Irrigation and Drainage
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Lecture - 27
Aquifer Properties

So, this is lecture number 27, we are going to talk on I mean continue talking on this Aquifer Properties.

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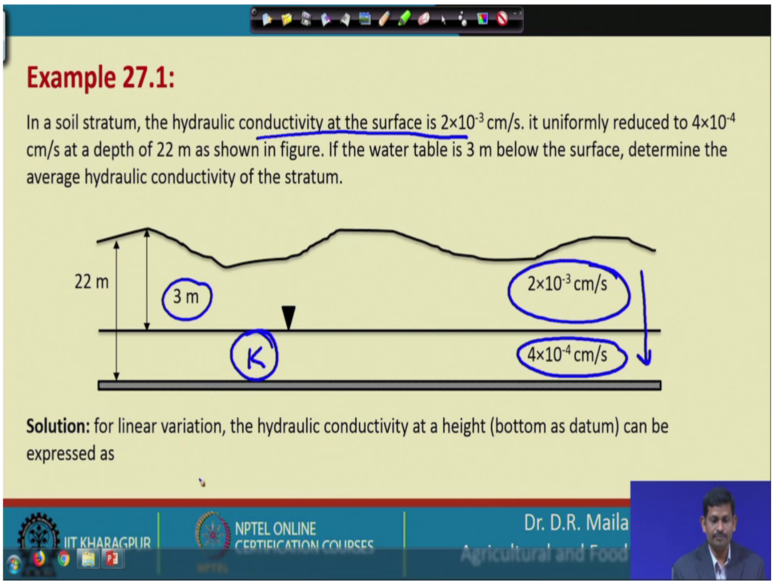

So, before going to that there is an example on, how to find out the average hydraulic conductivity? So, here in this example in a soil stratum, the hydraulic conductivity of the surface is 2 into 10 power minus 3 this is that surface. And, if it uniformly reduced to 4 into 10 power minus 4 from here to here it is it gets reduced.

Right so, and then at a depth 22 meter and is shown in figure, if the water table is 3 meter below the surface. So, if there is a water table which is 3 meter below the surface, determine the average hydraulic conductivity of the stratum. So, what is the average hydraulic conductivity of this stratum? So, in this let us formulate equation. So, we to find out what is the linear because it is decreasing from 2 to 2 into 10 power minus 10 power minus 3 to 4 into 10 power minus 4 and how linearly it is decreasing we are going to get an equation.

I am using that equation and you will be integrating that equation with the and the distance right. So, then you get the average hydraulic conductivity. So, let us see that. So, here in the next slide we go. So, the before that let us see here for linear variation the variation the hydraulic conductivity at a height the bottom is a datum. So, we take this is a datum now this is the datum can be expressed as so, we going to express that as let us see.

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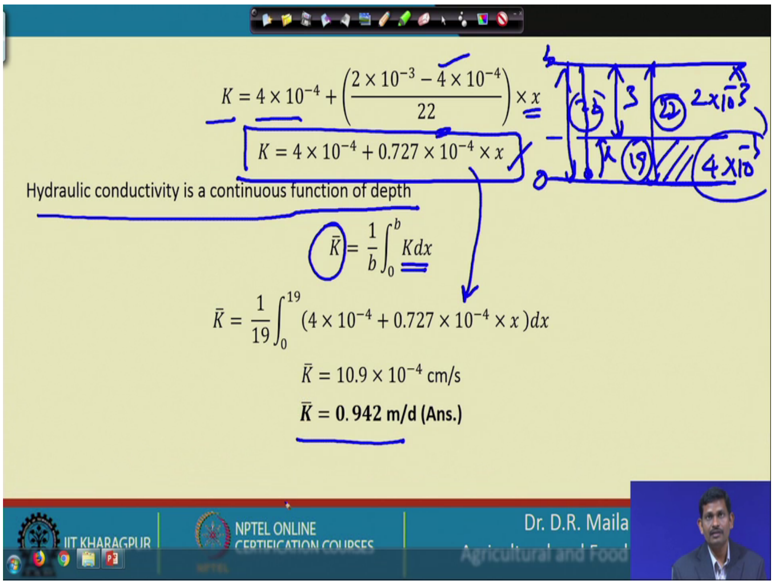

So, here K hydraulic conductivity, which is equal to 4 into 10 power minus 4, because our datum is bottom right, our datum is bottom top.

So, here you got 2 into 10 power minus 3 and the bottom it is 4 into 10 power minus 3. So, from the datum so, we take 4 into 10 power minus 3 plus the difference so, 2 into 10 power minus 3 minus 4 into 10 power minus 4 divided by the total length is 22 meter right into x. So, from 0 to x we are going up that is x. So, finally, you get K in terms of the distance right. So, this is kind of regression equation. So, knowing the distance from here to here you can estimate K value.

So, then hydraulic conductivity continuous function of depth say this in this and now average K which is equal to 1 by b 0 to b K into d x. So, here 1 by b; that means, 0 to b let us say this is 0 to b. So, here we know this is 3 meter and this is 22 meter right and from here to here this will be 19 meter right. So, from 19 0 to 19 so, we need to find out k for this you know stratum. So, 1 by 19 and 0 to 19 and put this equation here right and integrate it you will get K bar is 0.942.

