Geotechnical Measurements and Explorations

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Lecture No. # 18

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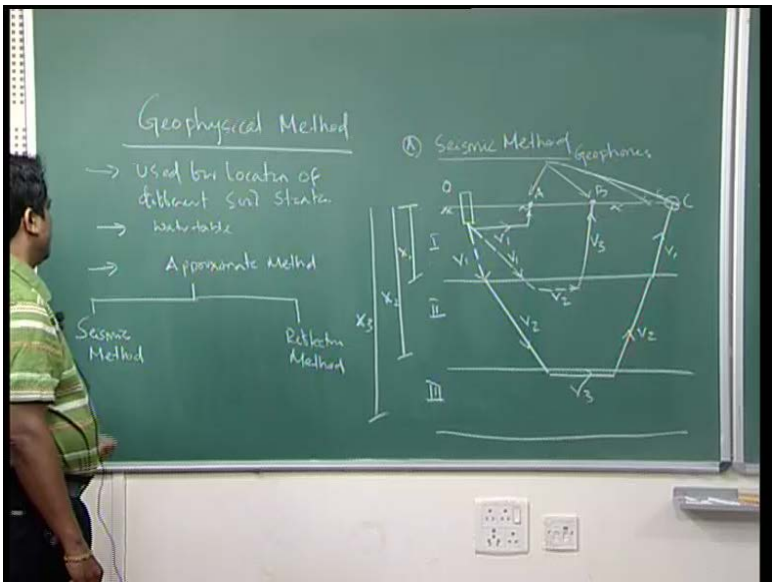

Next is your geophysical method; it is used for location of different strata, location of different strata, soil strata, also used for location of water table also; it is an approximate method. In geophysical method, there are two methods; 1 is there are 2 methods; one is seismic method, other is your reflection method. Now part a, seismic method, (no audio from 01:43 to 01:56) let us say 3 layers of soil say, layer 1, layer 2 and this is your say layer 3; A, B, C, where geophones many installed regular interval in the ground surface.

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This is v 1, v 2, v 3; (no audio from 03:17 to 03:40) v 1, v 2, v 3, then v 2, then v 1. So, this is o, this point is o.

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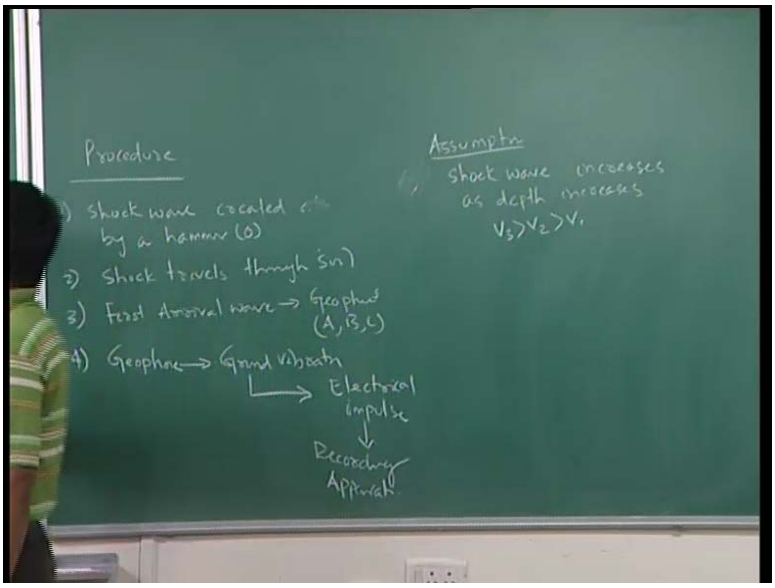

What is the procedure? Procedure is first shock wave generated at point or created created by a hammer, say at point o. Then a shock wave travels through soil, the observation of first wave, first arrival wave recorded by geophones located at point A, B, C; geophone converts, it converts ground vibration to electrical impulse, and transmitted to your recording apparatus. Assumption is shock wave increases as depth increases; so, in this case v 3 is greater than v 2 is greater than v 1.

Now if we look at this seismic method, first of all geophysical method, this is an approximate method, so used to find it out the different soil strata like if there is a ground surface here, suppose there are 3 layers; layer 1, layer 2, layer 3; at what distance, at at what distance from the ground surface say x 1, say x 2 or say x 3, how do you know that at what distance at the ground surface below here, the sub soil, soil strata changes? It can be done there are various methods by means of boring, auger boring or hand boring you can do it or you can do it also geophysical methods without doing any boring. So as this is an approximate method, there are also limitations; in this case, geophysical method has again two two methods; 1 is your seismic method, other is your reflection method.

