Civil Engineering

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Lecture No. # 26

We have already discussed the theories in these water requirements of crops and we discussed about the base period delta and duty.

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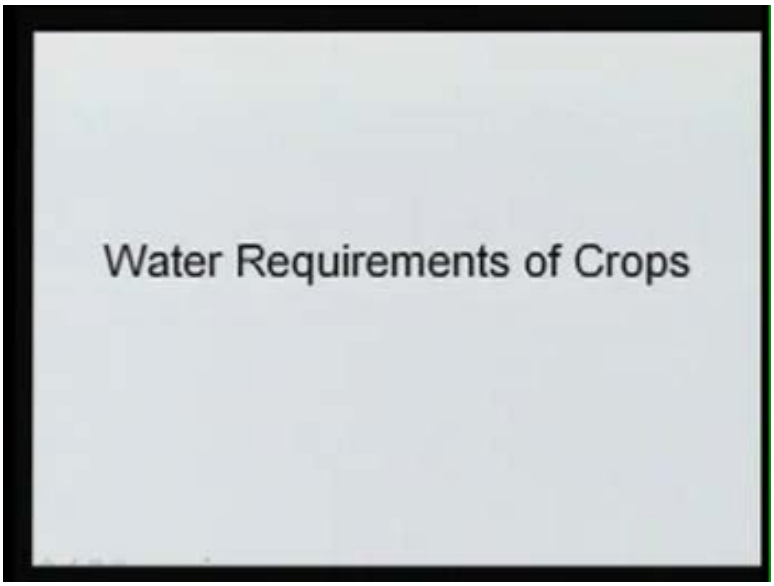

We have also discussed about different efficiencies in the irrigation system. Also we have discussed about the soil moisture relationship. Now we will solve some numerical problems so that the things will be clearer.

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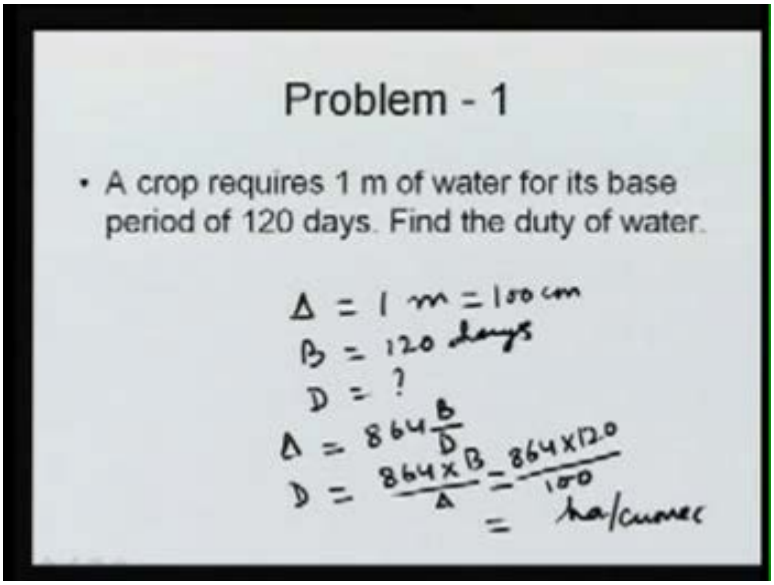

The first problem in this series is, a crop requires 1 meter of water for its base period of 120 days. Find the duty of water. Delta is equal to 1 meter. I can write these as 100 centimeter and B is 120 days and D is what? You know that the formula for delta is 864 B over D. If I exchange the terms, D will be equal to 864 into B over Delta which will be equal to 864, B which is 120 and in our case, Delta is 100. So you calculate and find out whatever be the number, these units will be in hectare or cumec. Let us go to the second example.

