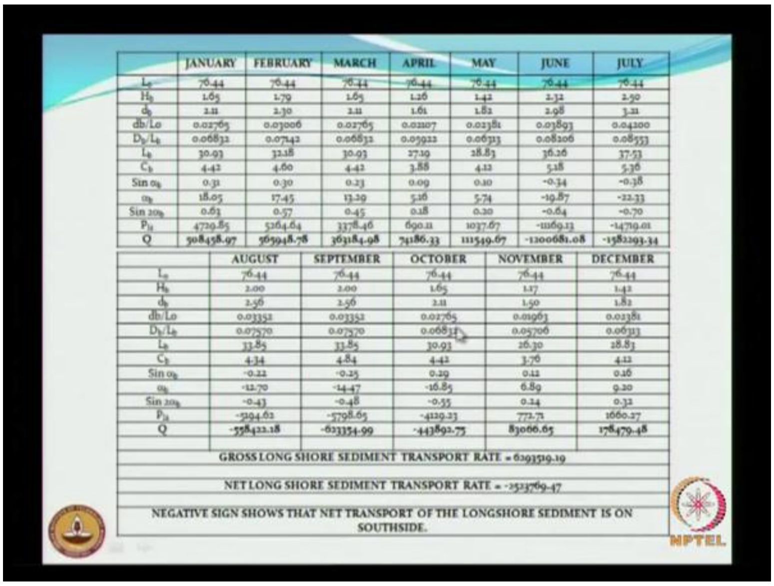

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY
L_o	76.44	76.44	76.44	76.44	76.44	76.44	76.44
H_b	1.65	1.79	1.65	1.26	1.42	2.32	2.50
d_b	2.11	2.30	2.11	1.61	1.82	2.98	3.21
db/Lo	0.02765	0.03006	0.02765	0.02107	0.02381	0.03893	0.04200
D_b/L_b	0.06832	0.07142	0.06832	0.05922	0.06313	0.08206	0.08553
L_b	30.93	32.18	30.93	27.19	28.83	36.26	37.53
C_b	4.42	4.60	4.42	3.88	4.12	5.18	5.36
Sin α_b	0.31	0.30	0.23	0.09	0.10	-0.34	-0.38
α_b	18.05	17.45	13.29	5.16	5.74	-19.87	-22.33
Sin $2\alpha_b$	0.63	0.57	0.45	0.18	0.20	-0.64	-0.70
P_{ls}	4729.85	5264.64	3378.46	690.11	1037.67	-11169.13	-14719.01
Q	508458.97	565948.78	363184.98	74186.33	111549.67	-1200681.08	-1582293.34

	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
L_o	76.44	76.44	76.44	76.44	76.44
H_b	2.00	2.00	1.65	1.17	1.42
d_b	2.56	2.56	2.11	1.50	1.82
db/Lo	0.03352	0.03352	0.02765	0.01963	0.02381
D_b/L_b	0.07570	0.07570	0.06832	0.05706	0.06313
L_b	33.85	33.85	30.93	26.30	28.83
C_b	4.34	4.84	4.42	3.76	4.12
Sin α_b	-0.22	-0.25	0.29	0.12	0.16
α_b	-12.70	-14.47	-16.85	6.89	9.20
Sin $2\alpha_b$	-0.43	-0.48	-0.55	0.24	0.32
P_{ls}	-5194.62	-5798.65	-4129.23	772.71	1660.27
Q	-558422.18	-623354.99	-443892.75	83066.65	178479.48

GROSS LONG SHORE SEDIMENT TRANSPORT RATE = 6293519.19

NET LONG SHORE SEDIMENT TRANSPORT RATE = -2523769.47

NEGATIVE SIGN SHOWS THAT NET TRANSPORT OF THE LONGSHORE SEDIMENT IS ON SOUTHSIDE.

So, when I use all these things please have a look complete look into the values when you have slowly you look into this how we have calculated take for example, your month of January I will just explain for month of January it is just, repeated for all the months. So, first you calculate the de porter wave length and then use the equation for let me write here, so that this is what is given, now we will just check for the month of January.