In seismic method, what is the procedure? If we look at here, in seismic method, wave is created, this is called shock wave is created that means, suppose let us say this is point o; at point o, shock wave has been created by means of hammer; here you hammers and

shock wave you created. At the same time, from this, this is called source; from source at equal distance, you put geophones A, B, C, you put this geophones. Then what will happen? The moment shock wave you create, it will first travel from here to here, it will be receiving by this by velocity v 1, first geophone located at point A. Then the shock wave also will travel at an at at a velocity v 1 in layer 1, then it will reflected in layer 2, then again it will be refracted, so that you will receive wave at point B similarly, for third layer, it will go you will receive wave at point C.

So first arrival means the movement you start create the shock wave from this, from ground, from here source to here, this is source, and these are receivers. In this receivers, first arrival of this waves at this from this point to here, it will be received at station A, B and C. So, what is the principle of geophone? Geophone whatever located here, it converts ground vibration, what happen? It converts the vibration to electrical impulse that means ground vibration will be created by from the source by means of impact, and it will by impact this vibration will start from layer 1 layer 2 layer 3; so, it will convert this ground vibration to electrical impulse, and it record as an receiver, how much time, it takes to receive this waves?

Then this another limitations you can say the assumptions is shock wave to be increases as depth increases; that means v 3 is greater than v 2 is greater than v 1; v 3 is your velocity at layer 3 is greater than velocity at layer 2 is greater than velocity at layer 1. Let us say this, how this how you are going to find it out H 1 and H 2. This is my layer 1, and height is called let us say this height is called H 1, and this height is called H 2, and this height is called H 3.

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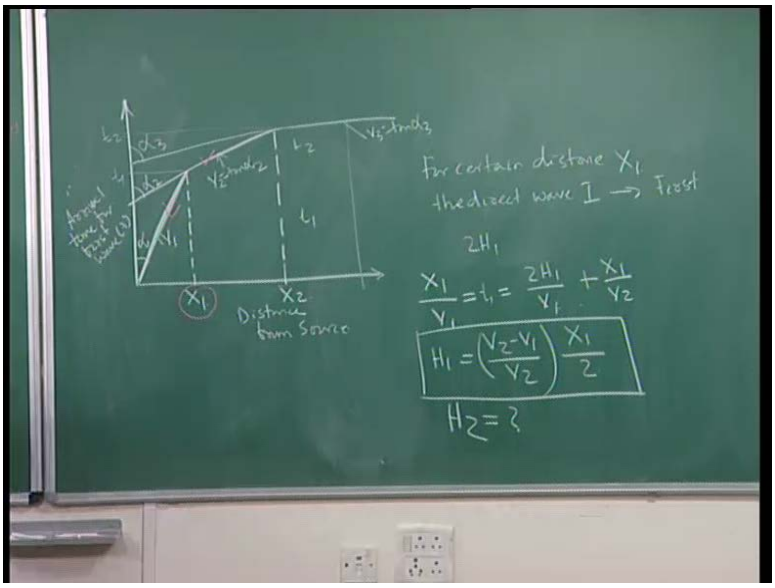

If I plot this arrival time for first wave, arrival time for first wave say t, so distance from the source, it is distance from source, (no audio from 11:59 to 12:09) this is alpha 1, alpha 2, alpha 3, x 1, x 2; if I write this is my v 1 and this is your v 2 - tan alpha 2, v 3 is equal to tan alpha 3; this will be we can say t 1 plus t 2 arrival time say, this is my t 1, this is my t 2. For a certain distance say x 1, x 1, (no audio from 13:36 to 13:45) the direct wave in layer 1, layer 1, the direct wave in layer 1, for a certain distance x 1, it reaches first, it reaches first. Similarly, at this point two lines intersect, which indicate direct wave travelling at an distance with your velocity v. If we look at here from this graph, these two points intersect; here is your direct wave you are getting at an distance velocity v 1; this is your x 1.