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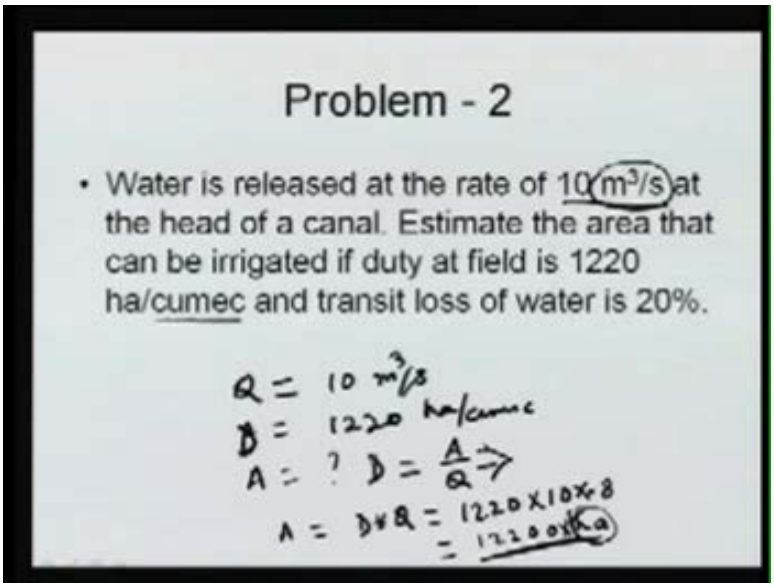

Water is released at the rate of 10 meter cube per second. So this is the cube given at the head of a canal. Estimate the area that can be irrigated if duty at field is 1220 hectare per cumec and transit loss of water is 20 percent. Here Q is given which is 10 metre cube per second and duty is 1220 hectare per cumec and the question is, what is the area, which can be irrigated if the duty is given as this? So as we know D is equal to A over Q, so these says A will be

equal to D times Q which is equal to 1220 into 10. Remember this cumec and meter cube per second are the same things. These become hectare, 12200 hectare.
Now there is a term transit loss of water which is 20 percent so when the loss is this much we cannot say that this is the area because there is some loss that means in place of the Q given we should have used the actual Q available to the field. It means in place of 10 we should have multiplied 80 percent of that because 20 percent will be loss. Multiply a factor of 0.8 which is 80 percent. This number will be changed to 0.8 and the answer will be in hectare. Now let us go to problem number 3.

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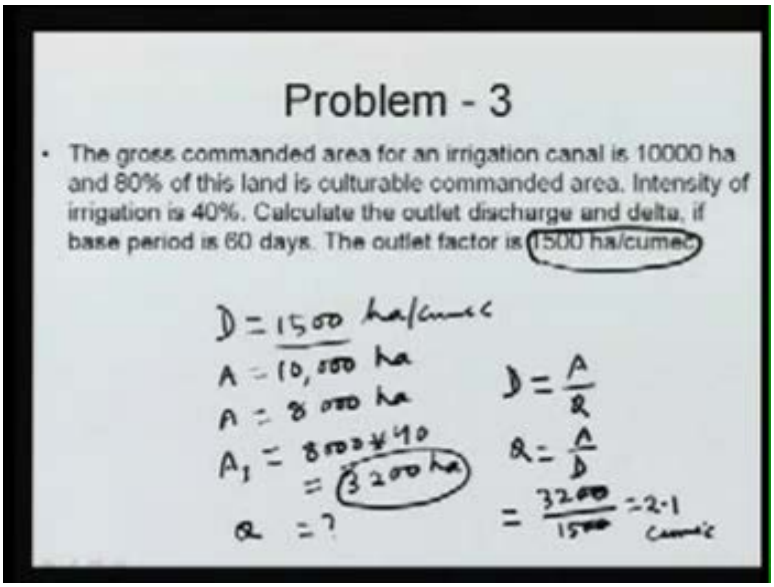

The gross commanded area for an irrigation canal is 10,000 hectare and 80 percent of this land is cultivable, commanded area. Intensity of irrigation is 40 percent. Calculate the outlet discharge and delta if base period is 60 days. The outlet factor is 1500 hectare per cumec, this is a kind of duty. Although it is written outlet factor, you can assume this to be duty and also you can verify from the unit that this is hectare per cumec. So 1500 is the duty hectare per cumec. The gross commanded area for an irrigation canal is 10,000 hectare. 10,000 hectares and 80 percent of this land is cultivable. So the area that will be cultivable will be 80 percent of this that means 8000. The intensity of irrigation is 40 percent. So out of this 8,000 hectare, we have irrigation at 8000. Irrigated land will be 8000 into 40 percent, so 0.4 which will give me 3200 hectare. Now for the calculation I should use these as the A and duty is given. Now the question is whether we have to calculate the outlet discharge. What will be Q? If this is area and duty is 1500 hectare per cumec, Q will be duty multiplied by A because duty is area divided by Q. So Q duty is area divided by Q. So Q will be equal to A divided by D which is equal to, in these case, 3200 hectare divided by 1500 or whatever is the number. You calculate this number, 2 point something which is this much cumec. The outlet discharge will be 2.1 or 2 cumec and also, it asks about delta because base period is given. If I have to calculate delta, what should I do?

