Basic Environment Engineering and Pollution Abatement
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Lecture 45
Tutorial 9

Hello everyone, now we will have a tutorial session and, in this class, will solve some numerical problems based on the discussion we have made in the last four classes.

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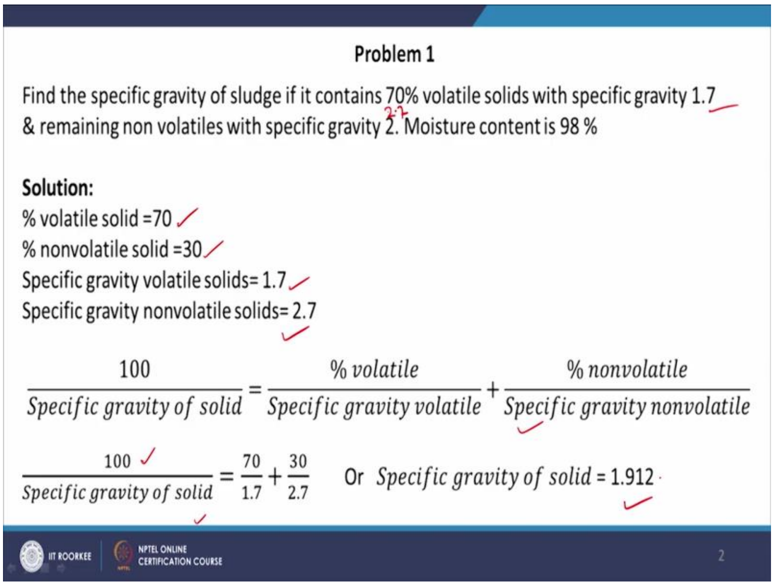

Problem number 1, statement is find the specific gravity of sludge, if it contains 70 % volatile solids with specific gravity 1.7 and remaining non volatiles with specific gravity 2. Moisture content is 98 %. This is a problem which deals with the characteristics of sludge basically, how to find out the specific gravity of sludge we have discussed in our previous class and on the basis of the same concept we will solve it.

So, the sludge had solid and that solid is basically 2 types as given here in the statement. One is non volatiles and another is volatile. And volatile solids has a specific gravity which is different from that of the non volatile and the values are also given.

% volatile solid =70

% nonvolatile solid =30

Specific gravity volatile solids= 1.7

Specific gravity nonvolatile solids= 2.7

$$\frac{100}{\text{Specific gravity of solid}} = \frac{\%\ \text{volatile}}{\text{Specific gravity volatile}} + \frac{\%\ \text{nonvolatile}}{\text{Specific gravity nonvolatile}}$$

$$\frac{100}{\text{Specific gravity of solid}} = \frac{70}{1.7} + \frac{30}{2.7} \quad \text{Or} \quad \text{Specific gravity of solid} = 1.912$$

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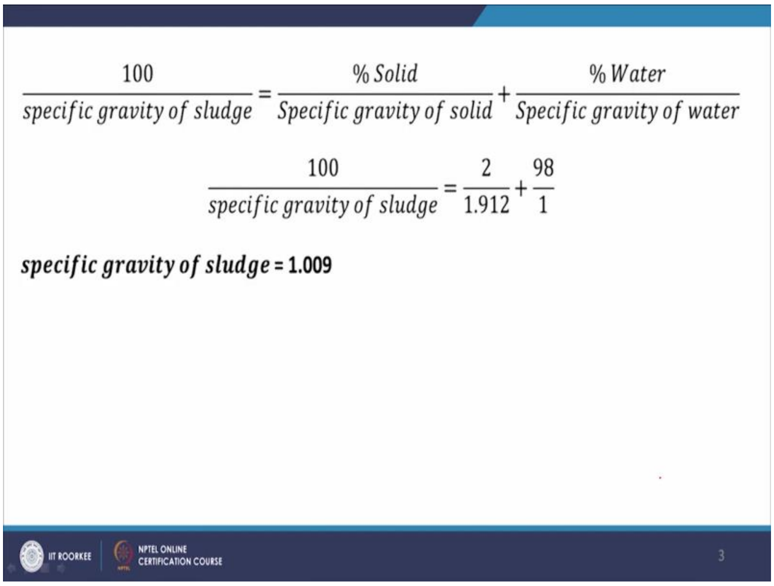