Now similarly, at a distance time t 2, so refracted wave travelling with velocity v 1 and v 2 at a distance 2 h 1; if you look at here from here to here, it is your direct wave you are receiving by means of geophone at an distance x 1, it comes first. Now come to layer 2 that means in this case only h 1, in this case h 1 and h 2, it is travelling what is the travelling distance? This is v 1, v 2 and v 3; v 1, v 2 and v 1, not this is v 3; v 1, v 2 and v 1, to v 1 plus v 2; it is travelling with a distance H 1 plus H 2. Now if I write x 1 by v 1, x 1 by v 1 is nothing but if I write x 1 is your distance travel from to here to here by v 1 that is your time, that is your time t, which is equal to also, which is equal to also 2 H 1 by v 1, because in case 1, case 1 you are getting direct; in case 2, the wave is from this source it is travelling twice at the velocity v 1 and v 1. So, it will be 2 h 1 by v 1 plus x 1

by v 2 plus x 1 by v 2, which is equal to again this is time t, you can get it from here, h 1 is equal to v 2 minus v 1 by v 2 into x 1 by 2.

If I plot a graph between arrival time for first wave t versus distance from the source; if you look at here, first this is this is your first, it is your source. From here to here how much time it takes? It takes t 1; from here to here it takes which is equal to distance travelled. What is your distance? Distance is from here to here let us say x 1; so x 1 by v 1 that is your time. At the same time at the same time, if you look at here at the same time, time t 1, because it is within this frame of time t 1, this and this. At the same time, what will happen? It travel from here to here with velocity v 1, then reflected with velocity v 2, then refracted with velocity v 1; that means twice twice there is velocity v 1 with a height of H 1.

So 2 H 1 by v 1 that means it travel a distance, in this case H 1 become a distance, here x 1 become a distance; in this case h 1 become a distance, because it travel it travel from here to here that means it covers the distance H 1, then it reflected, then it travel with a distance say x 1, then it then it it again refracted back, again it travel with a distance H 1; that means 2 h 1 by v 1 x 1 by v 2 this your time, from where you can get it, how much is your distance or may be H 1. At what distance from the ground surface the layer changes that you will get it from this graph.

Similarly, similarly, you can find it out H 2; how do I get it H 2? I will take this, this, this, this as well as this and this; that means in this case H 2, it will travel from here to here with a distance H 1, in this case to find it out H 2, if you look at here the source from layer 1, layer 2, layer 3, again it refract; that means H 1, H 1 that means 2 H 1, 2 H 1 by v 1; then H 2, this is your v 2, then H 2 that means 2 H 2 by v 2 plus v 3 v 3 x 2 v 3 x 2 that means x 2 by v 3. Then you can easily find it out what is the value of H 2? There are also empirical relations by means of impact shock, this is given by this graph has been drawn based on your reflection as well as refraction by empirical or impacts shock.

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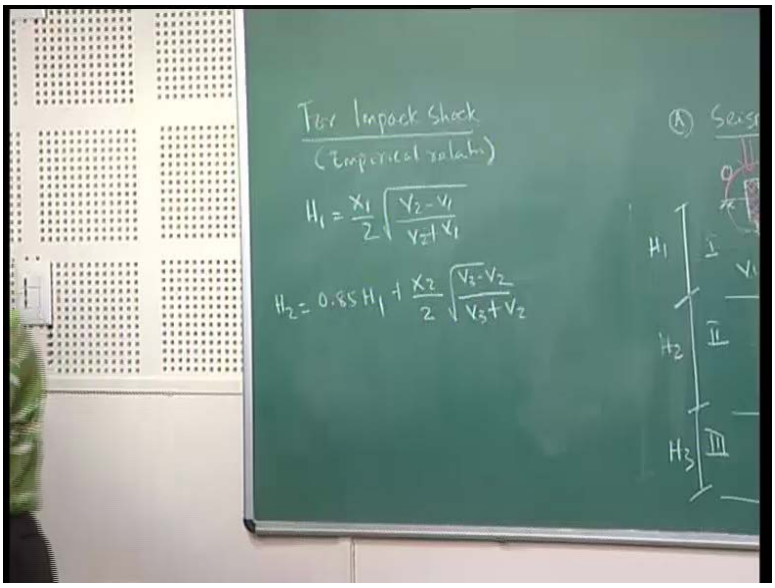