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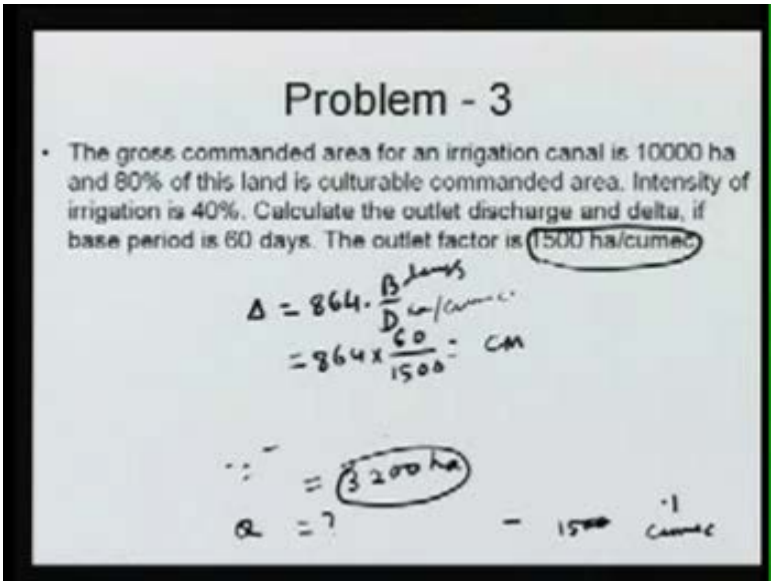

I should use the relationship between base period duty and delta which is delta is equal to 864 times B over D and here B is 60 days. So 60 divided by D is 1500, so you find out this number. So for Delta we should use this formula and whatever is the answer will be in centimeter because B is in days and D is in hectare per cumec. Let us go to the next problem.

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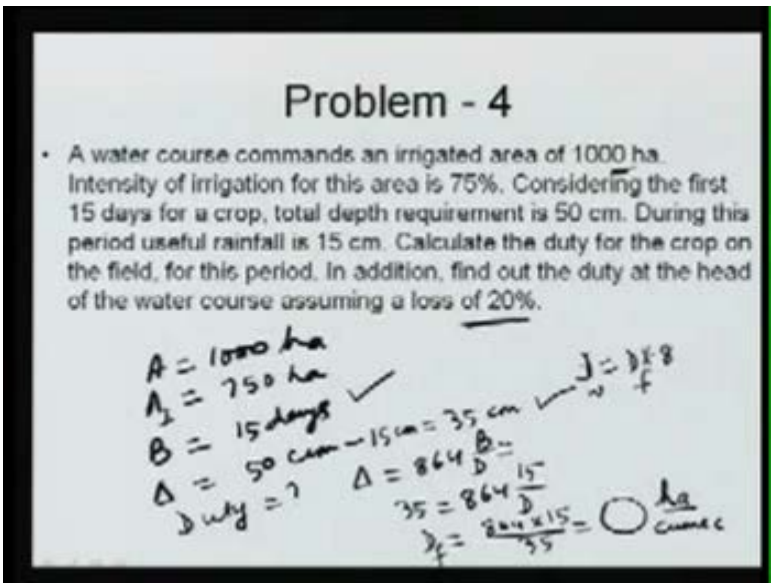

Problem number 4, a water course commands an irrigated area of 1000 hectare. Intensity of irrigation for this area is 75 percent considering the first 15 days for a crop, total depth requirement is 50 centimeter. During these periods useful rainfall is 15 centimeter. Calculate the duty for the crop on the field for this period. In addition find out the duty at the head of the water course, assuming a loss of 20 percent. In any problem what is required to be done is first, try to note down the data e given in the problem. Also note down what is required. In these problems, we have the area as 1000 hectare and intensity of irrigation is 75 percent that means area to be irrigated, will be equal to 750 hectare, 75 percent of 1000. Considering the

first 15 days for a crop, here though the base period is not 15 days, the problem is asked for the first 15 days. The time here is 15, so we can take B as 15 days. Total depth requirement is 50 centimeter. Delta is 50 centimeters. You can see during these periods, useful rainfall is 15 centimeter that means if the requirement by the crop is 15 centimeter and rainfall is 15 centimeters that means through irrigation, what is the amount of water we have to give? This will be 50 – 15 which is 35 centimeter. For the purpose of calculation, we should use delta equal to 35 centimeter and not 50 centimeters. Calculate the duty for the crop on the field so now B is given, delta is given and duty is asked. So what will the duty will be? You should use the formula delta is equal to 864 B over D and all are in consistent units. So here 35 centimeters will be equal to 864 here. B will be 15 and what is D? D will be equal to 864 times 15 divided by 35 and this will be whatever the number is, the unit will be hectare per cumec. This is the duty.