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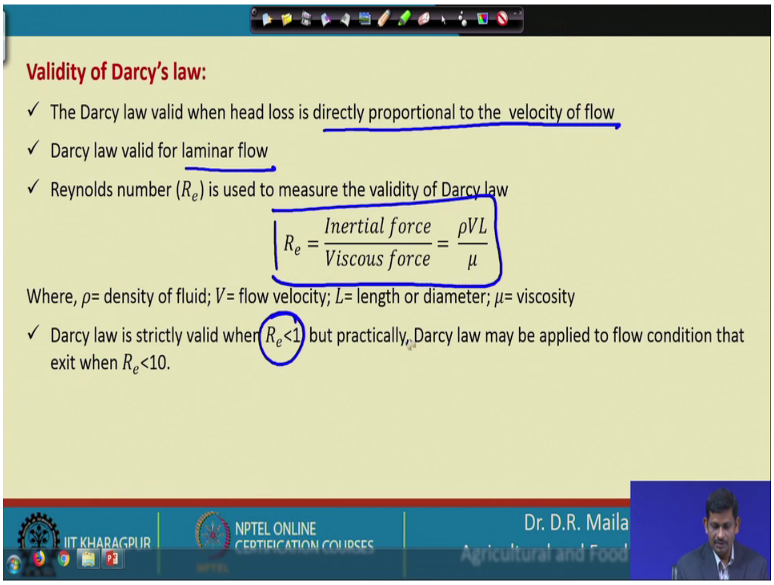

So, O and then look at the validity of the Darcy's law. The Darcy's law valid when head loss is directly proportional to the velocity of flow. And, the Darcy's law valid for laminar flows laminar flow you talking R e should be less than 1, strictly if it is less than one it is a laminar flow and we know we already know how to estimate R e rho V d by mu.

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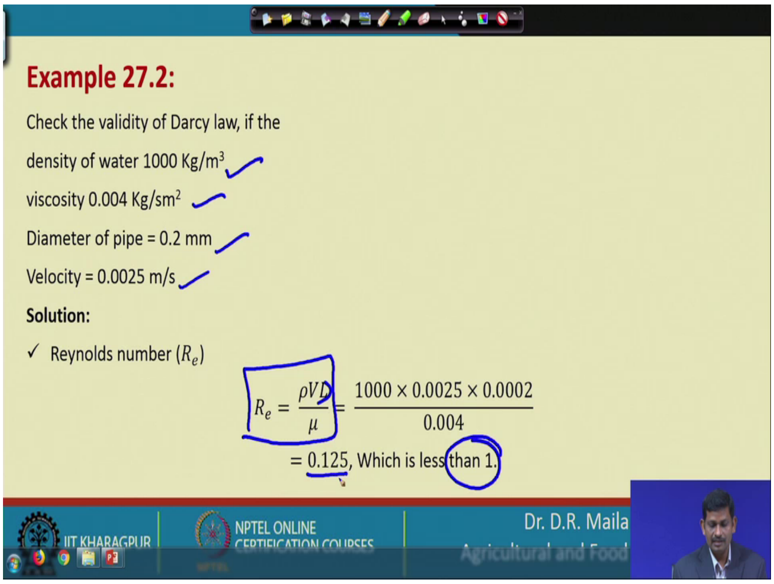

And, there is a next example here. So, check the valid of Darcy law, if the density of water, viscosity, pipe diameter, and velocity is given. So, put everything in this equation right R e rho V. So, rho V L is here is the diameter (Refer Time: 04:54) D rho V D by mu and this will be 0.125. So, R e is 0.125 which is less than 1 so; that means, this is a valid Darcy's law is valid for this.

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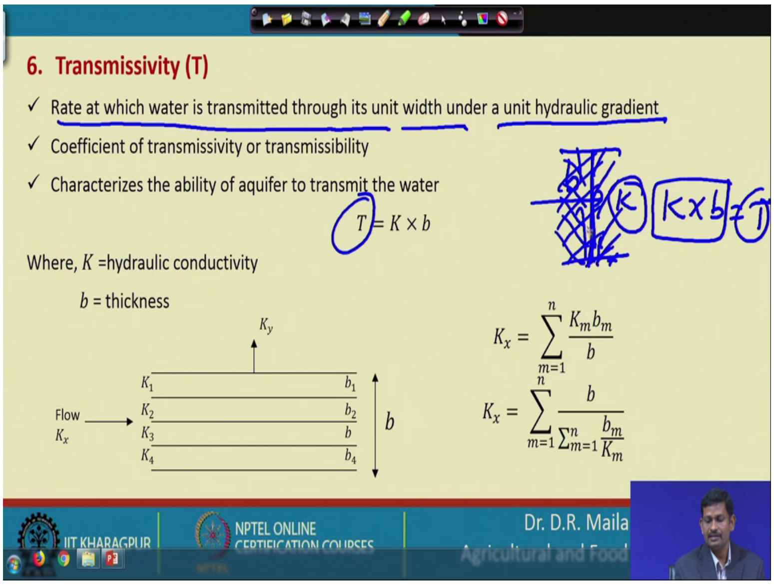

And, next is the transmissivity. So, the transmissivity is defined as the rate at which water is transmitted through it is unit width under a unit hydraulic gradient. So, the previously what we thought unit in a cross sectional area right, it is passing through unit transmit cross sectional area. So, if this if that one is passing through a thickness of aquifer thickness of aquifer.

So, not only unit so, if you considering the whole depth right the thickness and then the K multiplied by b. So, that will give the transmissivity T. So, if the hydraulic conductivity K for this geological formation, which has a thickness of b so, the K multiplied by b equal to T. So, that is the T is a transmissivity. So, for this particular aquifer, how much water which it can transmit right from the particular thickness of the aquifer. So, the coefficient of transmissivity or transmissibility this is also called transmissibility.