For impact shock, by means of empirical relation H 1 is equal to x 1 by 2 v 2 minus v 1 by v 2 plus v 1; similarly, distance H 2, as I said distance H 2, how do you get it? H 2 is equal to 0.85 H 1 plus x 2 by 2 root over v 3 minus v 2 by v 3 plus v 2. So similarly, you can find it out H 2 also by the method of principle of reflection and refraction, so there are two assumptions in this case you can say, one assumption is that the movement, the movement your shock wave generate, the movement shock wave generate, it will travel by means of reflection or refraction, that is your one assumption; that means from here this wave will generate, it will go, it will reflected here, again it will come start travel, again it will be refracted and it will go; this is case 1. Case 2 is that impact shock; it will travel impact by means of here and there by impact. So by means of method of reflection and refraction, you can find it out H 1 as well as H 2; so H 1 I can get it, v 2 minus v 1 by v 2 into x 1 by 2; H 2 I can get it 0.85 H 1 plus x by 2 v 3 minus v 2 divided by v 3 plus v 2 root over.

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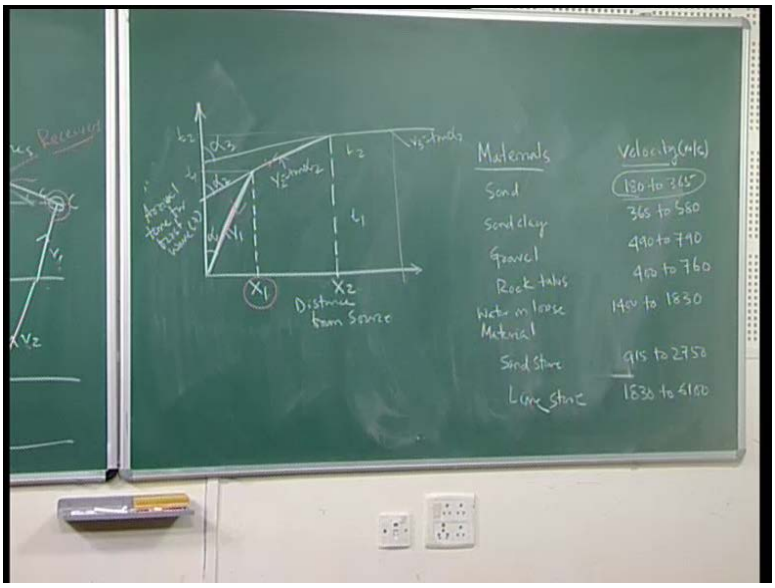

Now, there are some standardizations; materials, then this is the velocity meter per second; sand, sandy clay, gravel, rock, water in loose material, sand stone, then lime; in sand, it is 180 to 365, sandy clay - 365 to 580 and gravel - 490 to 790, then your rock, rock is your 400 to… Rock there are different types I can write rock tales 400 to 760, water in loose material it is 1400 to 1830, then sand stone - 915 to 2750, then lime stone lime stone is 1830 to 6100. These are well develop means, if this materials suppose say I got the velocity, I got the distance H is like whatever the distance may be 2 meter, 5 meter, but whatever I get it from the velocity from here with this time, I get 1080 to 365 velocity meter per second square; that means it will say that with this distance H 1, there is a sand layer, if it is 1080 to 365, then you can say this is sand layer; suppose it is said like 1400 meter per second in that case, you can say that there are some loose sand with water; that means water is there, with water is there loose sand with water is there; so with this materials this has been standardized, so there are also limitations, what is your limitations?

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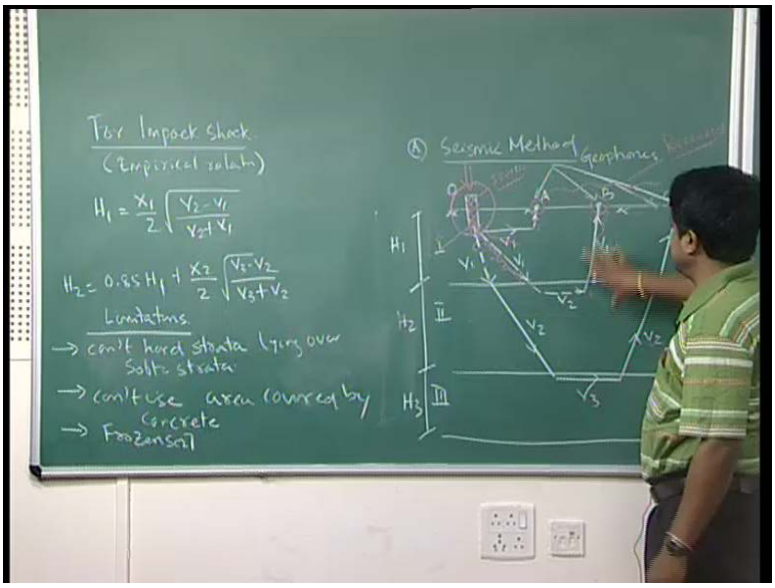

