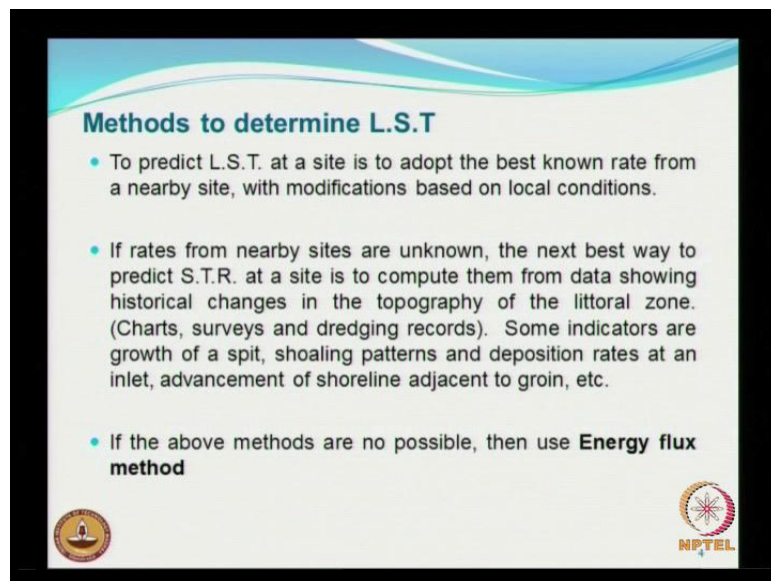


Coastal Engineering
Prof. V. Sundar
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 2
Sediment characteristics and longshore sediment transport
Lecture - 5
Longshore sediment transport – I

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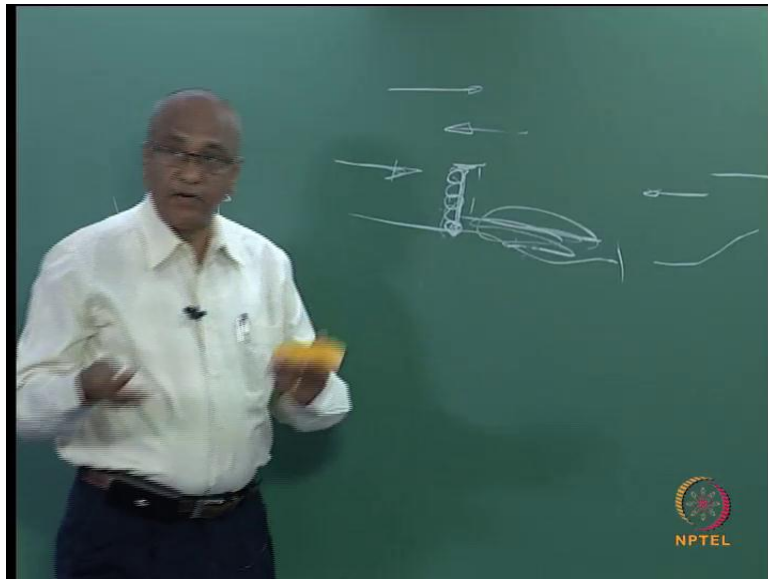
Methods to determine L.S.T

- To predict L.S.T. at a site is to adopt the best known rate from a nearby site, with modifications based on local conditions.
- If rates from nearby sites are unknown, the next best way to predict S.T.R. at a site is to compute them from data showing historical changes in the topography of the littoral zone. (Charts, surveys and dredging records). Some indicators are growth of a spit, shoaling patterns and deposition rates at an inlet, advancement of shoreline adjacent to groin, etc.
- If the above methods are no possible, then use **Energy flux method**

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In the last class, we had been looking at the methods; I have explained some of the basic methods that you could probably consider in order to understand the quantity as well as the direction of littoral drift. The direction may not be so difficult because particularly in case there are some obstructions jetting into the ocean in the sight of interest is very easy to see when there is the net drift based on the formation of the beaches. You can easily find out which is the direction of littoral drift.

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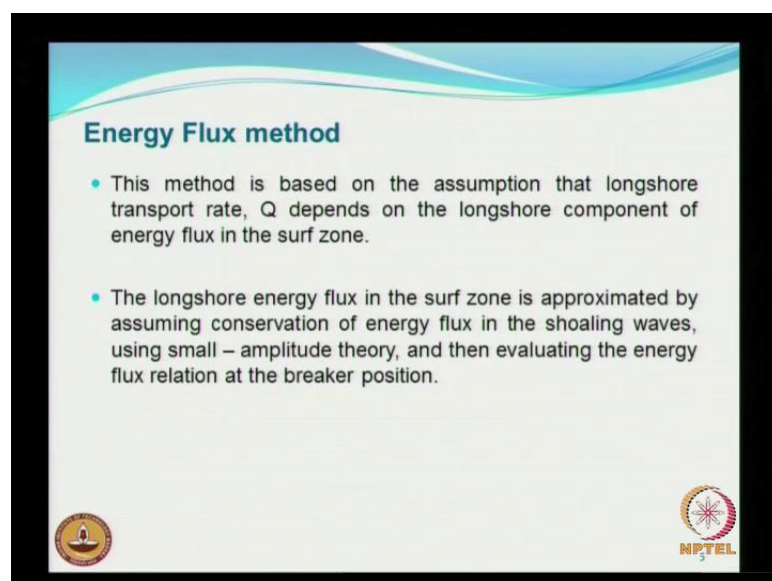
So what one can also try, suppose in case the direction of littoral drift is very important because that determines the location of your structure; for example, as I said earlier if you are supposed to construct a training wall and in the event or maybe you want to see that there is some amount of littoral drift either in this direction or in this direction. And you would like to have a kind of erosion somewhere here; maybe it is a training wall or maybe it is open beach where you want to develop, for example, let me say that you want to develop either this problem either this problem or you want to have something like a beach somewhere here may be for tourism purpose but you do not know whether the wave is coming in at the sediment transport is coming in this direction or in this direction.

One way of doing the calculations are using your littoral drift using some of the methods which I had already explained but then we will go in to the energy flux method later, that gives both the direction as well as the magnitude. But if you want to plan some structure and if you are in a sort of confusion particularly for India particularly the case of Kerala coast where the direction of littoral drift keeps changing for different stretches. So this problem does not arise as I told earlier for the case of east coast of India but similar to this there are several coasts all over. So, in such a case what you could probably do for example, if you have this kind of structure and you want to see that some kind of the direction to have some kind of information, you can have something like a temporary groin. So, the cheapest could be driving of Casuarina poles; quite cheap, you can drive it, wooden poles something like a barrier.