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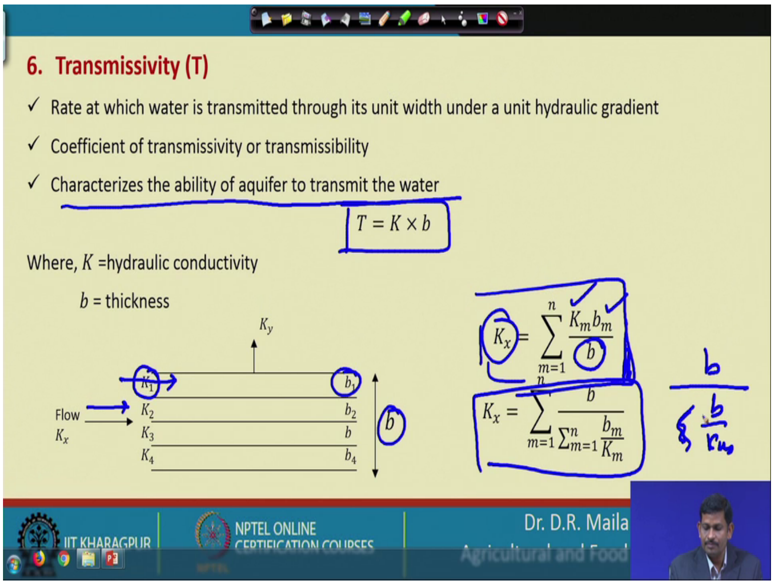

And, it characterizes the ability of aquifer to transmit the water. So, the here T equal to K into b. Suppose if, you have the water is flowing in x direction they at different layers. So, each layer got different K values and thicknesses the total is b is the thickness. So, the K x the entire K they means average K x average K can be estimated by knowing the K value individually right.

So, that K m into b m divided by b total b. So, this is called the this is called the average. And, another average is called you can say the distance average. So, the b divided by this called inverse distance. So, b divided by b by K m right individual b by K m. So, this is also you get the average K value.

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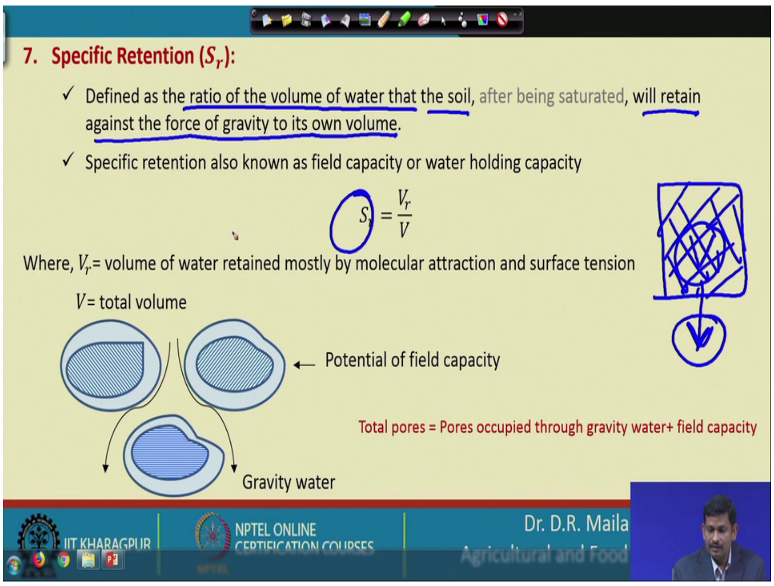

And, the other one is the specific retention. So, the specific retention of an aquifer is defined as the ratio of volume of water, that the soil after being saturated will retain against the force of gravity it is own volume. So, let us say this is the volume of soil saturated soil this is the saturated soil, it is volume is V right. This is a volume of water that soil after saturated will retain, against suppose there is a gravity initially saturated.

So, in after that what happen due to gravity? So, the gravitational water is going to going to escape from the so, specimen. So, in that case the volume of water which is retained inside against the ratio of water which is retained divided by the total volume that will give the specific retention. The specific retention is how effectively a particular aquifer retains water against gravity. So, that is a specific retain you might have seen the similar to field capacity. So, that is similar to thus this is a similar to field capacity.

And, then so, that is the volume of water retained and total volume. So, this is the specific retention. And, then the total force so, suppose if we have. So, this is the, you know the sand grains the sand particles these are the sand particles. And, then over that initial suppose this is completely saturated right, if this is completely saturated. So, due to gravity, so all this water which is not influenced by particles will be or influenced by gravity will be flown out.

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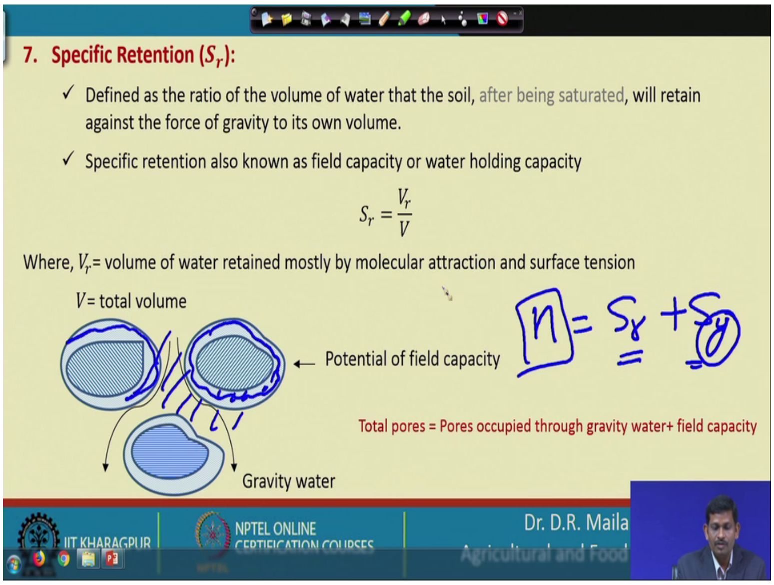

So, the rest will be so, this water. So, this will be attached to the soil particles right and this is called water is retained in soil particles. So, the volume of water which is retained divided by the total volume of water or term volume that will give the percentage of I mean specific retention and then. So, since it is making up the pores. So, the total porosity which is equal to the S r right S r plus the S r this is water which is an S g let us say or S g or S y, S g is a gravity due to gravity is got. So, S r plus S g this combinely make up the soil pores. So, the pores occupied through gravity water plus field capacity.