This method has also limitation; cannot use hard strata with a greater seismic velocity over lies softer, cannot use hard strata lying over softer strata, cannot use area covered by concrete, cannot use frozen soil. Case 1, it says cannot use hard strata lying over soft strata; so it is if there are hard strata, then this is soft strata, so what will happen? The hard strata it will refract, and whatever wave come to the soft strata, it will absorb all these things; that means it should be soft, slightly softer, then this will be slightly harder; this kind of assumptions should be there. Cannot use area covered by concrete, if this area has been covered by concrete, this wave may not propagate beyond the concrete; also cannot use this frozen soils; in European countries where the soil becomes always frozen state, this method cannot be used.

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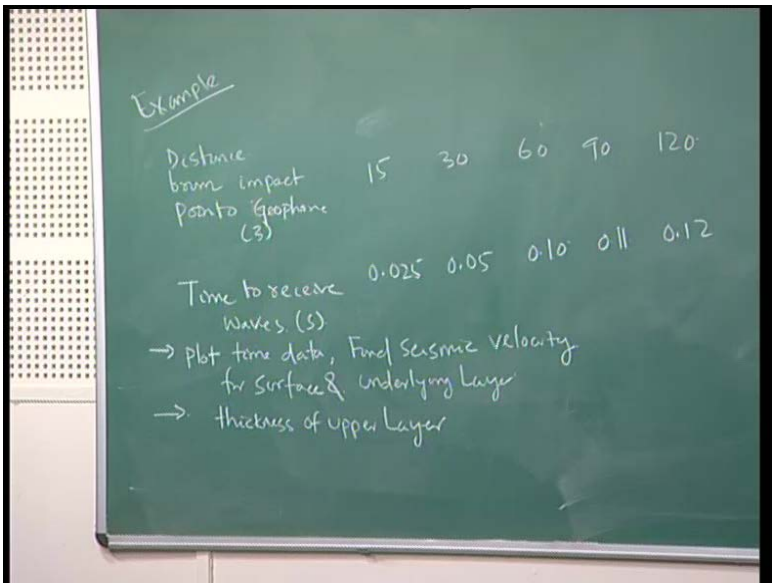

Now we will go for solving one example; example from this seismic reflection method, refraction method, so it says a seismic refraction study of an area has the given following data. So, this is your distance from impact point point to geophone; time to receive waves; it is given 15, this is in terms of meter, 15 meter 30 meter, and time to receive in you can say second, 15 30 60 90 120 and 0.025 0.05 second 0.10 0.11 and 0.12. So, what has been asked? Plot time data, find find seismic velocity for surface and underlying layer; then find thickness of upper layer. Now, with this data, first you plot your time versus this distance, travel distance

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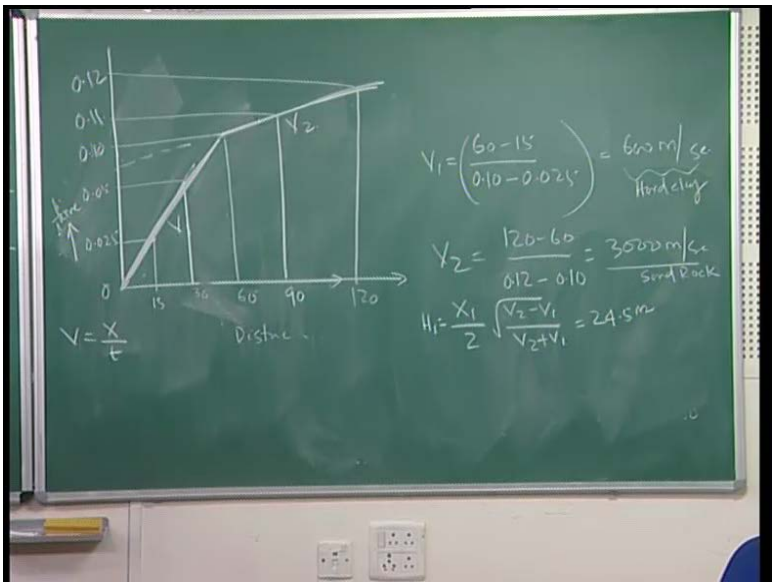