So, the basic idea is to create the temporary barrier and that itself will indicate you whether the net drift is in this direction or in this direction. In fact if you carefully monitor, you can also find out during which months the drift is in this direction and during which months the direction of the drift is on this side and you can have this kind of an exercise as the initial field study if before prior to going in for major investment into the formation of beach or whatever. Because naturally if the net drift is in this direction there is no point in having structure here when your area of interest is here, probably you might have to shift. So, this gives you the direction of littoral drift is extremely important. So, the other aspect is the length of your structure.



This I have already told you surf width up to the surf width it has to be constructed and the other aspect is the distribution of sediments whether there is a groin, suppose if you are thinking of a groin, whether it has to be like this or it has to be like this. This depends on the distribution of sediments in vertically; do you understand. Vertically in the sense, either you have a dominant of the bed load being dominating the whole sediment transport or the suspended load dominating the sediment load. This will detect the crest level of your groin; you understood. So, these are all indications wherein you can some kind of basic information which can be used for investigating or planning for costal protections. So, you might need structures to create erosion or you might need structures to allow for deposition; mostly we fight against erosion but the other aspect also sometimes plays an important role.

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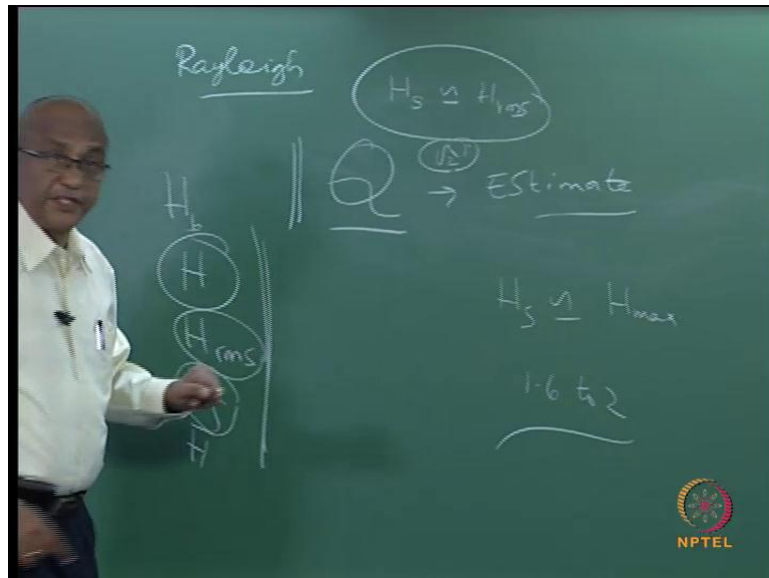
Energy Flux method

- This method is based on the assumption that longshore transport rate, Q depends on the longshore component of energy flux in the surf zone.
- The longshore energy flux in the surf zone is approximated by assuming conservation of energy flux in the shoaling waves, using small – amplitude theory, and then evaluating the energy flux relation at the breaker position.

The method of energy flux method, there are few other methods but the most widely method is the energy flux method; quite straight forward although you are having of coefficients and a host of parameters.

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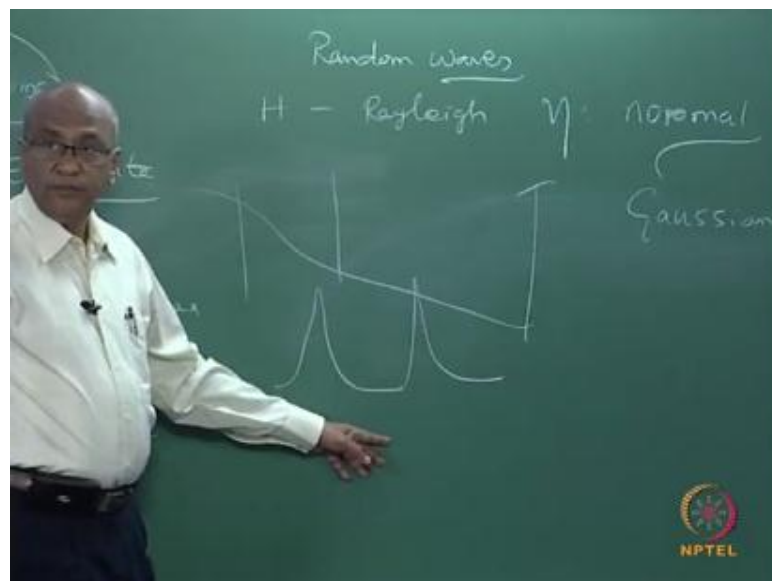


And please remember that the quantity of the sediment is only an estimate; it is it is just an estimate. How closely you estimate sediment transport in close to reality; that is important, that is where your formula comes into picture, the method also comes into picture and all these things are governed by number of empirical constants also. So, the method itself the method of estimating Q itself is quite straightforward. You are not dealing with implicit equations, etc. It is a straightforward close form solution but then why are we talking so much about the Q . So, because you have formulas you just put in some of those values for the different variables associated that is going to control your Q ; that is fine and then you use the expression you get some value.

But then you have to remember how exactly you are representing those variables; that is very important and the kind of data you are using. So, in that matter anything when you are talking about wave height. So, wave height you have just the wave height represented by a regular wave that represents a regular wave or you also have a H_{rms} or you have H_s and you also have H_{bar} . So, you see that there are so many variables and also you have H_b . This is a breaking wave height, this is H_{rms} root mean square value, H_s , H_{bar} , H_b . Please remember that H_s and H_{rms} are also related by square root of two.

On the basis when we looked at when we say that the waves follow when we assume that the waves follow a Rayleigh distribution. Then H_s is H_s and H_{rms} is related by square root of two. And similarly, H_s is also related to H_{max} whereas here it is square root of two but here it varies from 1.6 to 2. And all these relationships are on the assumption that the wave heights follow Rayleigh distribution but anyway the validity of Rayleigh distribution, although it has to be followed, if you want to use all these expressions but remember that in coastal waters the waves are mostly steepening; do you understand.