This is the duty on the field. The next question is to find out the duty at the head of water course and the loss is 20 percent. Remember that this is the duty. Whatever number is obtained here, it is the duty on the field. I am just writing it through a subscript f. So at the head of the water course, the duty whether it increases or decreases, in the discussion on duty, it varies with the downstream movement of the canal system. As we go down, the duty increases. It means here this duty is on the field. So as we go up, duty will decrease. So this loss is 20 percent which means 80 percent is available. We should multiply 0.8 to these numbers. So D duty on the head of water course will be equal to whatever number obtained here multiplied by 0.8 and 5.8 because 20 percent is the loss while water is moving down stream. There will be a loss of 20 percent. Duty here will be less, so this problem is over. Let us go to the next problem.

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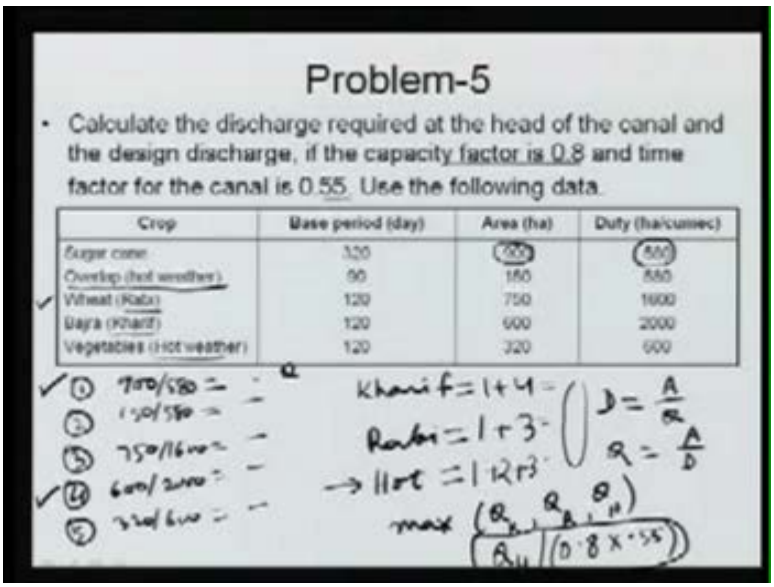

Problem number 5 includes, calculate the discharge required at the head of the canal and the design discharge. If the capacity factor is 0.8 and time factor for the canal is 0.55, use the following data. This is an interesting problem because you are asked to design your canal system. At different periods of a year, the water requirement might be different but while designing what we should do is we should look for the maximum water requirement and it is generally in the summer days. You should look for that and depending on that maximum

value we should design the canal system. Now let us solve these problems here in the table 1, 2, 3, 4, 5 different crops are given. One is sugarcane and the base period is 320. It almost covers most of the year and similarly this is sugarcane overlap in hot weather which is for 90 days and also you have a typical Rabi crop, a typical Kharif crop and a typical hot weather vegetables with different base periods. The area irrigated will be 900 hectares, 150 hectares, 750 hectares, 600 hectares and 320 hectares respectively. The duties are 580, 580, 1600, 2000 and 600. Why duties are different? We are considering the same length, for duty may be different depending on the base period, depending on the water requirement of the crop. So let us consider individual crops and let us try to find out the discharge for individual crops. If I designate 1, 2, 3, 4, 5 for 5 different crops then I can find out the required discharge for each one of these crops.

