Lecture – 19
Dynamic Testing in Pile Driving

Welcome all, to lecture 19. So in this, this is particularly the part of module 5 that is module 5 has been divided into two lectures. Where we, I will be trying to cover the Dynamic Testing of Pile. As we know like, many of the location where we have problematic soil or soft soil, let's shallow our location or where the sufficiently strong bearing capacity medium is available at deeper depth. So we have option to go for pile foundation. But what happened during, particularly driving of the pile, it will cause some kind of disturbance in the soil medium. So the soil properties, which we have determined on initiative investigations, will remain same or it may change, depending on the kind of disturbance, created during the pile driving. So as a result of which, the resistance offered by the soil medium, against external loading, which will govern the bearing capacity of the pile foundation, may change. So dynamic testing of the pile, I mean, there are two ways, like, you can go for high strain testing, there are, you can go for other method, which are particularly, low strain testing. So overall, the objective of dynamic testing is to, ensure, whether it is related to the cross section, whether it is related to the length, whether it is related to the bearing capacity. Like what are the design parameter you have taken into account? Whether the same parameters, related to bearing capacity or related to resistance offered or related to cross section? Same the earliest have been obtained, after you install the pile, at the site of the interest.

Because, if the resistance offered by the soil, at the site is, different from the resistance, we have taken in design consideration, later it will cause problem in the foundation. It can be because of the bearing capacity failure, it can be because of excessive settlement. So inorder to ensure, whatever foundation has been designed, considering the certain parameters, same parameters has been obtained or whatever parameters, making sure into account, that the safety of the overall structure, should be, is ensured. So that, that all whether its low strain testing or high strain testing, collectively comes under dynamic testing of pile. So this is, you can call it as, Lecture 1, under dynamic testing or you can call like, particularly we will be discussing today, 'High Strain Testing of the piles'. So as I mentioned, driving of piles into the soil causes disturbance and thus alter the soil structure. So 1; there is a change in the soil structure. There might be a possibility that the actual resistance offered by the soil, will be significantly different from the resistance offered by the soil, as indicated during in-situ investigation. Like you go to a particular site of interest, determining the strength or resistance offered by the soil, by means of, maybe, standard penetration test, phone penetration test, as we have discussed earlier or maybe, based on, geophysical measurements.

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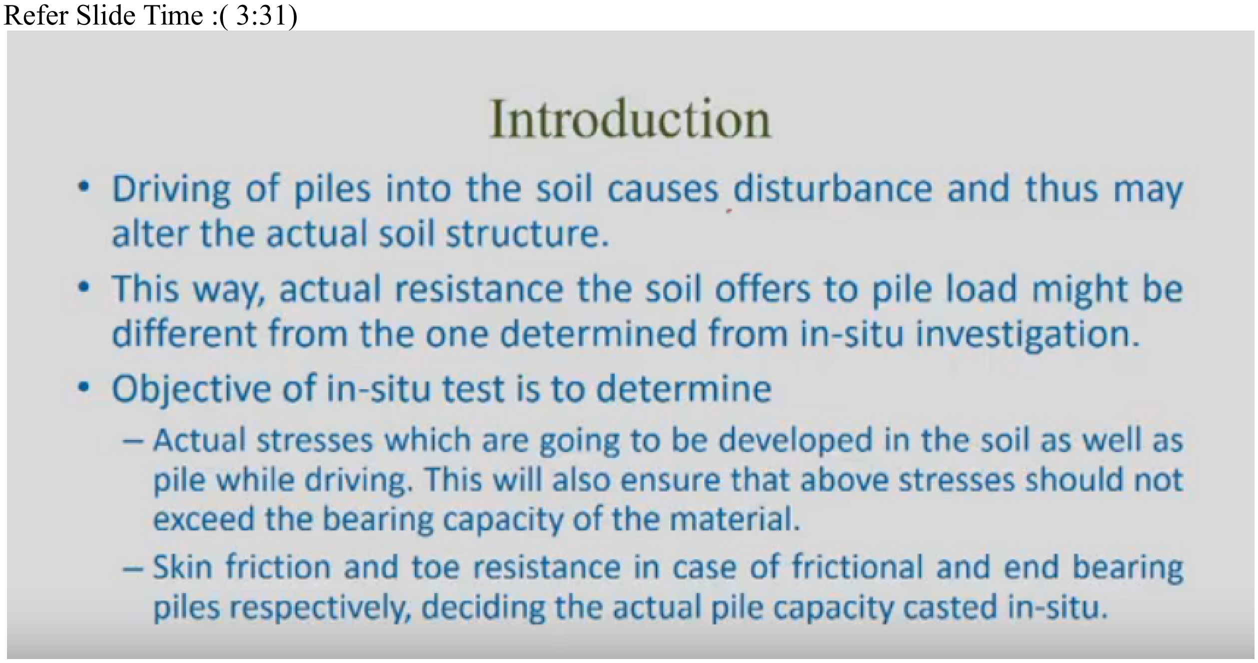

But because of that disturbance caused, while deriving the pile into the soil, which has changed the soil structure, it might be possible. It is offering more, different resistance. So objectives; so, so, the, with this change in the soil resistance to the external loading, we, we have to ensure like, what is the characteristic? What is the bearing capacity of actual pile, which is erected at the site of the interest? So with this, the dynamic testing of pile, particularly high strain testing, comes with two objectives. Like; Actual stresses which are developed, particularly during impact load. Because we know like, pile driving means, you have some, pile head, over which you are providing, hammer impact, as a result of which, the pile is gently pushed into the ground. So one is, the actual stress which are developing, in the pile cross-section, should be significantly lower, so that it will not cause any kind of sheer failure, either in the material of the pile or in the surrounding soil.
Second, 'The Skin Friction', which is developed, as a result of different layers, which are available, along the shaft of the pile, as well as the, toe resistance, based on whatever is the soil property available at the base of the pile medium. Whether they are offering sufficient resistance, taking into account, the odd, design consideration. So this will also help in deciding, whether the actual pile capacity, which is casted in-situ, how closely it is matching with your design parameters. How closely it is matching with your design consideration? So there is two parameters; one is like, stresses, should be significantly lesser than the strength of the material, which is coming into account, particularly the pile material and second thing, the pile which is, once it is finished installation, whether the, two resistance earn in skin friction or collectively the actual bearing capacity of the pile, has been met, has been met at the in-situ condition.