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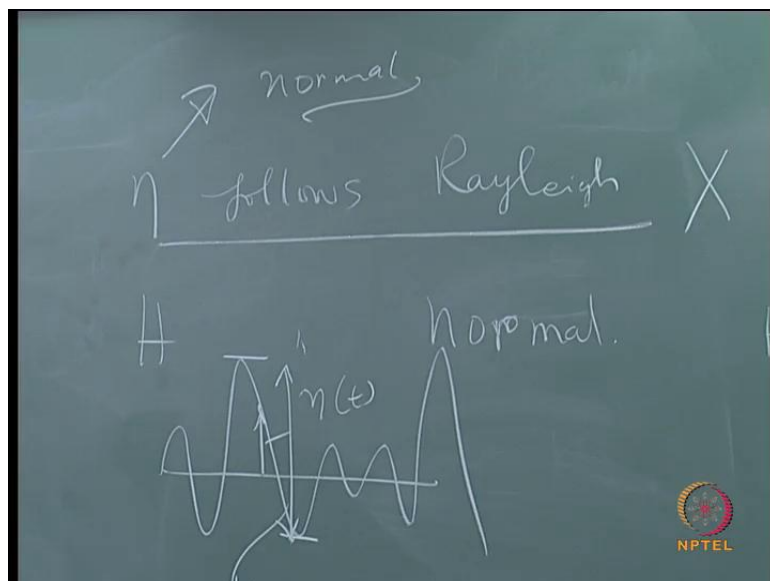
See Rayleigh distribution if you are talking in the deepwater, Rayleigh distribution can be okay, it is okay, because one thing you had to recollect the basics under waves statistics or you see my lecture on random waves. There I have clearly explained about all these different wave characteristics. So, when I say that the wave height follows a Rayleigh distribution that would automatically mean that η is a normal is a Gaussian process or it follows a normal distribution. This mostly I do not say I do not want to hundred percent generalize but in practical if you see, this would be mostly applicable in deeper waters. But in the shallower waters, you see that the steepening of waves would take place. The troughs are mostly flat.

Then the waves following a Rayleigh distribution is rather I do not say questionable; it is rather not that common. It is not that common as it is a bit more common in deeper waters for the simple reason the waves in shallow waters is steepen. So, there are some literatures

that say that such waves or the waves in shallow waters are best represented more closely as a function of Weibull distribution. It follows mostly Weibull distribution but Weibull distribution itself is nothing but an extension of Rayleigh distribution. Because this is a single parameter distribution but here it is a three parameter distribution; please look into the lecture material on random waves or you can look into any standard text book that has been mentioned in the literature.

So, we will be dealing with some of these variables. So, have that in mind and before going into this have a look at this material and then come back to this. So, what is this energy flux method? So, this is basic introduction, because some of these variables are going to appear in the energy flux method and that is the reason I gave a brief introduction about this normal distribution and the wave heights following a Rayleigh distribution. Please remember when you are attending the interviews, one of the common question they ask is what do you mean by Gaussian process?

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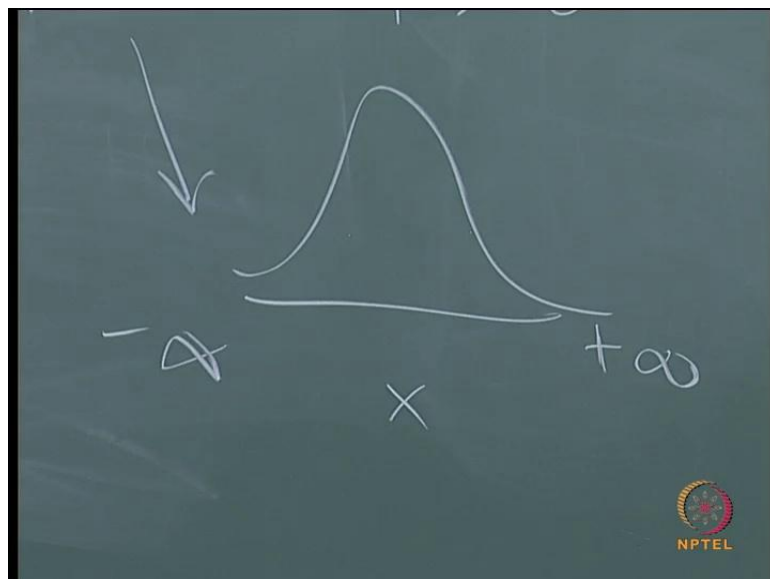


I have noticed many people many students saying eta follows a Rayleigh distribution. They interchange and wave height follows normal distribution. This is a common mistake made by the students. See Rayleigh distribution is valid for any variable which is greater than zero but eta can it be less than zero. First of all you should know what is eta and what is it. So, this is eta and the wave height is may be from this distance to this distance. So, wave height is always greater than zero. But what does normal distribution say? Normal

distribution is, but what is eta? Eta has a negative sign. So, naturally it will not be Rayleigh distribution.

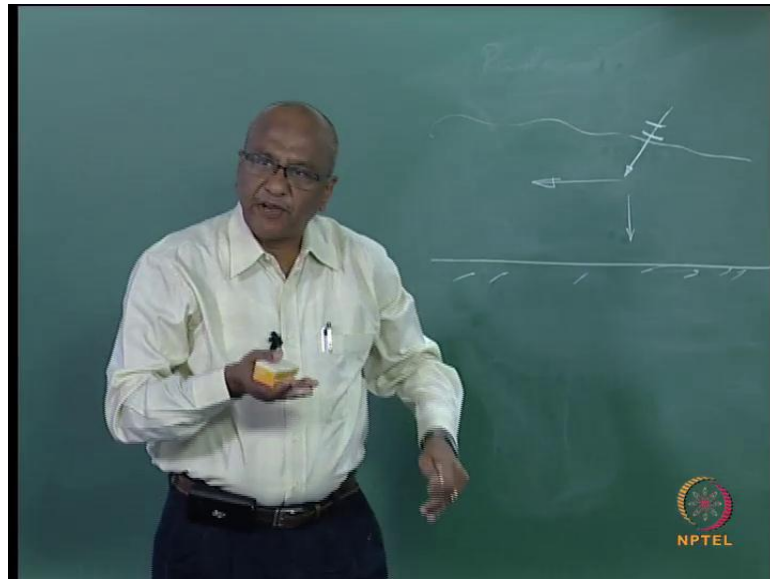
So, what about wave height? Wave height will always be greater than zero. So, this is wrong; eta following Rayleigh distribution is not correct; you understood. For the simple reason that eta can have negative values, not can, will have negative values. So, eta follows a normal distribution or it is a Gaussian process. And this I have clearly explained in the random waves lecture but this is only just a recollection of what we have already done in that course. Now the wave height will always be greater than zero.

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But here normal distribution is valid for minus infinity to plus infinity; that is the variable can vary from minus infinity to plus infinity. The probability distribution looks like this; try to recollect. So, this is also not correct. So wave height follows Rayleigh distribution. So, do not make the mistakes such mistakes as made in the past; have this in mind. So, shall I remove this? So, the energy flux method is based on the assumption that the longshore sediment transport Q depends on the longshore component of energy flux, longshore component of the energy flux; should we have to say surf zone. Here it is more specific surf zone.