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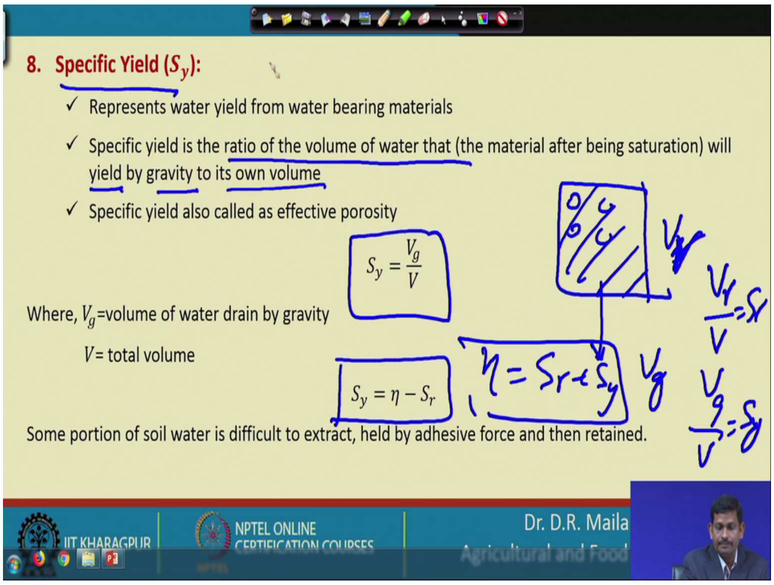

So, the next is specific yield. So, specific yield is the we are talking about the rest of water. So, here so this is the specimen right the party initially saturated solution initially saturated and due to gravity some water is gone out. So, and the rest will be enough. So, that is V s is let us say, V s is retained and V g came out now let us say V r. This is V r, which is retained and V g came out. So, V r by V will be equal to S r whereas, V g by V which is equal to S y. So, the volume of so, this is called specific yield.

So, the specific yield is the ratio of the volume of water. So, that will yield by gravity to it is own volume that will yield by gravity to it is own volume. So, that is specific yield. So, V g volume of drain by gravity and V total. So, S y is equal to n minus S r because n is equal to S r S y. So, that is previously we have seen. So, some portion of the soil water is difficult to extract held by adhesive forces that is retailed we have seen.

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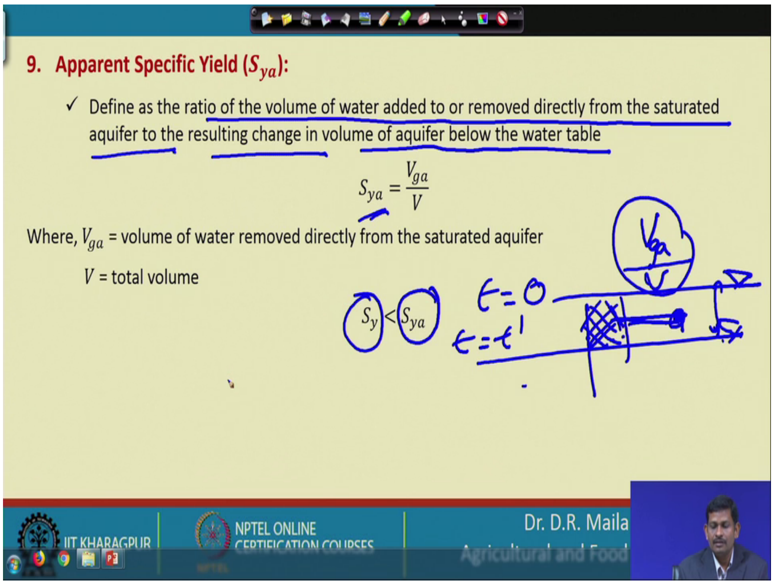

So, the next is the apparent specific yield. So, all water which is we are expecting to yield or all water, which is expected to yield may not be make up back yield back. So, some water is due to a trap by water air. So, due to air entrapment so, water even sometimes difficult to pass through gravity so, that means, definitely the gravity water may not be equal to 100 percent gravity water. So, then that is why there is a apparent specific yield term come into the picture.

In specific apparent specific yield, if you see is defined as the ratio of the volume of water added or removed directly from the saturated aquifer to the resulting change in volume of aquifer below the water table. If suppose there is a water table right. So, here initial is time t equal to 0, the water table level is this and that time equal to some time so t dash. So, the water table has come down. And, if you see the water which is present I mean the water which is zealed out or which is came out due to this change right.

So, due to the change so, that let us say that is V g a that volume of water, which is came out due to the change in the depth of water table divided by the volume total volume. So, this will give the apparent specific yield. So, definitely the apparent specific yield is less than the specific yield because of the I mean because of the air entrapment.