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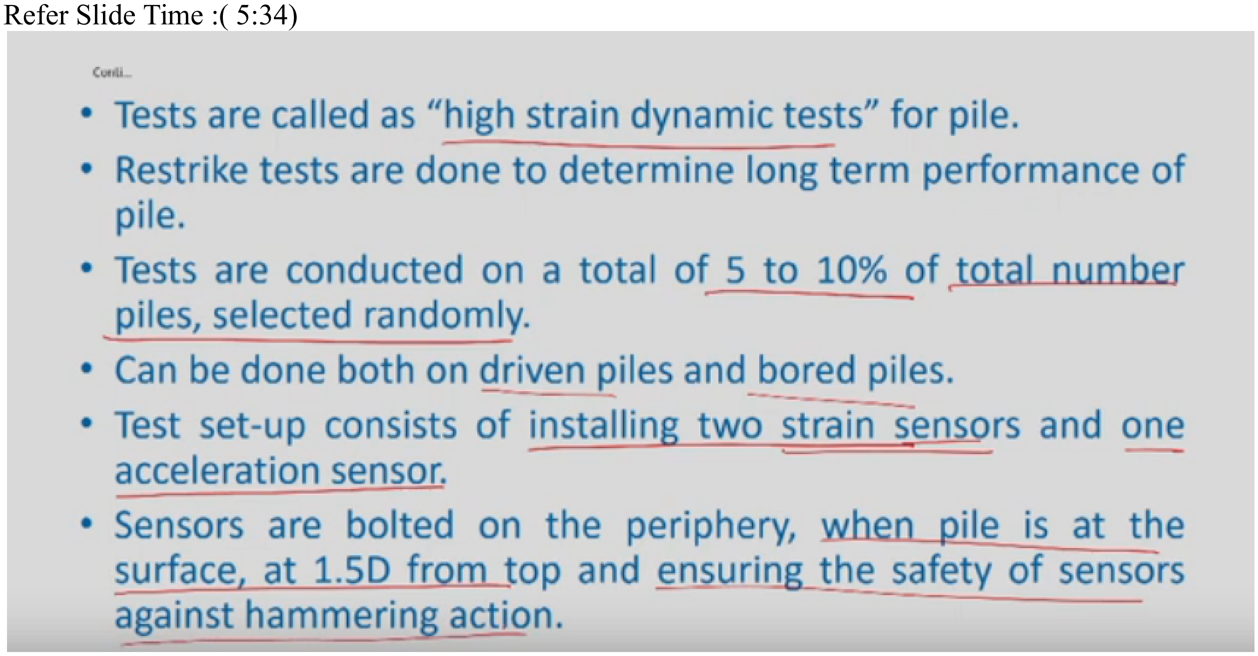

So there are tests, which we are going to discuss today, are called as, 'High Strain Dynamic Test'. These tests are becoming more and more popular nowadays, because in majority of the locations, as I mentioned earlier, like the kind of structure, we are going. So the amplitude of the load is significantly higher, then maybe little loads are also playing a dominant role, particularly, because of water waves, when we say about flood condition or maybe seismic condition. So there maybe lot of cyclic loads, as well. Then, so as a result of which, more and more foundation people are going for pile foundation or maybe, combination of pile and some other kind of foundation. So those tests are called as, 'Dynamic Testing of the Pile'. The beauty of these tests, like, you need not do any tests separately, anyway you will be driving your pile into the soil. So you have put some sensors, based on the recording of those sensor, you will be able to understand, the, the in-situ characteristics of the pile medium, that will help you in understanding, how much resistance the pile can offer against external loading. Similarly you are having, 'Restrike Test', which is done to understand the long term performance of the pile.

So you need not do the test on all the piles. Suppose at a particular site, you are, if you are installing 50 piles or 100 piles, so this kind of test which is to ensure, the bearing capacity of the pile foundation, as well as to ensure the stresses developed during hammer impact, not causing actually any kind of failure. So you can actually select, randomly, 5 to 10 percent of, total number of piles. So if there are 50 piles, you can go from anything like, 3 to maybe 5 piles or more than that, just, just giving you an example. Similarly, so you can do the test both, both in driven piles, as well as in bored piles. Cast in-situ you cannot do the test, because there will not be any kind of him, hammer impact there. The test setup, as I mentioned, like the beauty of this test is, you, you need not go for any external source of loading, because anyway you will be driving the pile into the soil, so hammer impact will be there. So against the hammer impact, the behavior of the soil, of the pile will be detected by means of installing two sensors, generally the two strain sensors and one is, acceleration sensor.

So strain sensors will help you in understanding the, mostly the resistance offered by the soil and value this, acceleration sensors will help you in understanding the, what is the, particle motion, at different, different medium, depending upon the intermediate depth or maybe the toe, which, whatever is offering more and more resistance, to the external loading. So that's why you are having strain sensors, more precisely and you have acceleration sensor. So these sensors, which will be, maybe P Jo electric sensors and other kind of sensor, which will be bolted, not P Jo electric, the other kind of sensors, maybe, so these can be bolted, on the periphery of the pile, such that the minimum depth should be 1.5 times the diameter of the pile, from the top of, from the top of the pile. That is from the bottom of the pile head, 1.5 meter diameter, 1.5 times diameter you go and from there onward, you can put those sensor. Generally we put sensors on, diagonally opposite end. So that, even there is some kind of bending during installation, that kind of bending can also be detected by means of, the sensor recording. Of course, you have take like, 1.5 times is the dimension given to, take as a reference, you have to also ensure, that the, the sensor should be installed at certain, at such a depth, that the hammer impact is not going to compromise the safety of those sensors.

So you have to also, take into account, 1.5 times the diameter, as well as the safety of the hammer. Because, above the hammer, there is continuous hammering happening, which is actually driving, as well as, it might be possible, like it is, it may cause some kind of damage to the sensor. So you have to make that into account. Now, the sensors, as I mentioned, will be oppo, will be attached diagonally opposite ends, inorder to also check, whether there is some kind of bending, while driving the pile. So as you hammer, the pile will be pushed into the ground and sensors will detect, any kind of resistance offered, by the pile medium, at different, different depth, collectively, the pile medium is, resistance finally offered by the soil to the pile, which will be the resistance offered, by the pile, to the external loading.