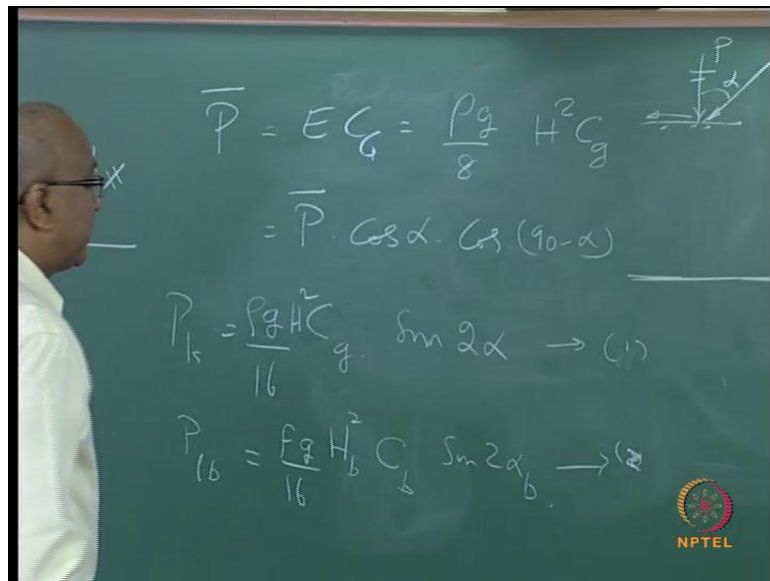
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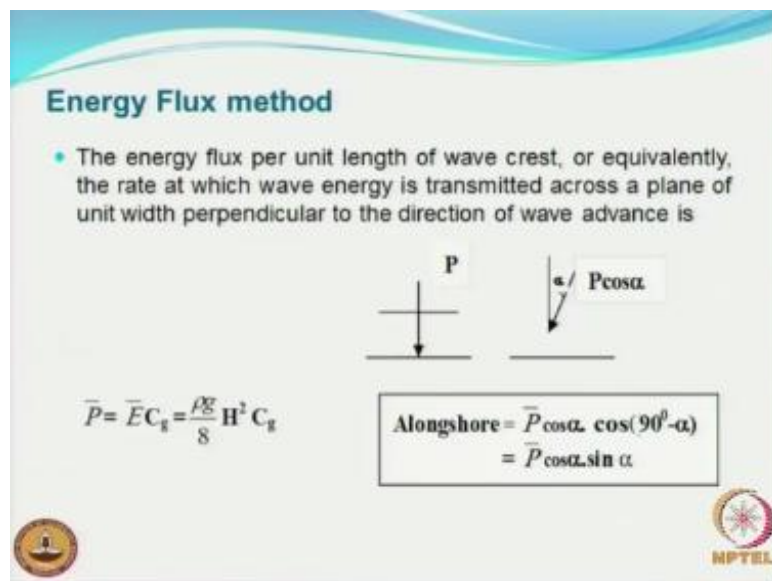
When we are talking about the sand movement please recollect that how the movement of sand takes place. Somewhere near the breaker zone, the waves break. The waves break and because of the wave breaking at an angle to the shoreline, you have two components as I mentioned; one is the on shore and the other is the longshore and also said that the longshore sediment transport is more dominant within the surf zone. Although there you may have certain amount of sand beyond the breaker zone but it is more dominant within the surf zone.

So, naturally we are considering the longshore component of the energy flux within the surf zone, understood. So, the longshore energy flux in the surf zone is approximated by assuming conservation of energy flux in the shoaling waves using small-amplitude wave theory and then evaluating the energy flux at the breaker zone. So, this we will be looking at the energy flux within this region and what is energy flux? Energy flux is nothing but some kind of driving force; that is nothing but you are driving force. So, that is what we are trying to evaluate here and how do we do that.

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So, now let me write this P. So, the energy flux when you have the energy power, what exactly is the power? The power is rate of change of the energy flux in the direction of wave propagation across the plane vertical extending from the seabed piercing the water surface. You are considering that vertical plane when the waves are moving towards the coast; is that clear. So, when the waves are moving; so we are considering a plane when you have the waves, we are considering a plane; all right. So, that is this plane and what is the energy flux across the plane that is what we did when we did the power calculations, basic wave mechanics.

So, now P is what? P is energy into group celerity which we have already seen and that is going to be $\frac{\rho g}{8} H^2 C_g$. This is for the case when the waves are attacking the coast normal to the, this is OP. But what is its component when it is attacking the coast? I also said that when we refer to the angles, we refer to the angles normal to the wave directions. We refer to the wave directions either with respect to north geographic north mostly in deepwater but when you are coming to the coast, even if you have with respect to north, you normally represent it as a function of with respect to the shore normal. Please have that in mind; in the last class also I said that this is the angle. When I say wave direction it is always with respect to shore normal as far as coastal engineering is concerned.

So, we will be talking about the power or the energy flux in the direction of wave propagation that is the power. Now you have a wave moving in this direction; that is that is going to take alpha. So, what will happen to your flux? Flux will be, so let me call this as P into cos alpha, right. In order to have the flux in the direction of wave propagation but original way of defining is power is normal to the shore. Now it is approaching the coast at an angle, hence you have P into cos of alpha but then what are we talking about which is going to be your driving force. The driving force will be along the shore; that is the one which is going to. So, actually this is the wave direction but what we are interested is the component in this direction the component of this in this direction. How do you get that? That will be resolving you will have sin of 90 minus alpha to get this.

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Energy Flux method

If the wave crests make an angle, α with the shoreline, the energy flux

$$\bar{P} \cos \alpha = \frac{\rho g}{8} H^2 C_g \cos \alpha$$

α = angle between wave direction and shore normal and the longshore component is given by

$$P_1 = \bar{P} \cos \alpha \sin \alpha = \frac{\rho g}{8} H^2 C_g \cos \alpha \sin \alpha$$

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So, that is what is explained here $P \cos \alpha \sin$, this will be this \cos . So, that will be \sin α but anyway this can be written as.