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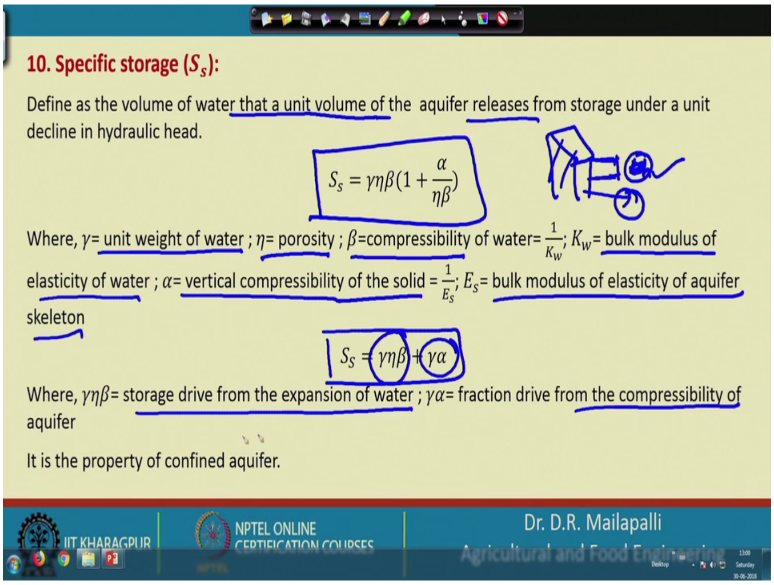

So, the next is specific storage. So, here the specific storage if you see so, it is defined as the volume of water that a unit volume of aquifer releases from the storage under a unit decline of hydraulic head.

So, suppose you have you have in the unit saturated you know unit saturated volume. So, let us say the initial water table is here. And, then the pressure at this one is here and the difference in sorry not here. So, there is a unit and initial water table is here and decline to a unit hydraulic head. So, it declined a head. So, it declined a hydraulic head and during that time the amount of water that unit volume of aquifer releases from the storage. So, here is the storage. So, during the declining the unit decline the amount of release due to the unit decline in head.

So, here specific storage the volume of water which is released from the storage due to the unit decline in hydraulic head, this unit decline in hydraulic head so, this is estimated assigned with S specific storage is equal to rho nu beta into 1 plus alpha by n beta, where alpha I mean sigma is unit weight of water, and eta is porosity beta is compressibility, compressibility of water, and K w bulk modulus of elasticity of water, vertical compressibility of solid, and S bulk modulus of elasticity of aquifer skeleton.

So, here this is also can be written as like this. So, here all these terms are coming to the picture because so, initially this soil it is completely saturated right the saturated. So, the moment if you remove water so, that that is definitely causing the head declining right. So, for unit decline in head, unit decline in head. So, definitely that will influence the storage, which is present in the soil specimen. So, the storage how it is influencing because the moment you remove water so; that means, the water which is confined the state which is confined. So, that will be definitely is going to compress right.

So, when so, be because when the it is compressed so, this is called the compression, but definitely that will affect the expansion of the fluid. So, here the 2 components, 2 things are going on. One is compression is taking place and the other one is expansion of fluid. So, that it is going to release from the storage volume. So, here the first part indicates the storage from the expansion of the water. And, the second part which is derived from the compressibility of the aquifer yes compression as well as the expansion of fluid.

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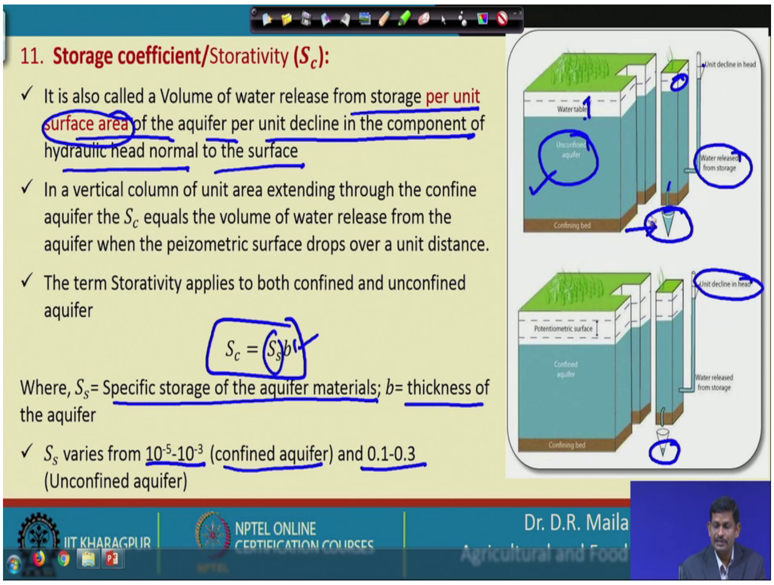

And, then the storage coefficient or the Storativity; Storativity or storage coefficient is also called volume of water release from storage per unit surface area of the aquifer per unit decline of the component of hydraulic head normal to the surface. Is similar to if S s is the K right and S c will be T transmissibility. So, similar to the that time we have transmissivity and K. So, here we have these 2 terms storage coefficient and then and then specific storage. So, the storage coefficient is defined as this is also called so, this storage from unit surface area of the aquifer per unit decline in component of hydraulic head normal to the surface, here unit surface area we need to consider.

So, for example, in a vertical soil column so, let us say it is a vertical column right. So, this is unconfined aquifer let us say the water table is here, water table. So, initial water table is here and let us say the unit decline, this is the unit decline for unit decline. So, if you the amount of water which is released from the system from the storage right water released from the storage. So, this is this is this is called the storage coefficient. Similarly, in confined aquifer the for unit decline so, the water which is released from the system right is called the storage coefficient.