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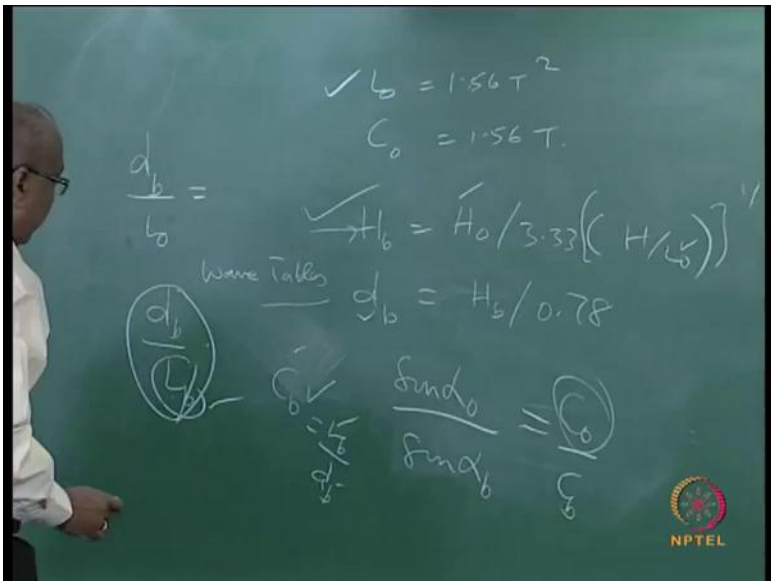
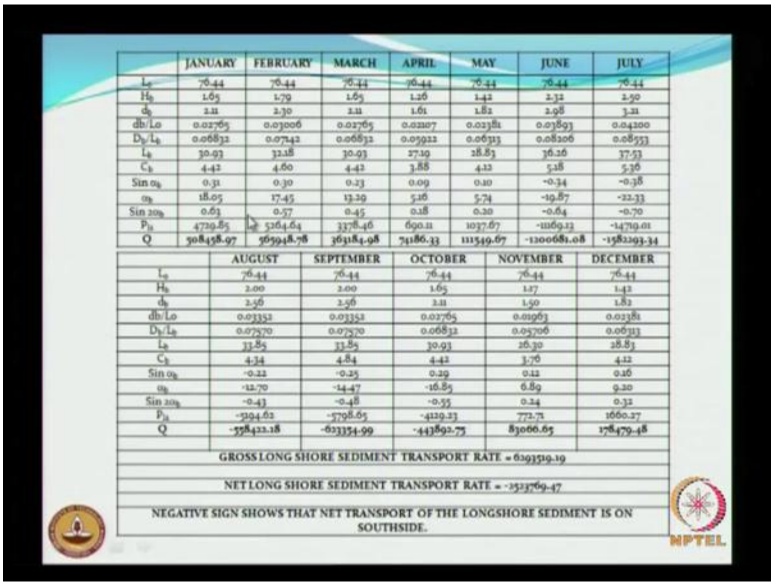


So, L naught is calculated look at the board where I have written all the formulas then you have H b using the second formula because here wave height is known to you L naught you have calculated. So, you can calculate H b, now you have, now u can since L naught is also known the third rho can be easily calculated. Once you calculate d b d add b by L naught you can calculate d b by L b using the wave tables which we have already done then once that is known once this is a then l b can can be calculated once L b is calculated.

So, once this is known you can calculate this because d b is already known to you d b are already known to you. So, once you have picked from the table the corresponding to D b by L naught I will repeat D b is calculated then D b by l naught is calculated. Once this is calculated go to the tables arrive at the L b once L b is calculated, calculate your C b, which is nothing but l b by D b. So, this is known this is known, so this can be found, so L b by t sorry. So, C naught is known to you C b is known to you L naught is also known to you the alpha naught is already known to you it is an input, so you can calculate sine alpha b.

(Refer Slide Time: 42:12)



	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY
L_o	76.44	76.44	76.44	76.44	76.44	76.44	76.44
H_b	1.65	1.79	1.65	1.26	1.42	2.32	2.50
d_b	2.11	2.30	2.11	1.61	1.82	2.98	3.21
db/Lo	0.02765	0.03006	0.02765	0.02107	0.02381	0.03893	0.04200
D_b/L_b	0.06832	0.07142	0.06832	0.05922	0.06313	0.08206	0.08553
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Q	**-558422.18**	**-623354.99**	**-443892.75**	**83066.65**	**178479.48**

GROSS LONG SHORE SEDIMENT TRANSPORT RATE = 6293519.19

NET LONG SHORE SEDIMENT TRANSPORT RATE = -2523769.47

NEGATIVE SIGN SHOWS THAT NET TRANSPORT OF THE LONGSHORE SEDIMENT IS ON SOUTHSIDE.

So, calculate your alpha b, which is nothing but the, I mean the breaker angle then sine alpha 2 b is needed. Then finally, arrive at the value for Q. So, for each month you can calculate what is, what are all these parameters? Then you can also try to look at the variation of all these parameters month wise every month. How your breaker angle looks? How the breaker height looks like? All this information can be obtained from this, then then you simply add these things irrespective of the direction you get the long shore sediment transport gross long shore sediment transport.