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Energy Flux method

Since $\cos \alpha \sin \alpha = \frac{1}{2} \sin 2\alpha$

$$P_s = \frac{\rho g}{16} H^2 C_g \sin 2\alpha \quad (1)$$

The approximation for P_s at the breaker line is written

$$\bar{P}_{lb} = \frac{\rho g}{16} H_b^2 C_b \sin 2\alpha_b \quad (2)$$

For linear theory, in shallow water $C_g = C$ and

$$P_{lb} = \frac{\rho g}{16} H_b^2 C \sin 2\alpha_b \quad (3)$$

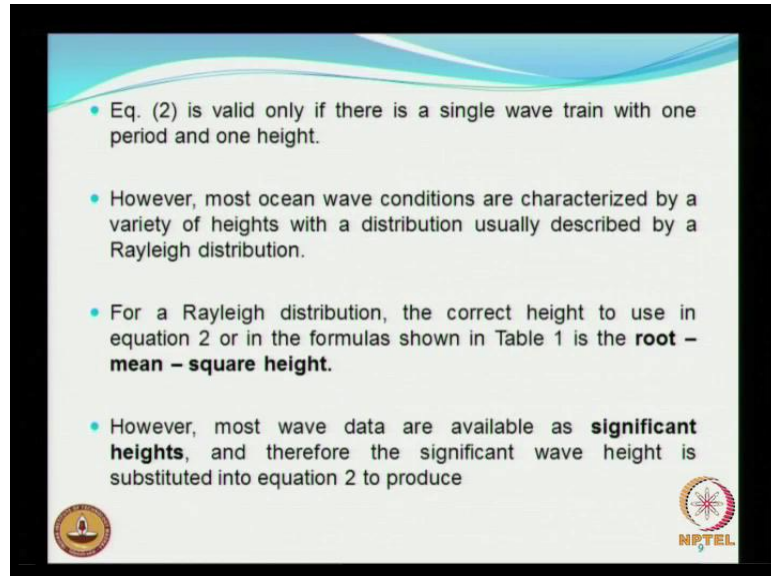
Where H_b and α_b are the wave height and direction and C_b is the wave speed evaluated in a depth equal to $1.28 H_b$.

So, once you have $\sin \alpha \cos \alpha$, you can write this in the usual trigonometrical sense as $C g \sin \alpha \sin 2 \alpha$ because of this $\sin \alpha \cos \alpha$ you will have half; that half will take place here and this is nothing but E is ρg . So, now you have ρg divided by 16; is that correct, of course you have H square. So, that is the energy flux within the surf zone. Now at the breaker zone this will let me call it as P_{ls} ; this is referred to as P_{ls} parameter. Now where does it initiate? It initiates at the breaker zone. So, if we want to have at the breaker zone then P_{lb} will be equal to ρg divided by 16. H will take the value of H_b , then C_g will take the value of C_b . So in shallow waters C_g equal to C itself right. So, then here it will be \sin of $2 \alpha_b$. This will be at the breaker zone.

So, now let me have this; this is going to be equation two, this is equation three. Of course, this I will just leave it as such. Let me call it as one and then because I will just reproduce the same thing here, this will be two. This is two and this one; is that all right. Because in order to match because it might be referring to some of these equations; so I do not want to keep changing my slides; able to follow. Now equation two is valid only if you are talking about a single wave train with described by or defined by a wave height and a period. However, most ocean conditions are characterized by a variety of waves and with the

distribution usually, it is not a must; usually it is it can be described by a Rayleigh distribution. For a Rayleigh distribution, if you want to apply the Rayleigh distribution.

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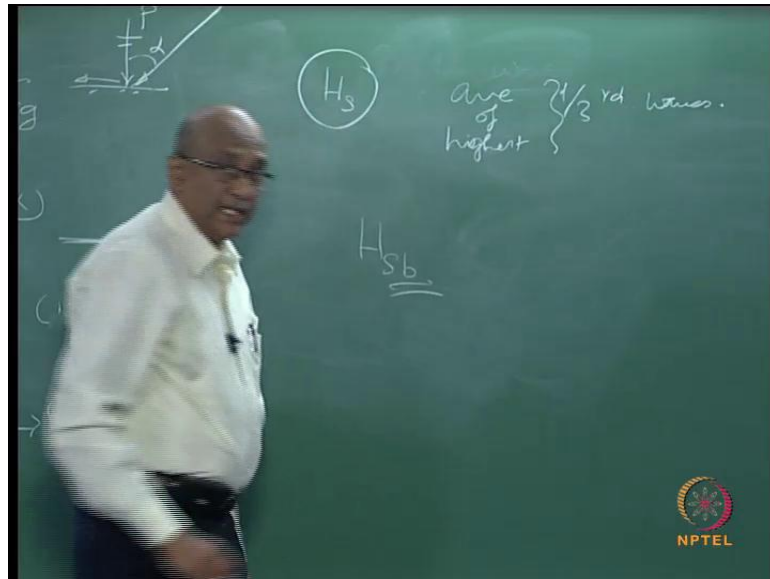


The slide features a light blue header with a wavy pattern. Below the header, there are four bullet points. The first bullet point states that Equation (2) is valid only for a single wave train. The second bullet point notes that most ocean wave conditions are characterized by a variety of heights, typically described by a Rayleigh distribution. The third bullet point specifies that for a Rayleigh distribution, the correct height to use in Equation 2 or the formulas in Table 1 is the root-mean-square height. The fourth bullet point explains that most wave data are available as significant heights, and these can be substituted into Equation 2. In the bottom left corner, there is a circular logo with a lamp. In the bottom right corner, there is a circular logo with a star and the text 'NPTEL' below it.

- Eq. (2) is valid only if there is a single wave train with one period and one height.
- However, most ocean wave conditions are characterized by a variety of heights with a distribution usually described by a Rayleigh distribution.
- For a Rayleigh distribution, the correct height to use in equation 2 or in the formulas shown in Table 1 is the **root – mean – square height**.
- However, most wave data are available as **significant heights**, and therefore the significant wave height is substituted into equation 2 to produce

The correct height to be used in equation two is a square root of root mean square height if you want to use the same equation for considering the real ocean waves that can be represented as a root mean square wave height. You know what is meant by root mean square the statistical parameter. So, you have to use and adopt this root mean square wave height. But mostly the random data is available as in the form of H_{rms} or in the form of significant wave height. Recollect that you wave two methods of analysis of ocean waves; one is the statistical method, another is the spectral method and significant wave height is the average of the highest one-third of the waves. So, most of the data are available with significant wave height and therefore significant wave height can be substituted in equation two.