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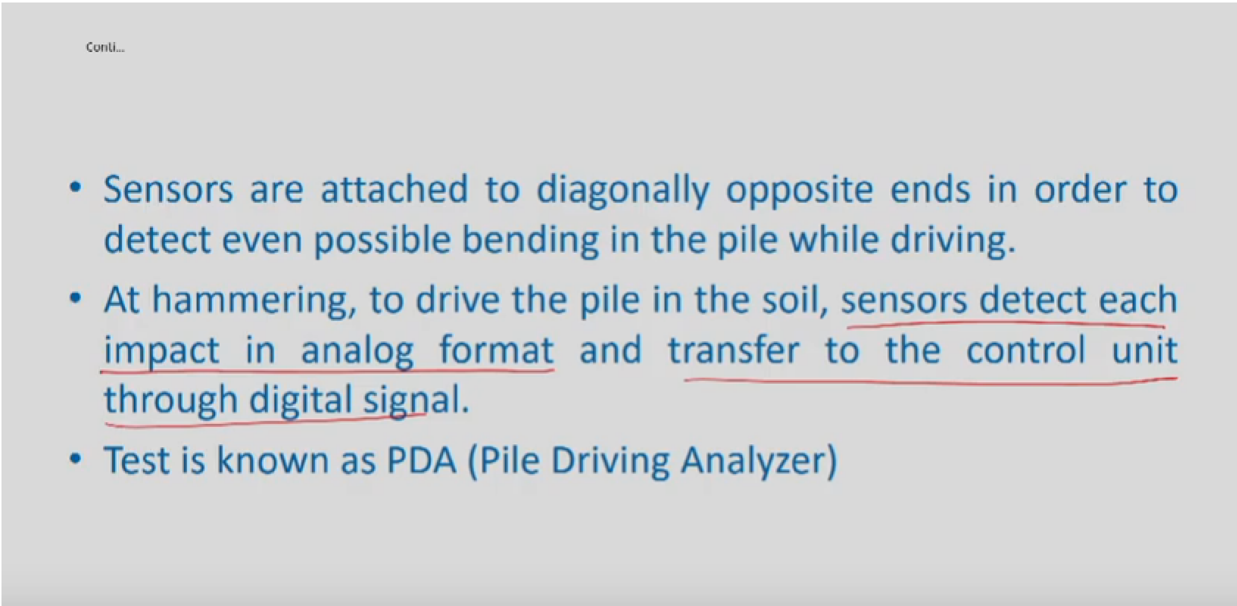

So, the sensors are detecting these things, in terms of Analog format, which will be sent to the control unit or PDA unit, in terms of digital signal. The test is known as, ‘PDA (Pile Driving Analyzer)’. So based on this test, you put the sensors and detect, how much is the resistance offered by the pile, for which, is an indication of how much is the resistance offered by the soil medium, against pile driving. Because the same resistance will be offered, when the pile is loaded to any kind of external loading. Here you have to take into account, whether, I mean, what are the mediums from which the, the records will be detected or the disturbance will be detected by the acceleration sensors or what are the medium which is offering resistance, which will be detected by strain sensors. So that will collectively help you in understanding, just like, if, if this is like, toe resistance, if it is provided, then whether it will be detected, it will result in velocity detections, or whether it will help in strain detection. So accordingly with this fundamental difference, this, whether the soil, whether the pile if free standing pile, whether it is, skin friction, frictional pile. So accordingly the, the, the importance of, each of those sensors, whether it is skin sensor, whether it is, acceleration sensor, will come into picture. Or it is like, partially it is skin friction and partly it is hand bearing. So both the sensors will come into picture, will detect how much is the resistance offered by the pile. So output we generally get is, how much is the load carrying capacity of the pile or how much is the resistance, the pile can offer against external loading, which in this case is, hammer impact.

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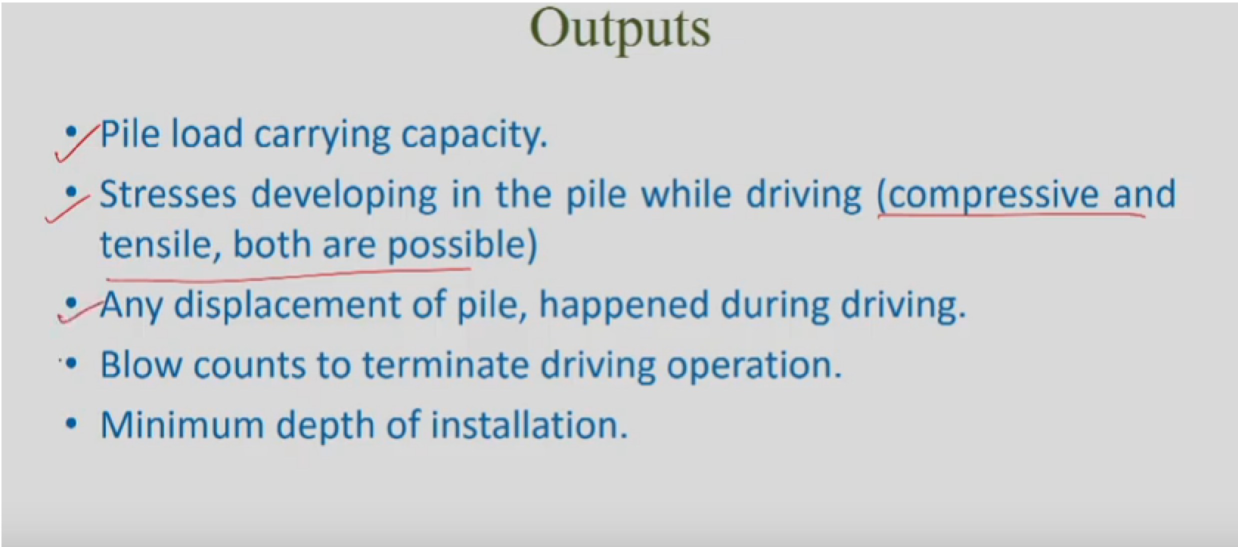