Then, we will be considering for the sludge we will be having on solid part and another your liquid part that is water. So, in that case, again the same type of formula will use considering total solid and water.

$$\frac{100}{\text{specific gravity of sludge}} = \frac{\%\ \text{Solid}}{\text{Specific gravity of solid}} + \frac{\%\ \text{Water}}{\text{Specific gravity of water}}$$

$$\frac{100}{\text{specific gravity of sludge}} = \frac{2}{1.912} + \frac{98}{1}$$

specific gravity of sludge = 1.009

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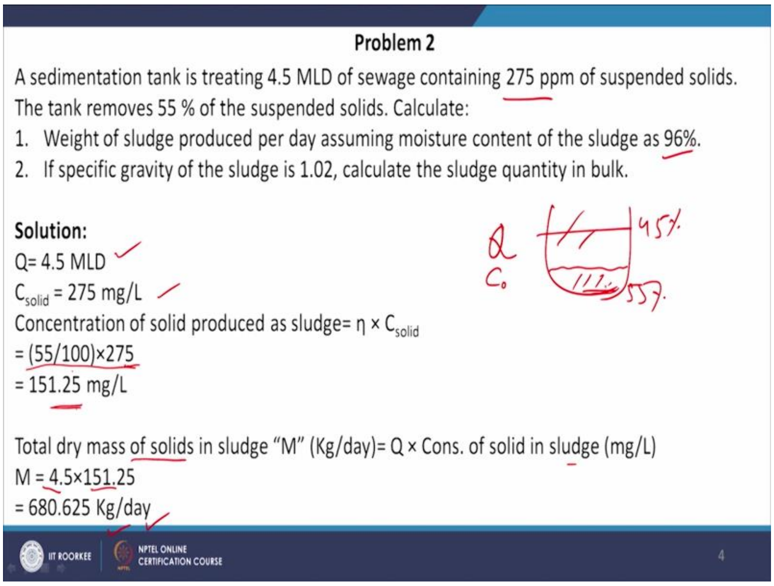

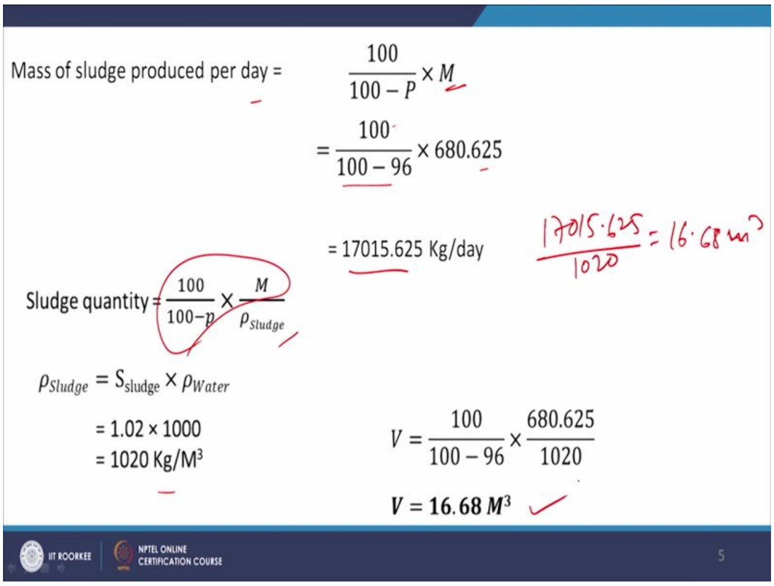

Now, we will see problem number 2. The statement is a sedimentation tank is treating 4.5 MLD of sewage containing 275 ppm of suspended solids. The tank removes 55 % of the suspended solids. So, calculate weight of sludge produced per day assuming moisture content of the sludge as 96 % and second is if basically gravity of the sludge is 1.0 to calculate the sludge quantity in bulk. So, this is the problem statement and you have to solve it.