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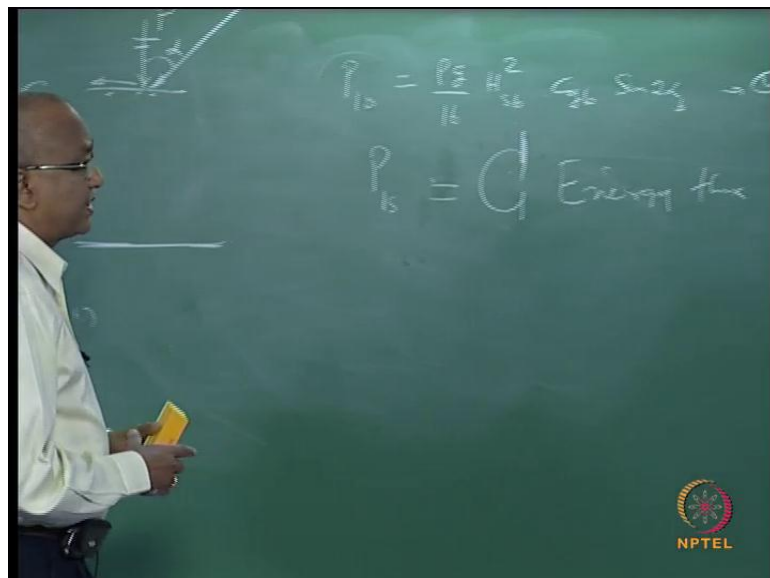


So, here I would like to say one thing. What is H_s ? H_s is average of highest one-third of the waves, average of highest one-third of wave height. So, you arrange the wave heights in descending order, say, you have 100 waves for example, arrange them in descending order, one-third of hundred may be around how many? 33 values, take the top 33 values after arranging them in descending order, take the top 33 values and take its average; that is your significant wave height. So, the definition of significant wave height is clear. What is the breaking wave height? Breaking wave height is the height of the wave at the breaker zone.

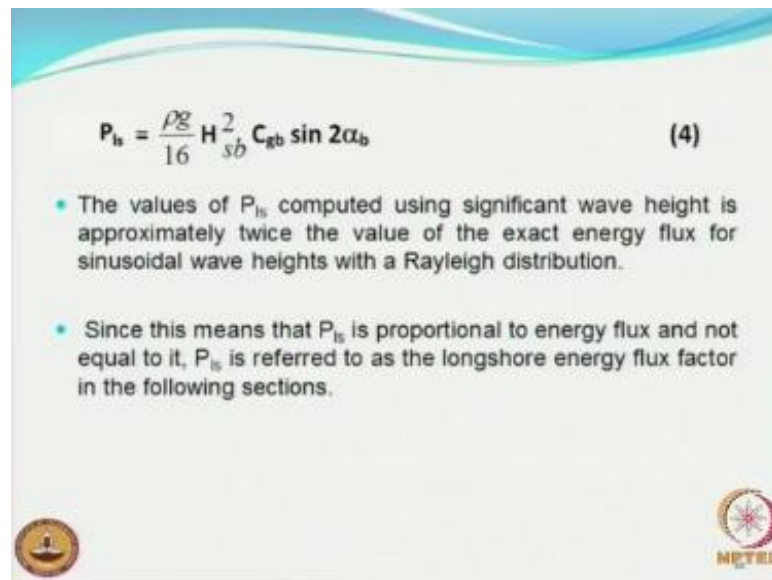
What do you do when you go to the beach, when you look into the ocean, you see the waves breaking. So, this is an estimate by eye judgment itself you can say, okay the breaker wave height is a 0.5 meters, 1 meters or whatever it is. You can have a guy a person who is stationed there to observe all this wave height and then report to you. Some of the ports are observing these wave heights. These are called as visually observed wave data. Although it has its own drawbacks, still it has some value in the initial planning process that gives you some kind of an idea. So, now you know what is breaker height; now you also know what is meant by significant wave height. Now you are having another term which is H_{sb} ; do not get confused, the definitions are clear. The wave height at the breaker zone is H_b and the significant wave height is highest of the one-third of the waves, this is very clear.

Now we are trying to merge the both, why? The kind of explanation I can give is that when you are stationed to observe the wave height, what normally a person does? He will try to look into the ocean and try to say there will be maybe I am in charge, maybe it is point 0.5, 0.55, 0.45, like this. We will try to make this kind of calculations or a kind of averaging while observing. So, we tend to average and while doing that you tend to miss the lower heights. The tendency would be to consider only the higher waves which are breaking in the breaker zone. So, unknowingly you are trying to get a kind of average of the higher waves. This could probably be one of the reasons why we can use the H_{sb} ; you understood, any doubts.

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$$P_{ls} = \frac{\rho g}{16} H_{sb}^2 C_{gb} \sin 2\alpha_b \quad (4)$$

- The values of P_{ls} computed using significant wave height is approximately twice the value of the exact energy flux for sinusoidal wave heights with a Rayleigh distribution.
- Since this means that P_{ls} is proportional to energy flux and not equal to it, P_{ls} is referred to as the longshore energy flux factor in the following sections.



So now, hence I will rewrite this expression as P_{ls} equal to and this is equation four. So, the values of P_{ls} computed using the significant wave height is approximately equal to or approximately twice the value of the exact energy flux for the sinusoidal waves with the Rayleigh distribution. So, this is how it is connected. So, if you want to use the wave height that is going to describe the Rayleigh distribution that is represented with the field, then you have to take care of this point that the significant wave height will be twice the value of exact energy flux of the sinusoidal waves.

So what does this mean? This only means that P_{ls} is proportional to energy flux. There are some kinds of variation with this wave height which you are assigning in this equation. So, you started with a regular wave, then went on to breaking wave height, then went to H_{sb} and now we are also talking in terms of ah your Rayleigh distribution or even you can discuss in term of H_{rms} . So, although the expression for the energy flux is same but you see that the values can differ depending on the wave height the kind of wave height you are using. So, since this means that P_{ls} is proportional to the energy flux and not equal to P_{ls} and not equal to equal to it.

So, here p_{ls} is only proportional to energy flux. It is proportional to energy flux and it is not equal. The moment I say energy flux, then that means it is going to be approximately or equal to some kind of a constant of proportionality. What is that because on the right side, you can easily estimate the energy flux but we do not know what is this; that is the


constant of proportionality and that is what we try to discuss. Now the variation of P_l and P_{ls} parameter depends on the type of wave data that we are going to have.

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• Variations of P_l and P_{ls} , depending on the type of wave data available.

Table 1. Longshore energy flux, P_l , for a single periodic wave in any specified depth (four equivalent expressions from small-amplitude theory).