So, and if you see the both cases right so, we will estimate the storage coefficient as S s into the b is thickness the specific storage aquifer material b is a thickness of aquifer material. So, S s varies from 10 point minus 5 to 10 power minus 3 in case of confined aquifer whereas, in case of unconfined aquifer it is 0.1 to 0.3. So, you can clearly see the how I mean the magnitude differences amounts.

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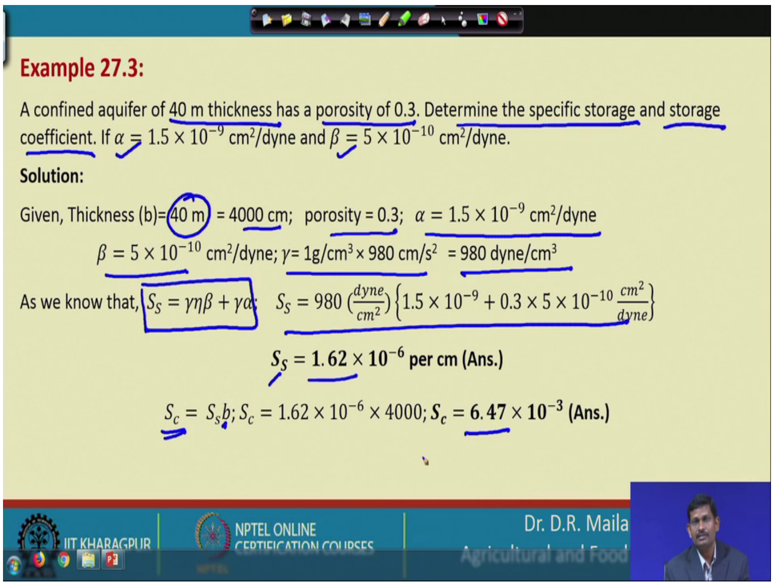

So, let us see an example here a confined aquifer for a 40 meter thickness has porosity 0.3.

And, determine the specific storage and storage coefficients. So, other terms are alpha is given beta is given. So, use the equation so, let us see the thickness is 40 meter, convert the centimeter porosity 0.3 alpha is given beta is given and gamma anyway for water is 1 gram per centimeter cube this 980 dynes per centimeter cube given. So, this is the equation we need to use S s equal to gamma n beta plus gamma sigma gamma and alpha. So, put the values and you get S s 1.62 into 10 power minus 6 per centimeter. And, S c the storage coefficient we multiplied with b to S s you get 6.47 into 10 power minus 3.

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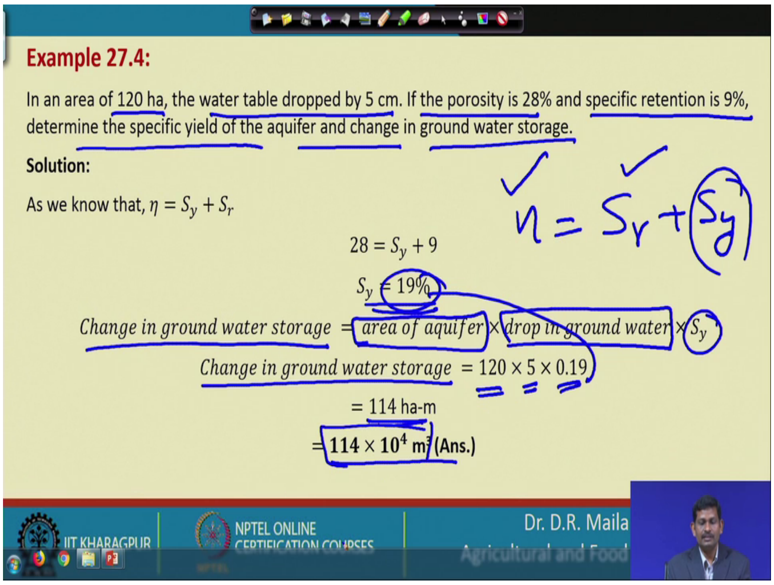

And, then there is another example here yeah area is given 120 hectare basin area and water table water table dropped by 5 centimeter. If the porosity is 28 percent specific retention is 9 percent, determine specific yield of the aquifer change in ground water storage. So, we know that you know n is equal to S r plus S y. So, the porosity is given right and then specific retention is given. So, find out S y. So, that S y is 19 percent you get.

And, then change in ground water storage. So, the area of aquifer is given drop in ground water right 1 ground water drop and S y S y is the retention. So, sorry S y is the specific yield specific yield. So, the change in ground water storage is 120 into 5 is drop and you got this specific yield. And finally, 114 hectare meter and this is meter cube of water can be released, they can be released.

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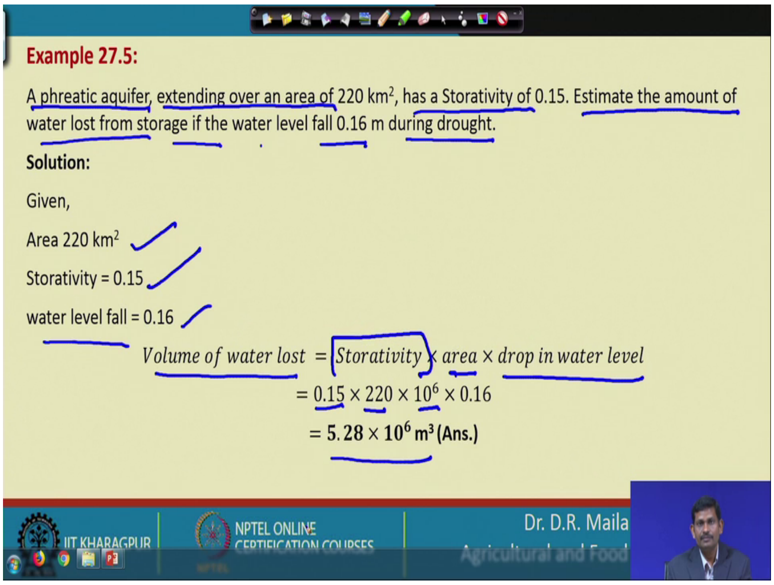

There is another example here if you see the phreatic aquifer. So, phreatic aquifers or are also called the water table aquifers.