Q= 4.5 MLD

C_{solid} = 275 mg/L

Concentration of solid produced as sludge= η × C_{solid}

= (55/100) ×275

= 151.25 mg/L

Total dry mass of solids in sludge "M" (Kg/day) = Q × Cons. of solid in sludge (mg/L)

M = 4.5×151.25

= 680.625 Kg/day

Mass of sludge produced per day = (100/100-P) *M

Mass of sludge produced per day = (100/100-96) *680.625

= 17015.625 Kg/day

Sludge quantity = (100/100-P) *(M/ρ_{sludge})

$\rho_{sludge} = S_{sludge} * \rho_{water}$

= 1.02*1000

= 1020 kg/m^3

V = (100/100-96) *(680.625/1020)

V = 16.68 m^3

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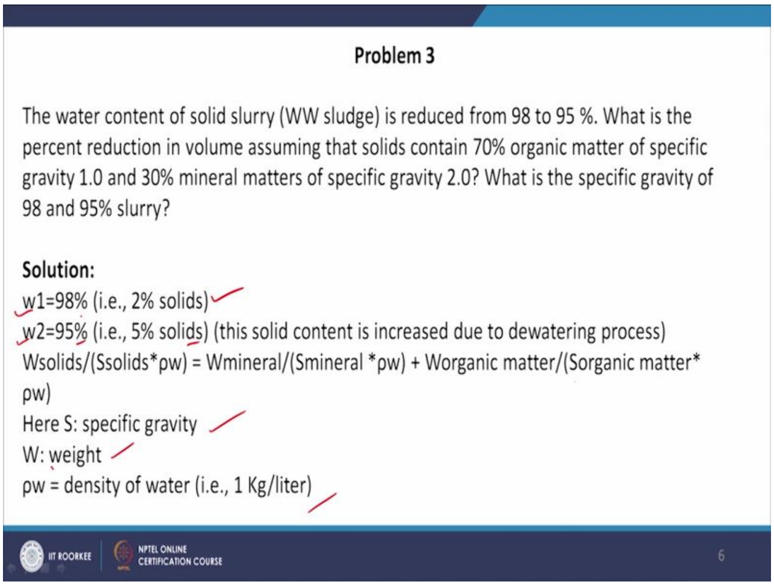

So, now, so, the problem is solved now. Now, we are going to problem number 3. The statement is the water content of solid slurry wastewater sludge is reduced from 98 to 95 %. What is the percent reduction in volume assuming that solids contain 70 % organic matter or specific gravity 1 and 30 % mineral matters of specific gravity 2. What is the specific gravity of 98 and 95 % slurry? So, this is another problem similar subject that is sludge its characterization and basically it is related to treatment. So, how to solve it?

So, here the sludge initially is having 98 % water and that water content is reduced to 95 %. Due to this reason, the percentage reduction in volume we have to calculate 0.75 % organic matter in the sludge and 35 % is mineral matters and they are specific gravity are also given. So, we will be using the similar type of expressions which you have used in our previous problems and discussed in previous classes.

w1=98% (i.e., 2% solids)

w2=95% (i.e., 5% solids) (this solid content is increased due to dewatering process)

$W_{solids}/(S_{solids}*\rho_w) = W_{mineral}/(S_{mineral}*\rho_w) + W_{organic\ matter}/(S_{organic\ matter}*\rho_w)$

Here S: specific gravity

W: weight

ρ_w = density of water (i.e., 1 Kg/liter)

Basically, this is mass.