For example here for sugarcane, I have duty equal to 580 and the area is equal to 900 hectares. So for sugarcane what will be the discharge? We know duty is A divided by Q. So Q will be A divided by D. I get this area divided by the duty, so for the first thing, it will be 900 divided by 580 (whatever is the number). Similarly for other crops too I can find out. 150 divided by 580, 750 divided by 1600. Then 600 divided by 2000, 320 divided by 600. Whatever number you get here, you write down. Please remember in the discussion on these problems, I am trying to give you only the clues. The detailed calculations are to be done by you. Now we get 5Q values and discharge values for the individual crops. Out of these crops, I should categorize them for Kharif, Rabi and hot weather and try to see the water requirement. For example in case of Kharif what is considered is, number 1 and number 4 which is Bajra. So for calculating the water discharge required in Kharif season, I should use number 1 and number 4. Similarly for Rabi what should I use? I should use number 1 and number 3 and for hot weather what should I use? I should use 1. Why 1 is used everywhere because sugarcane is almost running throughout the year. So you should use the water required for sugarcane in all these calculations. For hot seasons I should use number 1 then also number 2 and number 3. Common sense, senses that these will give you the maximum number because during hot weather needs more water. But you verify these numbers.

Whatever number you get, you choose the maximum out of these. You choose the maximum discharge Q Kharif, Q Rabi and Q hot season. Then that Q will be your design discharge but we have to use these factors too. The capacity factor is 0.8 and time factor for the canal is 0.55, so you have to use judiciously these factors to find out is the design discharge. Let us say QH is the maximum so whatever number you got by calculating these discharge you have to again take into account these factors. So QH should be divided by 0.8 for finding out. I am writing here 0.8 and you should divide by 0.55 for the canal. Now this is the design discharge for your canal. If you are planning to construct a canal system, your canal system has to be designed for a discharge of this amount. Let us go to the next problem.

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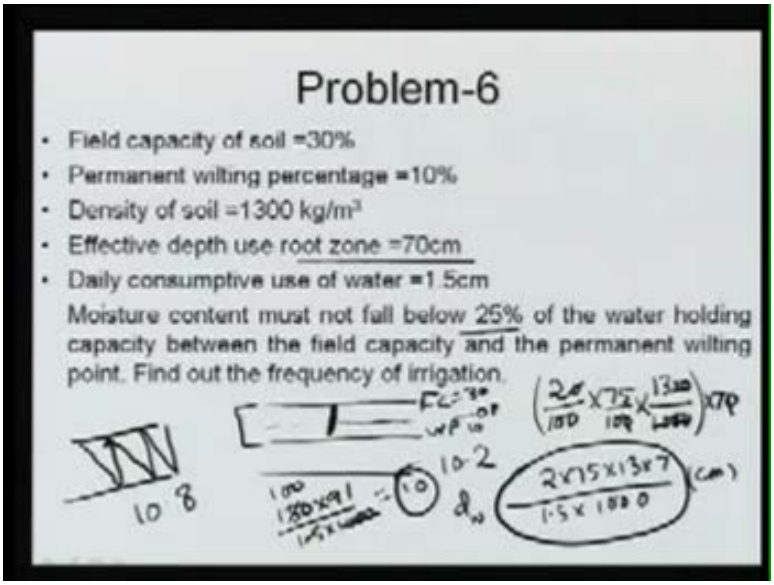

In problem six, the data are field capacity of soil is equal to 30 percent. Permanent wilting percentage is equal to 10 percent. Density of soil is equal to 1300 kg per meter cube. Effective depth use root zone is equal to 70 centimeter. Daily consumptive use of water is equal to 1.5 centimeter. Moisture content must not fall below 25 percent of the water holding capacity between the field capacity and the permanent wilting point. Find out the frequency of irrigation. Let us say this is the end of the ground water, this is the field capacity and this is the permanent wilting point and this is the optimum water content. This is 30 percent, this is 30 and permanent wilting point is 10 percent.

This is 0.2 or 20 percent and here it says moisture content must have must not fall below 25 percent of the water holding capacity. This is the water holding capacity that means we should allow only 75 percent of this because it should not fall below 25 percent. What is the water required by the irrigation? Water for these depths will be the moisture content which is 20 percent and again 75 percent which is this by 75 percent. I am using this information, then I should multiply the density of soil which is 1300 and I should divide it by water which is 1000. With this I should multiply the root zone depth which in our case is 70 centimeter. So my answer to these will be in terms of centimeters or whatever number is obtained. This is one 0, two 0's three zero's and maybe I can delete these zeros, basically 2 into 75 into 13 into 7 divided by 1000. This is D of water in centimeter because this number 70 is in centimeter. The question is the daily consumptive use of water is 1.5 centimeter and this is the centimeter we have to provide. When daily consumptive use is 1.5 centimeters, the number of days in which we should repeat irrigation will be this divided by 1.5. So these number will be the number of days we should repeat because first water will try to in one day it will come down to 1.5 centimeter and again we have to supply these water again it will in one day it may come down to 1.5 centimeter, so in these way you calculate these number whatever is the number it will be around this is 150, this is 91. Let us say 100 divided by 1.5 into 1000. So you get around 10 days.