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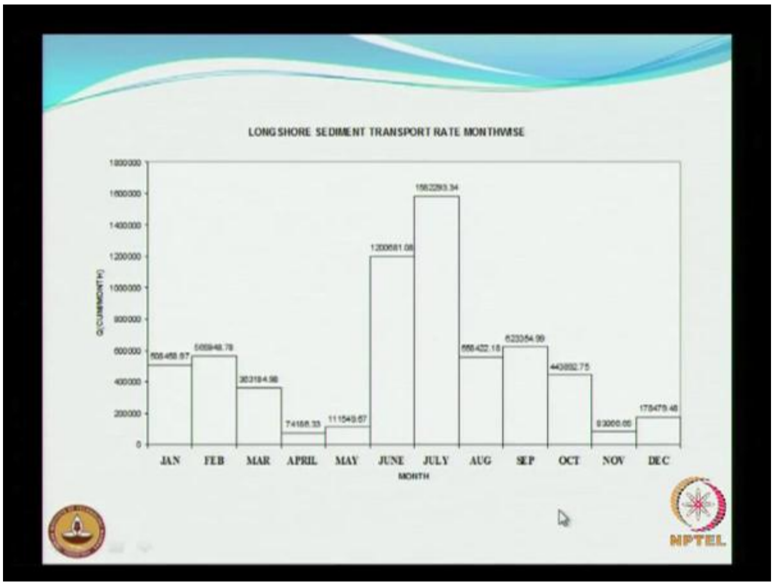
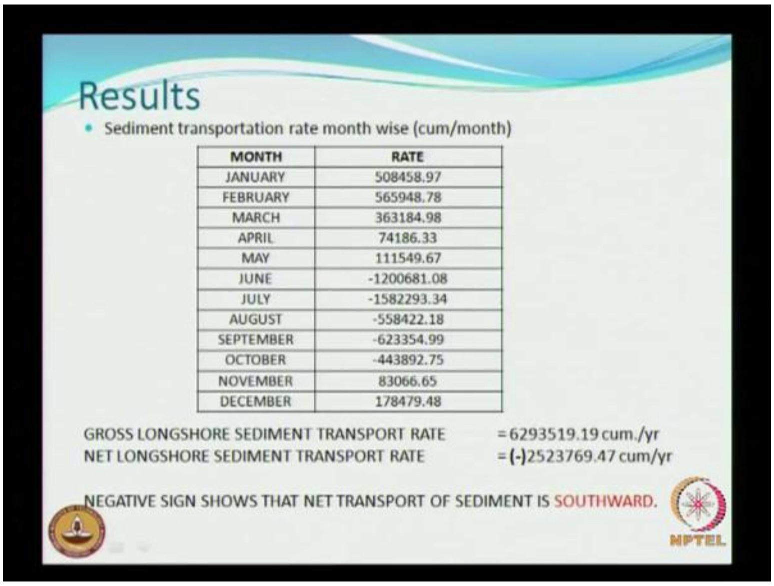


We have already seen why we need that and then next sediment transport by taking into accounts the directions. So, this is what I have said, then you this is the month wise sediment transport this is respective of the direction this is a pictorial representation or you can also represent in terms of net that is every every month with respect to with directions positive and negative. So, your line will be 0 and then it will be oscillating either positive or negative is that clear?

(Refer Slide Time: 43:30)



MONTH	RATE
JANUARY	508458.97
FEBRUARY	565948.78
MARCH	363184.98
APRIL	74186.33
MAY	111549.67
JUNE	-1200681.08
JULY	-1582293.34
AUGUST	-558422.18
SEPTEMBER	-623354.99
OCTOBER	-443892.75
NOVEMBER	83066.65
DECEMBER	178479.48

So, the results are shown here these are the results and this is the gross sediment transport and this is this net sediment transport. Negative sign shows that the net sediment transport is towards the south ward this is only a demonstration, how you go about in calculating the sediment transport is that clear all of you.

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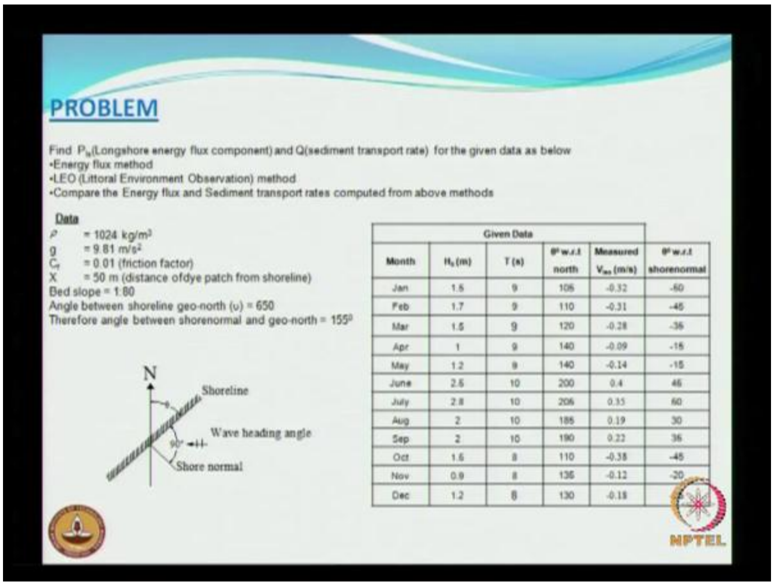

So, I think I think I will close with with this.