Second thing, the stresses which are developed, again this impact load, which is, particularly the drop of the hammer, what are the stresses developed, both compression as well as tension, both can be measured. Second thing, any displacement, happening while driving lateral displacement, which is, maybe responsible for bending of the pile also, so that can also be detected. Once you put the sensors on diagonally opposite ends. Then this is very important thing, like, how number of blows will be considered as for installation guideline, inorder to terminate further driving of the, pile. Otherwise, pile will not go further into the soil; rather, there will be crushing of the material. So that blow count termination guidelines, can also be attained or can, can be obtained, based on this institutors. Then minimum depth of installation, taken into account, how much is the resistance, the, the particular pile has to offer, again external loading. So the minimum depth of installation can also be detected here. The inputs which are required here is, pile dimension, what is the length of the pile? What is the, cross section of the pile? What is the characteristics of the pile medium? Like Young's modulus value and so on. Then hammer details; what kind of hammer you're using for actually driving it? Hammer efficiency also comes into picture. Then what is the weight you're dropping? What is the height from which you're dropping? That will govern your impact load magnitude. Subsoil information, depending upon the subsoil information, whether the, the pile has to be designed as skin friction pile or hand bearing pile or a combination of those, will come into existence.

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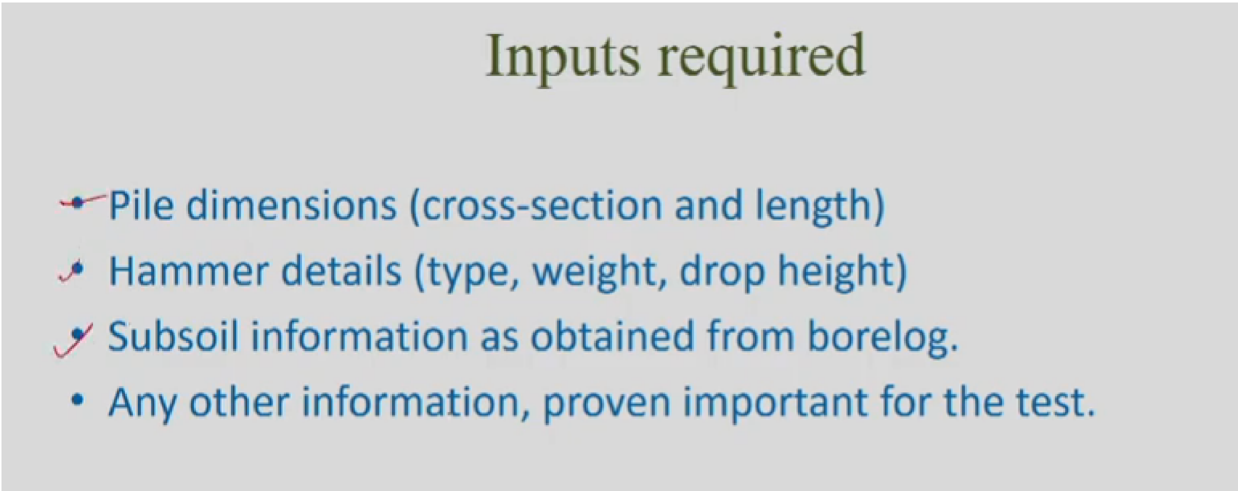

So generally this subsoil information you will get from borelog data. Then any other information, to give you an example, like hammer impact efficiency or some, some kind like problematic soil is there, some collapsible soil is there, water table depth. Other thing, which can actually affect the, your, your field recording, can also be taken into account, as possible input for analysis.

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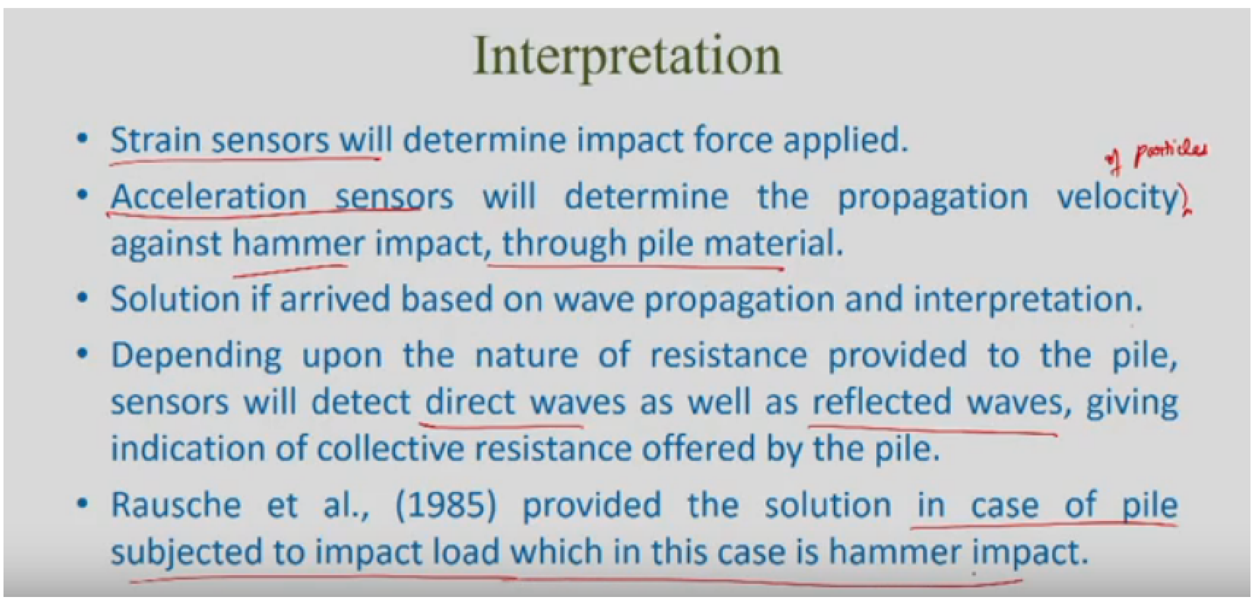