Here the frequency of irrigation is 10 days. There is a precaution here. Suppose your answer comes out to be let us say 10.2 or maybe it is 10.8, if it is 10.8, you should not feel that 10.8 is more than 10.5. So it should be equal to 11 because you cannot fix your irrigation at 10.8

days. It has to be either 10 days or 11 days. To be in the safe side 10.8 should be taken as 10 days not in 11 days. Similarly if it is 10.2, it will also be 10, so the nearest whole number or the nearest integer number, smaller than the number will be obtained here. That will be your number of days after which you should repeat irrigation. This problem is over. Now I will switch over to the next problem.

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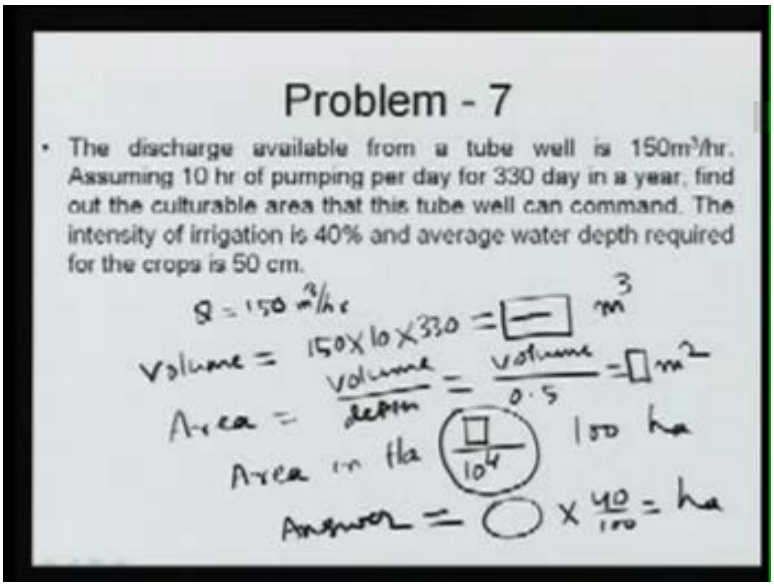

In problem 7, the discharge available from a tube well is 150 meter cube per hour, assuming 10 hour of pumping per day for 330 days in a year. Find out the cultivable area that this tube well can command. The intensity of irrigation is 40 percent and average water depth required for the crops is 50 centimeter. Let us write the data given in this problem and we will solve. This is 150 meter cube per hour and it is applied for 10 hours in a day. If I want to calculate the volume of water in a year, then it will be 150 which is the discharge multiplied by 10. This will be the water volume in a day but throughout the year I am supplying the water for 330 days. So you multiply these. Whatever number is obtained here will be in meter cube. We now want to find out the cultivable area. So this is the water volume. Now if I divide this to the depth then I get area and the water depth required for the crops is 50 centimeter. Whatever is the volume, the area will be volume divided by depth and in this case depth is 50 centimeter.

If I write this in meter, this will be 0.5, so this will be in meter square. Remember that you have to calculate this and place that here, then you find the final number here in terms of meter square this is the area and this will be generally a very large number and we express area in hectares. So for that method whatever is the number, it has to be divided by 10 to the power 4. This will give you in hectare. Now we must take this into account. The intensity of irrigation is 40 percent. Let us assume you get here 100 hectare. Then these should be multiplied by 40 percent because your intensity of irrigation is 40 percent. It can actually save 40 percent of this area. So the final answer will be this number. Whatever number you get at this step is multiplied by 40 percent hectare. In these calculations, we must take into account the losses or if there is intensity of irrigation, those factors have to be considered to find out the final answer. Let us go to the next problem.