(No audio from 30:17 to 30:36) This your 60, this is one point, this is other point, 15, 0.025 second, this is your (no audio from 30:53 to 31:09) say 30, this gives how much? 0.05; increase it, it gives 60, then it will go up to 0.10. Then afterwards 90, this will give 0.11, then 0.12 and this will gave 120; this is your distance, and this is fine time. First plot your time versus distance, you will find it out there is a breakage in this line, clearly there is a reflection; if there is a reflection, the line will change its path. So first up to 0 to 60; second, it goes straight line with increase in with increase in time, the distance increases it goes straight line; after 60 there is a reflection, you will find it out there is a reflection, so this is given well documented and you can find it out say this is my v 1 and this is my v 2.

Now you can calculate from this formula v 1 is equal to 60 minus 15, 60 minus 15 divided by 0.10 minus 0.025; velocity is equal to distance by time, so distance 60 minus 15, so it will be 45 and 0.025 minus 0.1, so this will give 600 meter per second; similarly, v 2 from this graph, I can find it out 120 minus 60 minus 60 divided by what is the time, corresponding to the time 0.12 minus 0.10; it will be 3000 meter per second. Now this is the velocity means, velocity profile you will get it, velocity is nothing but this is your distance by time; from this graph distance by time, you can easily calculate your velocity.

Now once you will get velocity, then you can calculate from here, what is your time means, what is your thickness H 1 as well as h 2. Now find it out H 1, which is equal to x 1 by 2 root over of v 2 minus v 1 by v 2 plus v 1; so which is equal to 24.5 meter; as it has been asked, thickness of only upper layer in the question may be thickness of lower layer you can calculate. So the question is plot time data, find seismic velocity for the surface and underlying layer; that means this under lying layer is this is your under lying layer, because this velocity profile it says it reflected; so v 1 and v 2 we calculate, then from there H 1 has been calculated.

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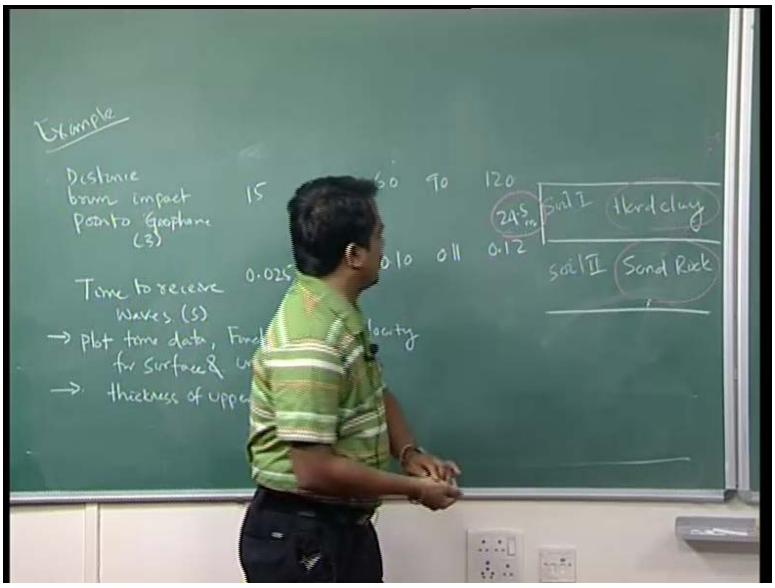

Then with this v 1 and v 2, with this velocity, can we predict, what is the material? Or what kind of soil it is, say soil 1, soil 2. As I said earlier from the chart as v 1 say 600 meter per second, so may be hard clay or maybe you can say clay, as it is 3000 meter per second, it will be a sand rock; based on the velocity profile, whatever velocity we get it, you can classify it may be hard clay and bottom one is sand rock. That means with this method you will get, you can you can predict what is the probable of soil, what kind of soil it would be; it may be a hard clay and layer 2 is sand rock; based on the clay means detail detail soil classification you can confirm, whether it is hard clay or sand rock. Then for soil 1, layer 1 and layer 2, thickness can be find it out; the thickness is your first layer thickness is your 24.5 meter. Once you find this thickness, you can say that up to this thickness, hard clay is there, beyond this it refracts; this has been refracted or reflected. So, H 1 and H 2 we can easily find it out as well as what kind of material is there inside, you can find it out