Now Interpretation, as I mentioned, strain sensors will have been on detecting, how much is the force applied or impact load or the resistance offered by the soil. Whether it is skin friction, whether it is hand bearing. So what is the resistance offered by the soil, at different, different layers. Then acceleration sensors will detect, the propagation velocity, because you are causing some kind of disturbance, as a result of which, there will be some kind of particle movement, within the hammer material. So that will

be detected by acceleration sensor. So this has to be clear, otherwise it will be difficult to understand, what is the role of strain sensor, what is the role of acceleration sensors. So, very clearly, like strain sensors will be used to find out the resistance to impact load, acceleration sensors will be used to find out the, the resistance offered by the pile material, maybe in the form of, propagation velocity, particle velocity. This, this should be like, propagation velocity of, of pile material.
Solution if arrived based on wave propagation, as well as interpretation. So depending upon the nature of the resistance provided, to the pile, sensors will detect a direct wave, as well as reflected waves. So it's like, there is a pile, maybe next slide I'm going to discuss like, what is the meaning of direct wave, as well as reflected waves, based on which, the sensor will be detecting, like strain sensor will be detecting the, force component, acceleration sensor will be detecting, corresponding velocity components, some will be from direct, some will be from reflected. So depending upon, whether it is a, whether the medium is offering some resistance, then reflection will be in which parameter or whether the medium is not offering any resistance, then reflection will be a word parameter. So we are going to see that thing in, coming slide. Rausche in 1985, actually provided the solution incase of pile, subjected to hammer load. So in this particular case, the impact load is hammering, or the, the, the top of the pile, which is actually causing the impact load. That will be, so Rausche in 1985, Rausche et. al., provided the solution for this.

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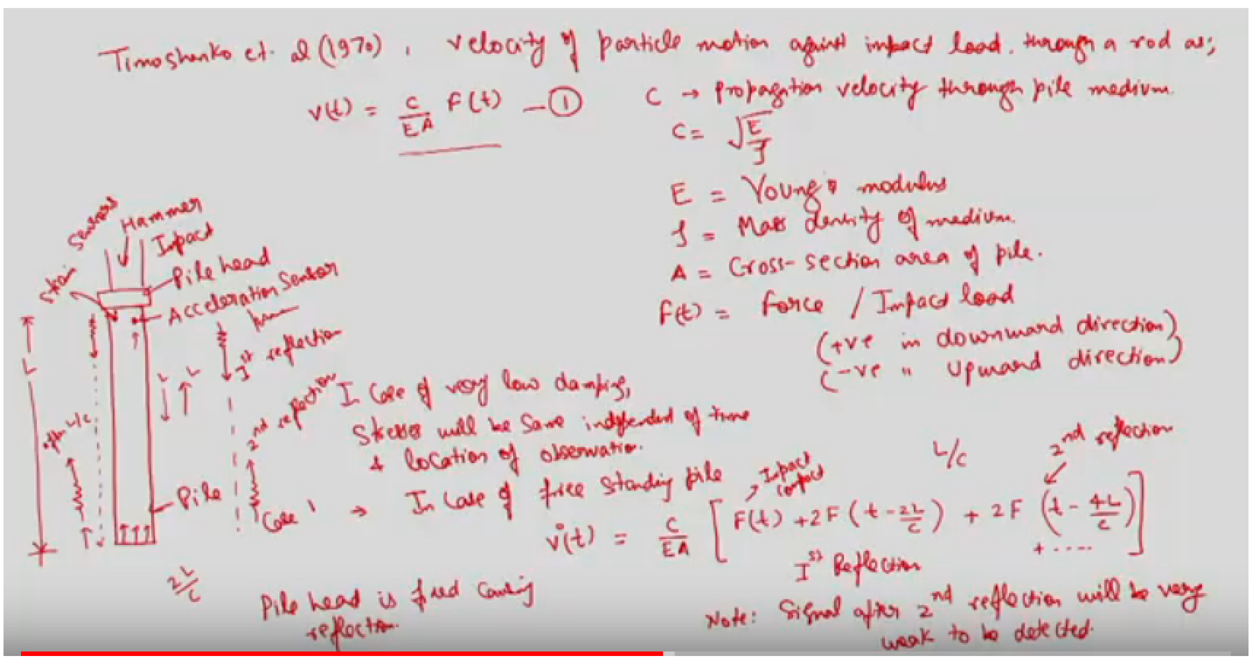

So what we are interested, first of all, as per Timoshenko et. al., 1970, provided the velocity of particle motion, velocity of particle motion against impact load, through a rod, as, velocity of propagation of, velocity of particle movement, is given as, C over EA, F (t), where, C is, propagation velocity through the rod medium, propagation velocity of wave. So one is propagation velocity of wave, second is, the velocity with which, particle velocity is happening, as a result of, passage of wave, propagation velocity through pile medium. Which will be, as, as discussed in geophysical test, which will be, depending upon the characteristics of pile material. So this is Young's modulus, E is, Young's modulus and row is, Mass density, of medium, now A is, cross section area, of pile. F (t) is, Force or Impact load, which is generally considered as , positive downward direction and negative, negative in upward direction. Now this is given like, you have some infinite rod and, you have some rod and you just, provide some impact load, as a result of this impact load, wave will be propagating and this wave depending upon the characteristic of a particular wave will cause particle motion.

So, if, we discussed like P wave, S wave, depending upon the wave, the particle motion will be varying from one to another. The, like, so, in this particular case, what we are doing is, we have some pile, this is your pile, this is actually you're driving into this, so you will having some kind of pile head and this you're actually putting some kind of hammer impact. Now as a result of this hammer impact, what will happen? There will be shock waves generated here, and we start travelling downward. So what we are detecting, we are putting some, maybe acceleration sensors, same way we will be detecting some strain sensors as well, strain sensors, acceleration sensor. Now what will happen, so this one the equation 1, which I told you, this is like you, you, you created some kind of impact, as a result of which, this disturbance will be created and will be going downward. So this is like first component. It's like I have created some kind of disturbance, as a result of which, this acceleration sensor detects on the disturbance, which is given by equation 1. Now what is, what is happening in this case, particularly in case of, again, so incase of, incase of, very low damping, stresses, will be same, independent of time and location of observation, as location of observation. Now what happen, this is as, I'm repeatedly telling, this is particularly the case, where you're having a rod, you provide some impact load and simply the wave propagated through it. What happen incase of, like suppose incase of, I'm telling here in case 1, in case of free standing pile.