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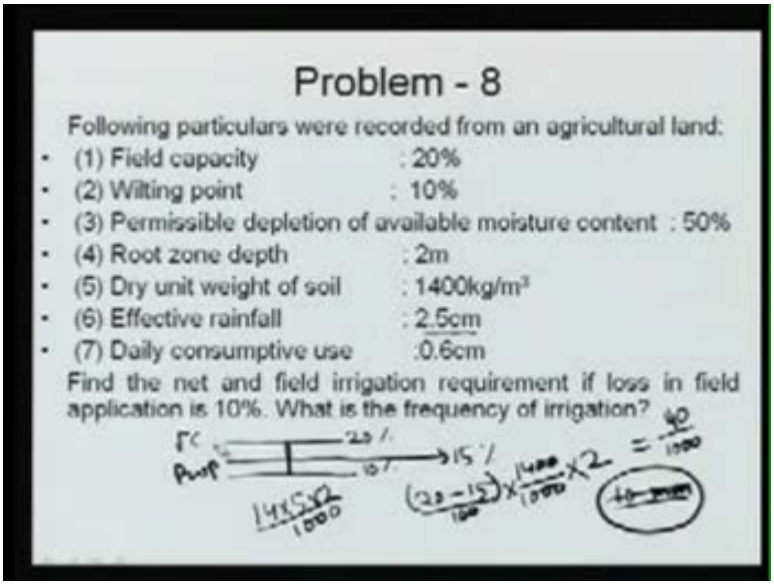

Problem number 8 is, following particulars were recorded from an agricultural land. Field capacity is 20 percent. Wilting point is 10 percent. Permissible depletion of available moisture content is 50 percent. Root zone depth is 2 meter. Dry unit weight of soil is 1400 kg per meter cube. Effective rainfall is 2.5 centimeter. Daily consumptive use is 0.6 centimeter. Find the net and field irrigation requirement if loss in field application is 10 percent. What is the frequency of irrigation? This is field capacity which is 20 percent and this is permanent wilting point which is 10 percent and 50 percent is permissible.

I am trying to explain you something. These data will be given in terms of moisture content like this optimum level. Sometimes it will be given 14 percent. It means that number is in between these two. But here it is 50 percent and as you have seen clearly, this 50 is not in between 10 and 20. What does this mean? This means we can use 50 percent of this moisture. You should allow it to drop down by 50 percent of this moisture that means if this 10, this is 20; we can go up to 15. What is the amount of water required? The water requirement in terms of depth will be 20 – 15. 20 is the upper limit, 15 is the amount up to which we can go and in percentage so divide by 100. Multiply the dry unit weights, which is 1400 and divide it by the unit weight of water which is 1000 and root zone depth is 2 meter. The answer here will be in terms of meter. This will be the water we have to supply through irrigation for the crop and here it is,

10 divided by 1000 or 10 millimeter of water. We have to supply 10 millimeter of water. Water required by the plant in these cases will be 10 millimeter of water. Out of this some amount is given by a rainfall of 2.5 centimeter. Here there are some errors. I have not included this 14. So it will not be 10 millimeter. I was wondering because this 2.5 centimeter is higher than this. If suppose this is the case, if the water requirement is 10 millimeter and the rainfall is 2.5 centimeter then there is no need for irrigation. In this case it will not be 10 millimeter, it will be something else. This is 5, this is 14, and this is 2, so it will be 14 into 5 into 2 divided by 1000 which is 5 - 10, 140/1000. So this is 140/1000, so 140 millimeter or 14 centimeters. Out of 14 centimeters in this case, we are supplied with 2.5 centimeters by the rain.

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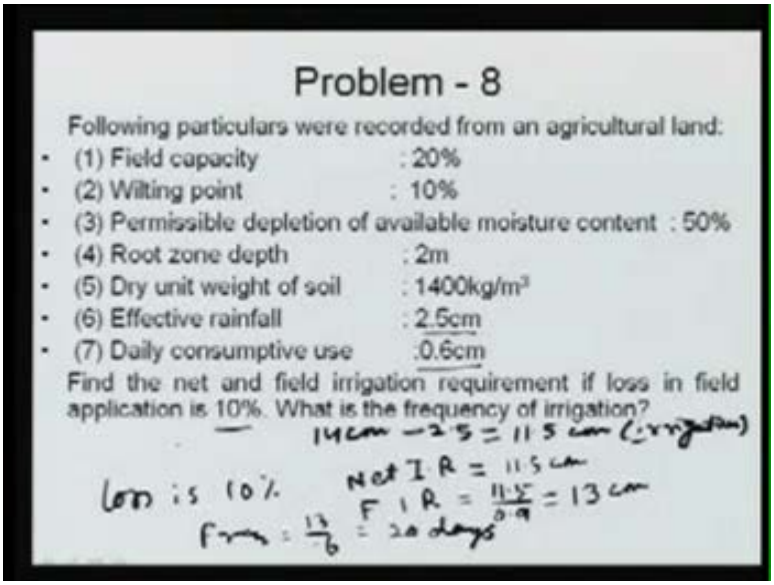