The extending over an area of 220 kilometer square has a storativity 0.15, estimate the amount of water lost from storage, if the water level falls from a 0.16 meter during the drought. So, given the area is given storativity 0.15 the water level fall 0.16, volume of water lost is equals storatitivity area and drop in water level. So, is everything is given so, put the values you get 5.2 6 into 10 power 6 meter cube is the volume of water, which has been lost right from the area or drainage basin.

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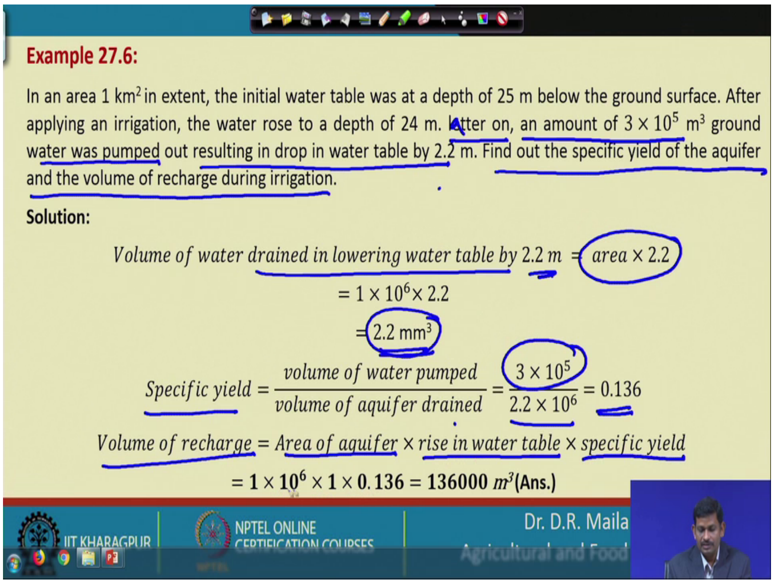

There is another so, this is there is a 1 kilometer square area. So, initial water table was at a depth of 25 meter below the ground surface after applying in irrigation the water rose to a depth 24 meter. So, initially there is a water table right. And, then when we irrigate the water table rose to 24 meter. So, we are this is a datum. So, initially 25 meter and it is 24 meter because of additional water through irrigation. So, this is later an amount of 3 into 10 power 5 meter cube ground water was pumped and resulting the drop of drop water table by 2.2 meter. So, find out the specific yield of the aquifer and the volume of recharge during irrigation.

So, here initial water table is there then after that irrigated it right and water table again raise rose then after that they pumped the water, then water table gone down to 2.2 meter upon 24 meter. And, the find out the specific yield of the aquifer and the volume of recharge during the irrigation so, the volume of water drained in lowering water table by 2.2 meter is equal to area into 2.2. So, that is 2.2 mm cube. So, this is the volume of water drained right as pumped you can say. So, specific yield is the volume of water pumped by volume of a aquifer drained right.

So, volume of water pumped that is 3 into 10 power 5 right and 2.2 into 10 power 6. So, that will be equal to specific yield will be 0.136 right and then volume of recharge the area of aquifer into raise in water table in the specific yield. So, putting the values you get this is the volume of recharge.

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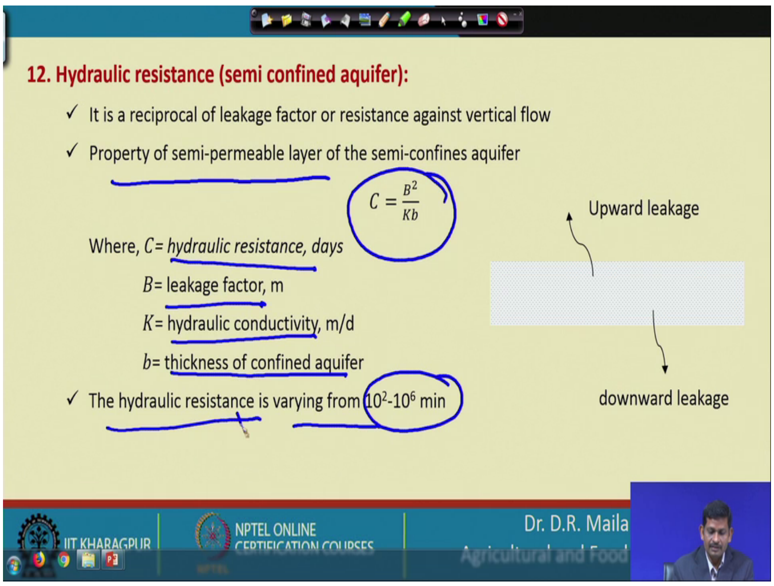

So the other properties here are hydraulic resistance. So, hydraulic resistance so, we are looking for these 2 properties hydraulic resistance and the leakage factor. So, these 2 properties belong to semi confined aquifer semi confined because the resistance we have. So, suppose this is the semi confined aquifer, upwards due to this is the leakage it could be a downward would be a another leakage.