So being a free standing pile, what will happen? You actually initiated or triggered some kind of disturbance, at the pile head, as a result of which, this disturbance, first it will be detected by the acceleration sensor, so there will be some kind of disturbance here, if you can con, con, con, call it as, 'Acceleration Time History'. Now again this will be, going till the bottom and again there will be strain sensors also, so that will be detecting your equivalent force or impact load. Now this reaches a particular depth and then again start travelling, because there will be some kind of reflection from here. Being a free standing pile, there will be some reflection incase of strain values. So there will be again some kind of disturbance. Now considering the pile to be L and the velocity of propagation through earth, through pile medium as C. So minimum reflection, the minimum time which will be required, by the impact load to get reflect from the bottom, will be L by C, from the bottom, so this will be after L by C, at this instance, I mean, at that toe. But by the time it reaches the acceleration sensor, it will become 2L by C, because L1 is downward and another L upward. So it will be like, 2L by C, delay with respect to , the, the direct load or the first recording. So that you call it as, 'V (t)'. If I'm calling, so that will be called as, C over EA, so first is F (t), I'm calling it as again, as free standing, so I'm just putting as suffix 'O'. Okay, F (t) plus more components will be there, strain sensors, F, so second disturbance will be like, this reflected, it will reach here, well upward component, then after that, once it reach the pile head, again it will be, there will be some reflection from there. So that will be called as, t minus 2L by C. Because L length, it took, I mean, L by C it took, from reflecting from bottom and again by, by reaching the pile head or the strain sensors, again it took additional time L by C.

So it is 2L by C. Now this will be like, a delay by, how many, so this will be like, one will be component which is coming from downward, that is F, same time almost with no, no significant change in that time, there will be another component, which will be equal to this. But will be reflected component, so you will have 2F. This is coming from first reflection, same way you can have another. So the reflected wave, first reflection, what will do, it will again just like your actual hammer impact, it will again start travelling downward and again there will be some kind of, second reflection. So again second reflection will be t minus 4L by C, because 2L by C was the actual starting of that reflection, from pile head and then came to that toe and then again reflected back. So it is like, 2, 2, 2 plus 2, 4L by C. And then again it will be twice F. So one is like directly coming from the bottom and second one is like, reflected from the top surface, because the top surface is fixed one.

So you can call it, the pile head is fixed, the pile head is fixed, causing reflection in, okay, so that is like, reflection from, this thing. Now this is particularly the case, so you have some kind of, this is like direct impact, impact component, as detected by the strain sensor, then you are having, first reflection, then you are having, plus some more component will be there. So this is like second reflection. Plus so many will be there, but, 'Note' we can put here; Signal after, signal after, second reflection, will be very low, will be very weak to be detected. So this is like, what I can say like, the reflection which is coming from free standing pile, is like this. So you are having the base, which is causing some kind of reflection in the wave and the pile head, which is again not allowed to go for any kind of motion, so which is again causing reflection, as a result of which, we had considered for our analysis, like two reflections; one is, Impact load, first reflection, then went to the pile head, then again came back, second reflection and after that, it will be considered as too weak, to be considered into analysis or interpretation part. Now this is a very simple case, where, where we are having a free standing pile. Now what will happen, if you are having, so the solution to this equation, the previous equation I should number it as, 'Equation Number 2'.

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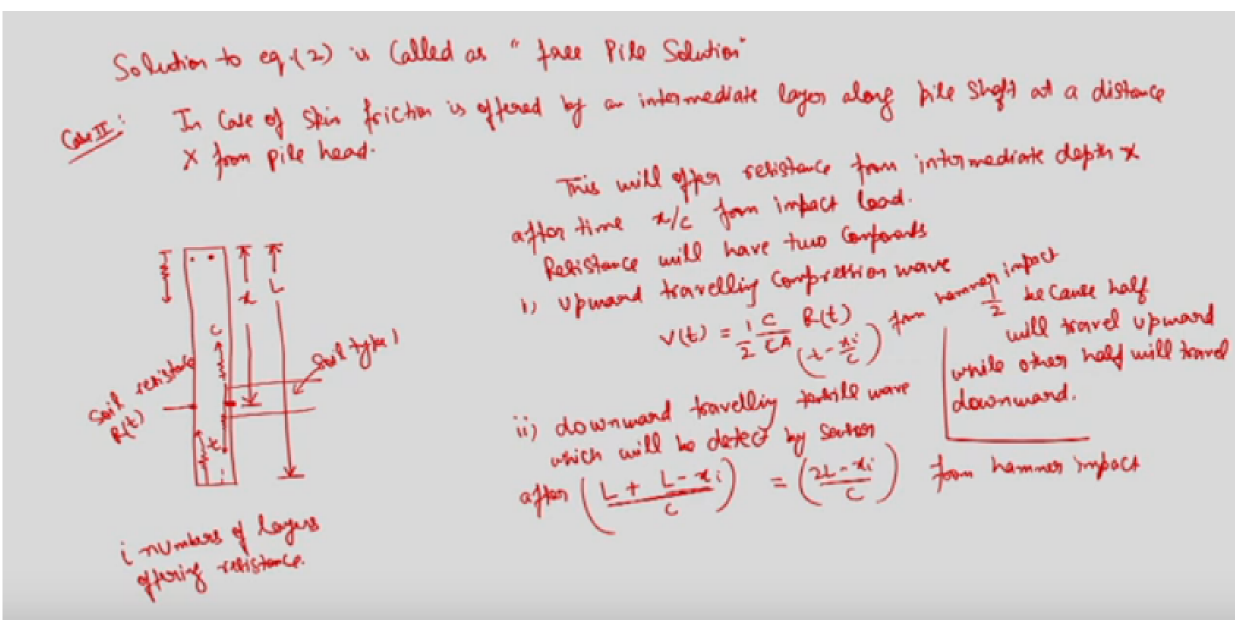

So the solution to this equation, solution to equation 2, it called as, 'Free Pile Solution'. This is a one particular case, free pile solution. Now case 2, can be, we consider here like, free standing pile, there is no resistance from the sides. What, what additional complication, can be work here? It's like, even the layers at intermediate depths are offering resistance. So I can say like, case2, incase of skin friction. Now, to, for simplicity we are not considering skin friction to be offered by all the layers along, which are available along the shaft. But I'm considering, incase, skin friction is offered by intermediate layer along pile shaft, at a distance X from the top, X from pile head. So in this particular case, what will happen? So you had, just now we discussed about free standing pile. Now in addition to free standing pile, suppose this is a location, which is at a distance X, what will happen? You started, you created some disturbance, travelled back and reflected, as we discussed in 1. But what will happen if at distance X, this is L, at distance X, it is offering, the, the, the soil is offering resistance, soil resistance. So in addition to your toe, even the intermediate some layer is there.