The requirement is 14 centimeter and 2.5 centimeter is by the rain. By irrigation we need 11.5. Let us see, what are the other data? Total water requirement by irrigation is 11.5 centimeter and here the daily consumptive use is 0.6 centimeter. The irrigation frequency will be decided on that but let us first calculate these. Find the net and field irrigation requirement, if loss in field application is 10 percent. To find that loss is 10 percent, the net irrigation requirement we call it N I R will be equal to 11.5 centimeter and field irrigation requirement will be more than that because losses should be taken into account. As in these cases the field application loss is 10 percent. So you can say 0.9 will be available. Requirement in the field will be 11.5 divided by 0.9. Whatever number is obtained, it will be 125, around 13 centimeters. Everyday consumptive use is let us say 0.6 centimeter which is a very small number. This is why the irrigation frequency will be this 13 divided by whatever is the number around 20. Remember while finding out the frequency of irrigation what we must not take into account N I R, Net irrigation requirement.

We should take into account the field irrigation requirement, F I R. In our case, the net irrigation requirement is 11.5 centimeter and field irrigation requirement is 13 centimeters. So based on 13 centimeter value, we should find out the frequency of irrigation and in this case, this is 13 divided by 0.6 which is approximately 20. Let us go to the next problem.

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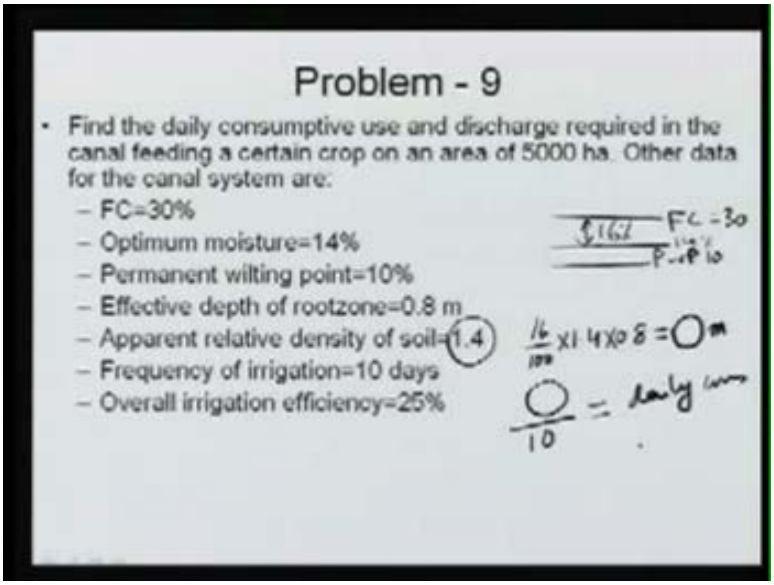

Problem number 9 says; find the daily consumptive use and discharge required in the canal feeding a certain crop on an area of 5000 hectares. Other data for the canal system includes field capacity 30 percent, optimum moisture content 14 percent. Permanent wilting point is 10 percent, effective death of root zone is 0.8 meter, apparent relative density of soil is equal to 1.4, frequency of irrigation is 10 days and overall irrigation efficiency is 25 percent. We have to find out the daily consumptive use. Let us do one by one. Let us say this is field capacity which is equal to 30 percent. Then this is permanent wilting point which is 10 percent and optimum moisture is 14 percent here. This is 16. If I have to find out what is the water required for these, then it will be 16 percent which is 16 by 100 multiplied by the density, dry density for soil which in these case is not given but it is given indirectly. These factors 1.4, the apparent relative density basically is when you divide the density of soil with the density of water, it is 1.4.

Remember that this 1.4 takes into account both and is multiplied by the depth and here the effective depth of root zone is 0.8 meter. So 0.8 meter and the number will be in meter. We need this amount of water and this is the total water requirement in meter and we know that the frequency of irrigation is 10 days. So if I have to find out the daily consumptive use, then what should I do? This amount water is consumed in 10 days, so this should be divided by 10 days. Whatever answer I get here, is divided by 10 days will give me the daily consumptive use and of course, the answer will be in meter which will be a very small number. What you have to do is you must express that in terms of centimeter or millimeter to have some meaningful number. With these, we conclude the series of problems and I am sure the theory is clear now and if you practice more problems then the concept will be clearer to you.

Thank you!