Equation	P_{ls}	Data Required(metric units)
(5)	$2C_g (1/4 E \sin 2\alpha)$	d, T, H, α_0
(6)	$C(1/4 E_0 \sin 2\alpha_0)$	d, T, H_0 , α_0
(7)	$K_R^2 C_g (1/4 E_0 \sin \alpha)$	T, H_0 , α_0 , α
(8)	$(2C) (K_R^2 C_g)^{-1} C_g (1/4 E \sin 2\alpha_0)$	d, T, H, α_0 , α



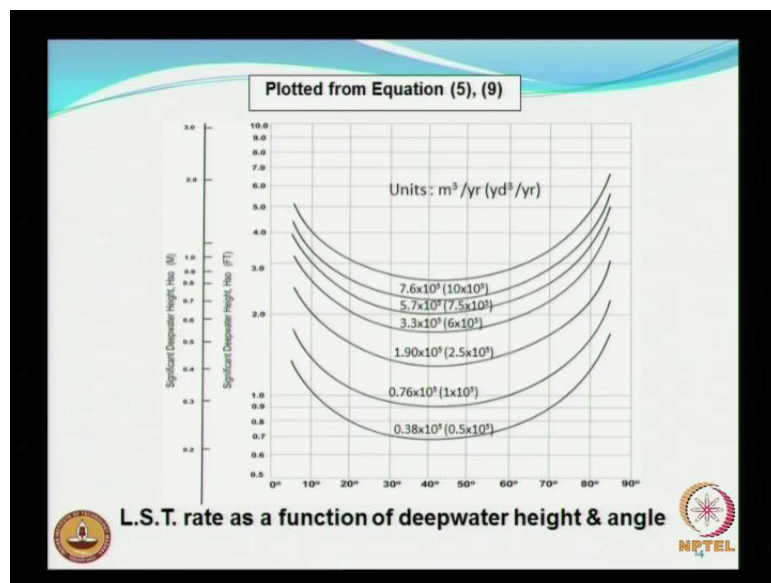
For example equation five, if you look at equation five, it depends on all these equations; there are four equations here. The basic equation is as given here. The basic or the expression that describes the P_{ls} parameter has been explained but the equations that are available at your disposal are given here which will be dependent on the data that is available; although I have written here data required. Data required is nothing but data available to you. So, for a given coast you may have only these data only this data or you may not have this data, you may have this data which is more common in fact. What is the mostly available data h naught and t naught. One way of getting this is from weather charts or from ship observed wave data.

You may have this kind of information, may be along the ports, may be some of this alpha, some of the ports they observe or for a specific project you might have all those data. So, depending on before you estimate the sediment transfer, it is very important to know what are the types of data you have? What are the data I have and what is the relevant equation I can use. So, all these variables are known to you where E is the energy, the moment α is the angle, the moment I use suffix zero it is deepwater conditions, suffix P it is breakwater conditions and k_r is the refraction coefficient, C is the celerity and etc. So, this

are also described here the parameters that are adopted in all those equations. So, what we have here is for a single periodic wave in a specified depth.

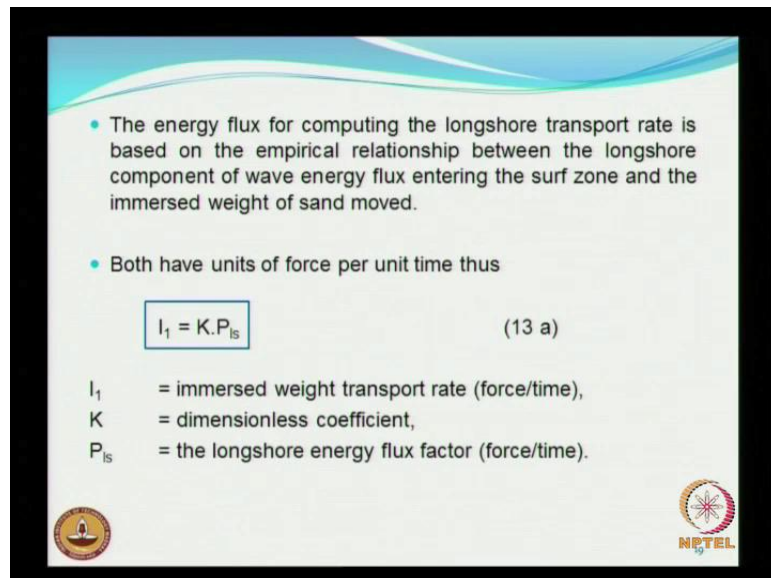
When you consider a wave to be a single periodic wave but then when you consider the P is parameter that enters the surf zone, then you need to use these equations particular this equation nine, 0.884 into rho g by, I will as and when we get to the equation, probably I can come back to the slide and show you. So, I know that none of you are taking down any notes; that does not matter because all this expressions are available. Now equation five is all this information are available in shore protection manual. None of the expressions is derived by me; it is all taken by shore protection manual. And this shore protection can easily be downloaded; for students there is absolutely no problem, it is so handy. So, this only helps you to understand better and the manual helps you to learn more.

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So, this equation is five and this is equation nine. So, plotted from equation five and nine you see on the x-axis the direction alpha naught deepwater wave direction and this is the H s that is the significant wave height in meters and the significant wave height in feet. And you have a nomogram as indicated here meter cube per year or yard cube per year. So, the one which is within the bracket its yard cube per year and the one outside the bracket which starts that is meter cube per year. So, once you know the deepwater wave direction and the significant wave height, you can probably use this as a kind of a tool to provide

you information on the likely quantities; as I said earlier it is only an estimate. (Refer Slide Time: 43:12)





• The energy flux for computing the longshore transport rate is based on the empirical relationship between the longshore component of wave energy flux entering the surf zone and the immersed weight of sand moved.

• Both have units of force per unit time thus

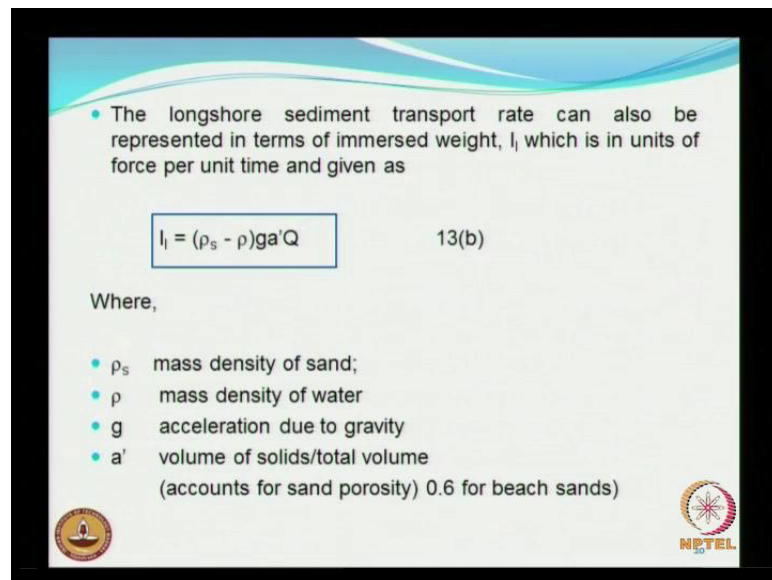
$$I_1 = K \cdot P_{1s} \quad (13 a)$$

I_1 = immersed weight transport rate (force/time),
 K = dimensionless coefficient,
 P_{1s} = the longshore energy flux factor (force/time).