Suppose maybe you can consider, maybe soil, soil Type 1, soil Type 1, offering some resistance. As a result of this, what will happen? From the intermediate depth itself, we will be having some kind of reflection, travelling upward, half component that and some kind of component, which will be travelling downward. Upward component is actually causing some kind of compression, so you will be having, you can say like this will offer, this will offer resistance from intermediate depth, intermediate depth X, after time, X by C, from impact load, from impact load. So again there will be resistance offered, will have two components, so it will have two components here. Resistance will have two component, have two components; First one: Upward Travelling Compression Wave, which will be called as, V (t), C over 1 by2, C over EA, R (t), I'm considering the resistance offered as R (t), at this particular location. Half (1/2) will be, because half will travel upward, while other half, will travel downward. So one is like upward, this is first component and second component will be downward component travelling tensile wave. But what will happen? Once it reaches the bottom, like this component, I'm calling it as T, this as C. So this component, once it reaches the bottom, again it will reflect back and travel like a compression wave. Travel, because your sensors, acceleration or strain sensors are here, so whatever, whether it is coming as direct from compression wave or the tensile wave after reflection, to come as compression wave, will be detected, only at this particular location, where sensors are there. So the other one will be V (t), but at a time, which will be detected after time, tensile wave which will be detected, which will be detected, by sensor, after, how much time? So it will be like, L, which is the total length it has to travel, plus, what is the additional thing is like, L minus x over C, L is that length, by which like, L minus x, is the length by which it has to travel downward and then reflected back onto the surface, by the sensor.

So it will be L minus x, that will be equal to x, I'm keeping, considering 'i' number of layer are there, i number of, numbers of layers offering resistance, resistance. So that is Lxi. Now if you consider, so this is like, as a result of this unconfirm, as a result of this, layer which is capable of produce, offering resistance, there will be some component again travelling upward, there will be some component, which is travelling downward. But before getting detected, the receiver, it will be reflected from the base or toe and getting detected. So it will be like this, you can call it as, 2L minus xi over C, from hammer impact. So this is like, duration after which, the travel, the wave which was travelling downward will be detected by the, this sensor. The first one will be definitely like, t minus xi by C, delay from hammer impact. So this is like the time of delay, with respect to the hammer impact. The one which is detected by the compression or which will be travelling upward and the second one which will be travelling downward, then after reflection will be going upward. So the first one will be causing compression and the second one, after reflection will be causing compression.

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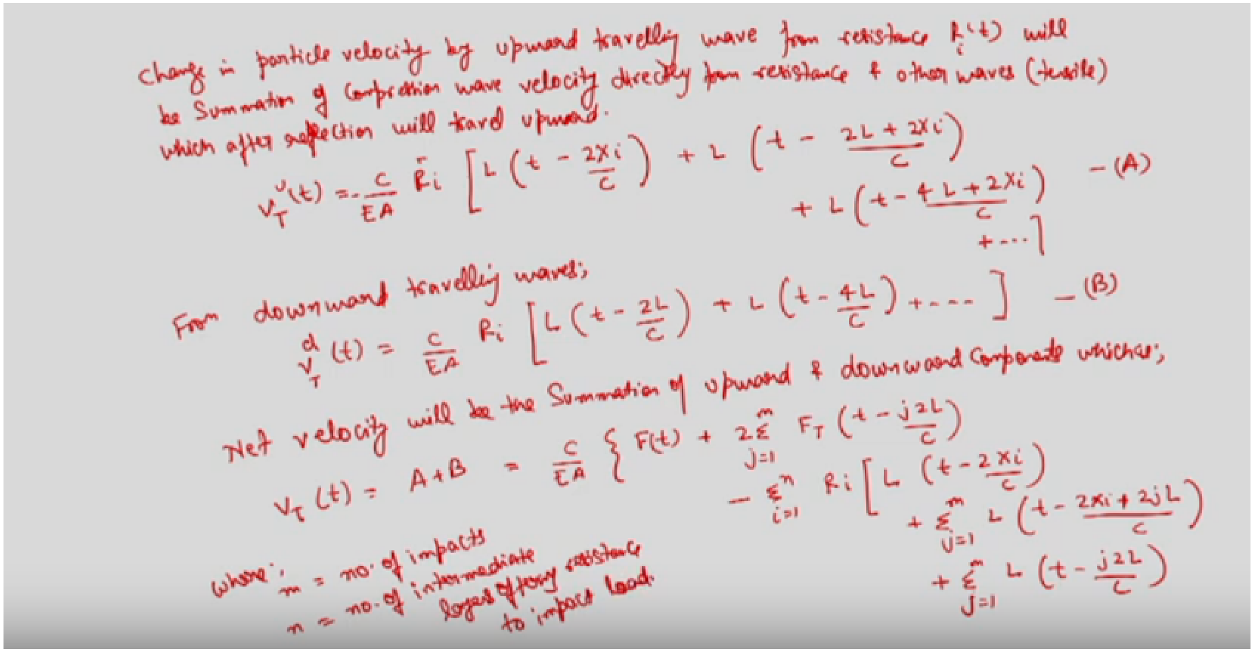

So we can call it as, so change in particle velocity, by, upward travelling wave from resistance R (t), R (t), will be summation of, summation of compression wave velocity, directly from the resistance, resistance and the waves and the other waves, precisely tensile, which after reflection, reflection will travel, travel upward. Because this component, which is called as, 'V (t)' U (t), is given as C over EA, Ri, L t minus twice x i over C, plus L, t minus twice L, plus twice xi over C, plus L, t minus twice L, should be 4L, plus twice xi over C, plus so on, which is not considered, because it will be like third reflection, should be too weak. So this is from upward component, particularly from the resistance at, xi distance. Okay, this should be Xi, capital X, so I'm just writing here as Capital X. Then from downward, from downward travelling wave, it will be called as, 'VTd, that will close to C over EA, Ri, H minus L, t minus twice L over C, plus L, (t) minus 4L over C, plus and so on, third component, which will not be collect, considered here.