So, it is the reciprocal of leakage factor or resistance against vertical flow. So, ones you have the like a permeable surface right so; that means, water can easily pass through because this is impervious air and or semi pervious. So, water pass through, but not at that ease. So, that is why it is called the leakage.

So, the property of semi permeable layer of semi confined aquifer that is equal to b square by K b. Where C is hydraulic resistance in days and B leakage factor in meter and hydraulic conductivity K and b is the thickness of equation of confined aquifer. So, the hydraulic resistance is varying from 10 square to 10 power 6 minutes. So, hydraulic resistance is measured in minutes where time minutes.

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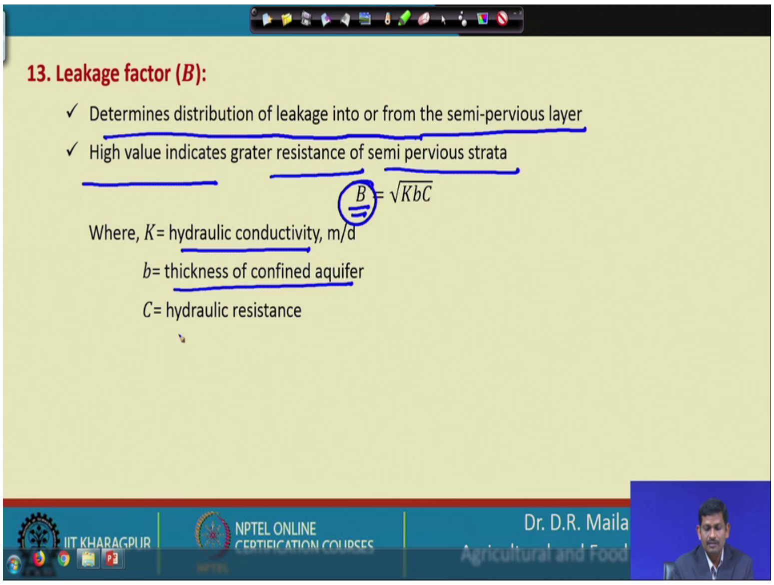

So similarly in the same equation if we use. So, you can take B out. So, that is square root of K b C that is a leakage factor. So, it determines distribution of leakage into or from the semi pervious layer. So, high value of B indicates the there is a greater resistance so, because high value indicates greater resistance of semi pervious strata. So, the K is hydraulic conductivity b is thickness of confined aquifer and hydraulic resistance is a C.

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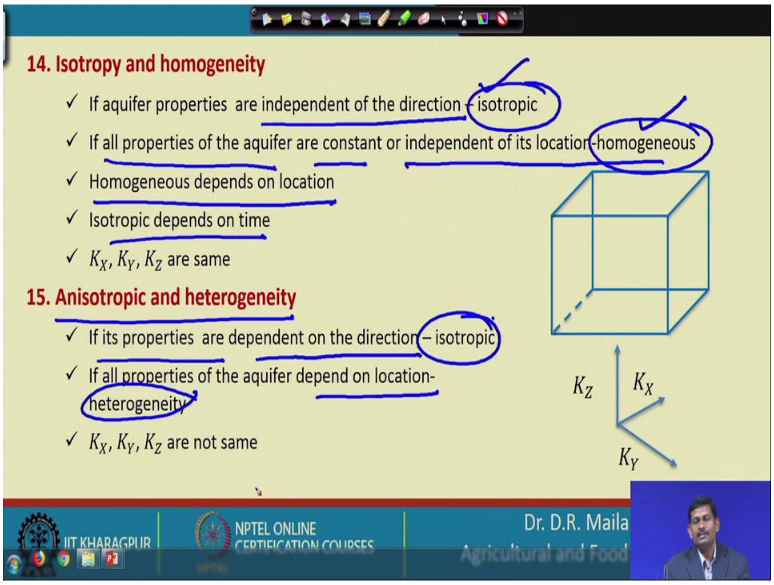

So, I think there is other properties is called isotropy and homogeneity. So, isotropy definitely it is aquifer properties if the aquifer properties, whatever properties we have discussed all the properties or if their properties or any of the property here independent of for the direction that is called isotropic.

So, the if the k is same with all directions it is called the case isotropic. If all properties of aquifer are constant or independent of the locations it is called homogeneous. So, the properties are homogeneous when the particular property does not change with direction with the direction sorry, with the caution with the location the location. So, the location indicates homogeneity direction indicates isotropy. So, homogeneous depends location isotropy depends on the time and, anisotropic or heterogeneity is opposite to the previous property.

If the properties are dependent on the direction is not dependent on direction is isotropic, if all properties of aquifer depend on location is called heterogeneity. So, mostly we consider for hydraulic conductivity, because it because the soil formations vary in the I mean the properties of soil formation vary in the location mostly. Since, we are dealing with the flow the K is the most impressive parameter in ground water flow. So, we consider this isotropic homogeneity anisotropic and or non-homogeneity or heterogeneity for K hydraulic conductivity.

So, with this the aquifer properties the mostly like porosity, the bulk density porosity specific yield apparent specific heat yield specific retention right. A storage coefficient, specific storage right and then the properties of leakage aquifer properties of semi confined aquifers like leakage factor and hydraulic resistance. And, then the condition of aquifer and the flow system is concerned like the properties are though same with the directions, not changing with the direction with called anisotropic.

If the changing with the locations it is called homogeneity and the quite opposite to that it is called anisotropic and heterogeneous. So, with this and also we solved some of the examples I think with this the properties of aquifers I mean completed. So, we will be studying more on well hydraulics in the next few lectures and, then the tutorial for solving few examples on the well hydraulics.

Thank you.