Now the energy flux for computing longshore sediment transport is based on empirical relationship between the longshore current longshore component of the energy flux entering the surf zone; that is nothing but the kind of driving force and that is going to lift the sand. How it is going to lift the sand, because the sand has some kind of characteristics some characteristics. So, the driving force is related to the immersed weight of the sand; am I right; that is what is written here that immersed weight both have the same units force per unit time. Now we can obtain an equation as immersed weight of transport rate is directly proportional to the longshore energy flux factor; that is P_{1s} parameter, P_{1s} parameter or factor; is that clear.

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• The longshore sediment transport rate can also be represented in terms of immersed weight, I_l which is in units of force per unit time and given as

$$I_l = (\rho_s - \rho)ga'Q \quad 13(b)$$

Where,

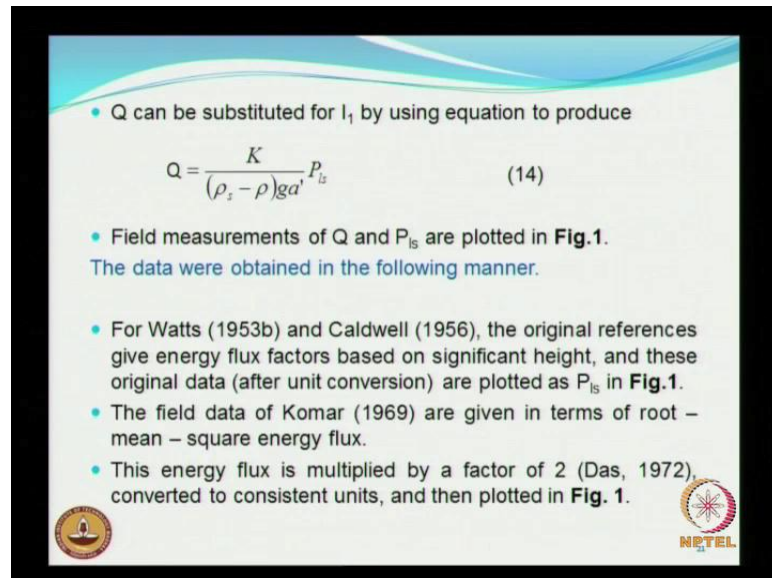
- ρ_s mass density of sand;
- ρ mass density of water
- g acceleration due to gravity
- a' volume of solids/total volume
(accounts for sand porosity) 0.6 for beach sands)



So when I do that, I can get an expression for the immersed weight; the immersed weight of the sand can be obtained as the difference in the densities; one is rho is the mass density of the sand, rho is the density of water and a dash is the volumes of solid divided by total volume which actually accounts for the sand porosity which in general it is set to be around 0.6 in the case of beach size. So, you see that there are a lot of approximations here and it depends on site.

If you want to have a serious values as close as possible to what is happening in the real field, you should be careful with all this coefficients and try to obtain it yourself, not simply use the coefficients given. So once you substitute, so I l s we have got I l s. Then we know I l s is I l equal to K into P ls. So, I l has already been evaluated. So that is rho into, now we can relate this and the earlier one; I l is calculated down, so I can substitute, so I get an expression for q; is that clear. So, that Q will be as shown here.

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• Q can be substituted for I_1 by using equation to produce

$$Q = \frac{K}{(\rho_s - \rho)ga' z} P_{ls} \quad (14)$$

• Field measurements of Q and P_{ls} are plotted in **Fig.1**.
The data were obtained in the following manner.

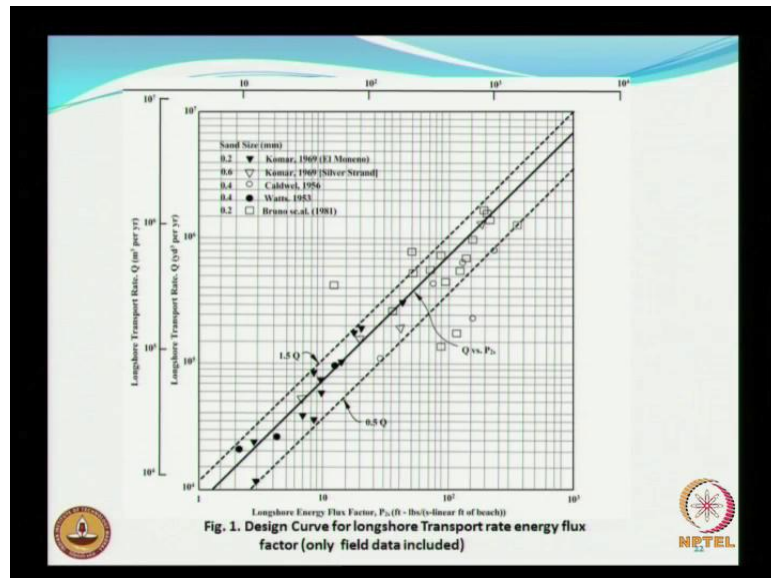
- For Watts (1953b) and Caldwell (1956), the original references give energy flux factors based on significant height, and these original data (after unit conversion) are plotted as P_{ls} in **Fig.1**.
- The field data of Komar (1969) are given in terms of root – mean – square energy flux.
- This energy flux is multiplied by a factor of 2 (Das, 1972), converted to consistent units, and then plotted in **Fig. 1**.



Q will be K divided by rho s minus rho into g into a z into P ls. Now you see a kind of a closed form solution for obtaining the quantity of sediment transport. We were talking about the complications involved. But finally it lands up into a very simple equation to obtain the sand transport but here you have to be very careful in using your judgment. A small variation in one of the variables can result in a huge difference. So, field data for Q and the P ls are plotted.

Now this is nothing but P ls can be easily calculated. Now you see that P ls is related to I l. I l can be calculated, yes or measured; it can also be measured or calculated. Similarly, this can also be calculated provided you have all the other variables. P ls is given here. So, that means we can also have a relationship between P ls and Q. So, there is one particular, please read all these things, this gives some information about the data which we are going to have here.

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So, you see that some of these authors have used their results from the field measurements and this is only the field measurements are included here. So, here on the x-axis is shown the P_s parameter and on the y-axis the quantity of sediment transport that is Q are shown. But please note although you have a clear line of this way, you have a deviations of 50 percent plus 50 and that is this is $0.5Q$ and this is Q and this is $1.5Q$; you understood. So, that is plus or minus $0.5Q$; that is 50 percent of variation. You can have a variation in the estimate by as high as 50 percent and that is the reason why we are here to understand more about the quantity of sediment transport is that clear. So, I shall stop here and then we will proceed in the next class.