So the net velocity change, net velocity will be the summation of, summation of, of upward and downward components, which is, which is given as, so the downward component, is considered as, the upward component is considered as, negative, downward component is considered as positive, so net will be equals to VT, (t), which will be equal to, last we had given equation number, maybe 3, that, I'm calling it as equation number B. That will be considered as, A+B. It will be equal to C over EA, F (t) plus 2 times summation, J equals to 1 to m, FT, t minus, j times twice L over C, minus summation i equals to 1 N, Ri, Lt minus twice xi, over C, plus summation, J equals to 1 to m, L, t minus twice xi plus twice jL over C, plus summation, j equals to 1 to m, L, t minus j2L over C, where, m equals to number of impacts and, and n equals to number of intermediate layers, layers offering resistance to impact load, impact load.

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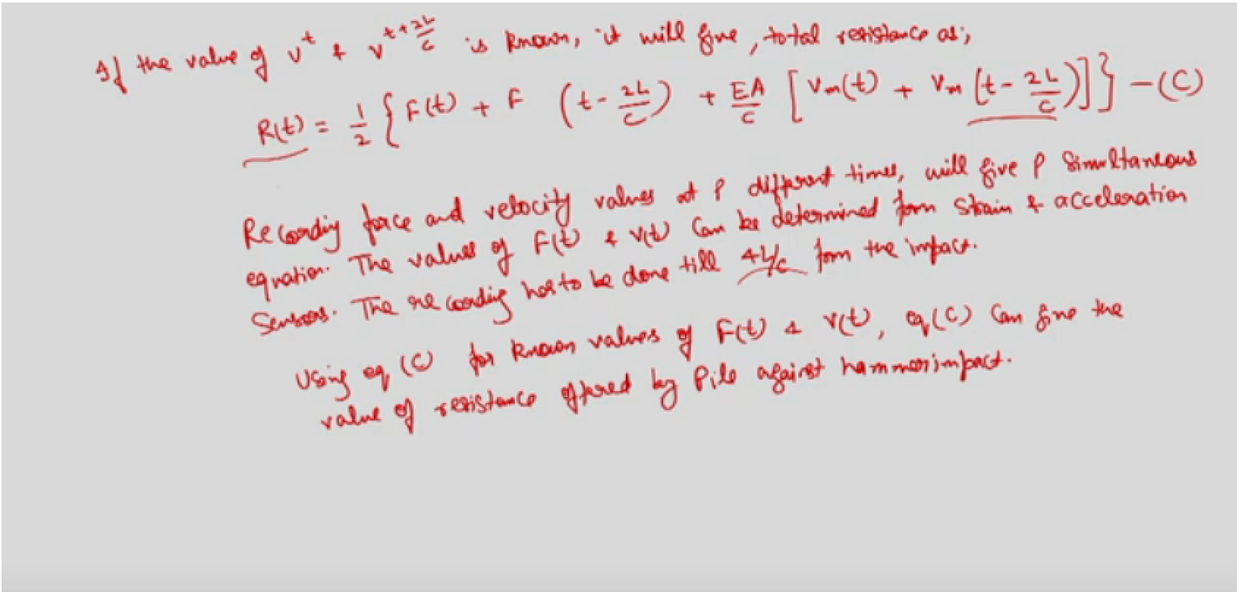

In this way, if the value of V at time T and V at time t plus 2L over C is known, it will give total resistance, resistance as, R (t) this is given as half (1/2), F (t) plus F (t), t minus 2L by C, plus EA by C, Vm plus Vm (t) minus 2L by C or this can further be written as F (t) plus F t minus 2L by C, plus M, okay, let it be like this. What collectively I want to say here, like if you know the equation number C, Recording Force and Velocity Value is, Values at, n different times, you'll get the value of F and you get the value of V, using equation C, will give n simultaneous equations. Okay, maybe n we have used earlier, so I can write it here at P different time and that will give you, P simultaneous equations, equations. The values of, of F (t) V (t) in general, can be determined from, strain and acceleration sensors, sensors. The recording has to be done till, 4L by C from the, from the impact. Based on this, so using equation for known values of F (t), V (t) up to 4L by C, use equation C and you will be able to determine the value of R (t). Using equation (C), for known values of F (t), again in general, and V (t), in general. So this equation is like generalized one. Whether if you are having resistance from intermediate depth, it will take into account, because the second component is actually taken into account, the resistance from, intermediate depth. And if you are not having only two resistances there, then the reflection from intermediate depth component will not be there. So for known values of V(t) and F (t) and V (t), equation C, can give the value of resistance, offered by Pile against hammer impact. So this way, based on the resistance or based on the ref, response of the pile or more precisely, the ray, ray, resistance offered by the soil layer, which is available at different, different depths, collecting the resistance or the signature, against the shock wave, you will be able to determine the value of R (t) at that particular depth or collectively the value of R, summing over 4L by C, duration.

So that is like, this is how you can get an idea about, the total resistance, because that was the objective. So this way you can actually get an idea, how much is the resistance offered by the pile, while deriving, which maybe equal or which may not be equal to the resistance for way, considering the C5 value of soil, obtained from over log. So this way you can actually determine, how much is the actual resistance, the pile in it's in-situ condition, can offer. Because, if you allow the, the soil to, to regain the strength or by leaving the pile for some more time to, to regain the strength, so that resistance mostly will be higher than, resistance you're getting from this. But this is going to give you the, the minimum bearing capacity of the pile, against the impact load. And this resistance, you can also compare with the in-situ strength of the soil and, but precisely the pile material. Inorder to ensure, there should not be any kind of failure in the pile material, because of the impact load. So this is, about the High Strain Dynamic Testing, which is run precisely to understand the stress developed and also the, the resistance, the pile medium can offer to external loading.

So same way, in the next class, which is, lecture 20, we will be discussing about, Low Strain Test, which can help you in understanding the integrity of the pile, with respect to the depth, the cross section as well as the length, which has been achieved, after the pile is placed in is, in it’s in-situ condition. So we will discuss that in, maybe coming lecture. I hope that, today’s lecture is more clear to you? This, this discussion is a new one and has not been considered in many of the text books. So try to go through this derivation, try to sketch, the diagrams yourselves, so that you will get more understanding about the direct component of shock, the reflected component of the shock, which will be detected by the, sensors. Because so far, we, we knew like, some shock is there and you put some sensor and it is detecting. But why it is detecting, from what interface the reflection is coming into picture. So, so, I hope, this will be much useful to each of you. Thank you, so much.