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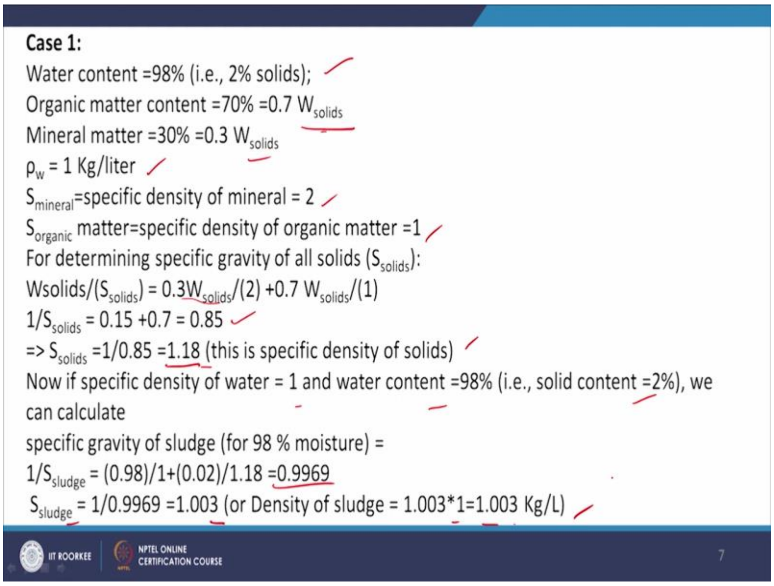

Case 1:

Water content =98% (i.e., 2% solids);

Organic matter content =70% =0.7 W_{solids}

Mineral matter =30% =0.3 W_{solids}

ρ_w = 1 Kg/liter

$S_{mineral}$=specific density of mineral = 2

$S_{organic}$ matter=specific density of organic matter =1

For determining specific gravity of all solids (S_{solids}):

Wsolids/(S_{solids}) = 0.3W_{solids}/ (2) +0.7 W_{solids}/ (1)

1/S_{solids} = 0.15 +0.7 = 0.85

S_{solids} =1/0.85 =1.18 (this is specific density of solids)

Now if specific density of water = 1 and water content =98% (i.e., solid content =2%), we can calculate

specific gravity of sludge (for 98 % moisture) =

1/S_{sludge} = (0.98)/1+(0.02)/1.18 =0.9969

S_{sludge} = 1/0.9969 =1.003 (or Density of sludge = 1.003*1=1.003 Kg/L)

So, this is for case 1.

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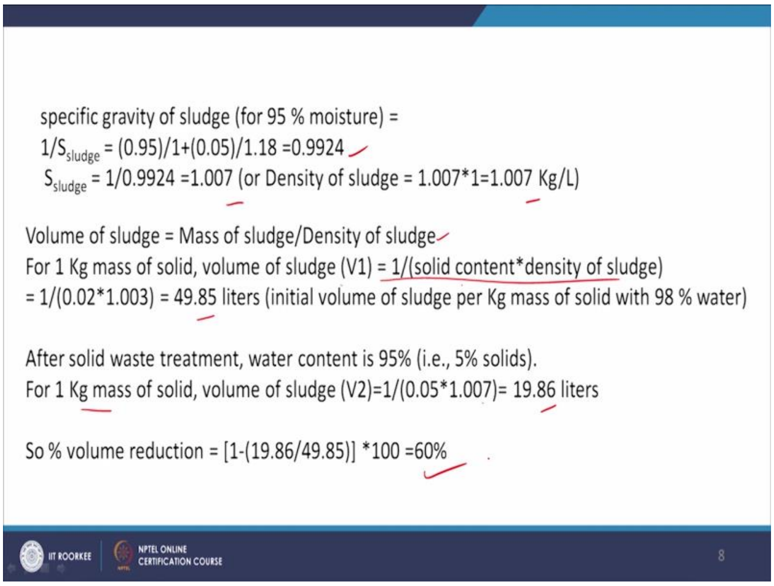

And for the second case

specific gravity of sludge (for 95 % moisture) =

$1/S_{sludge}$ = (0.95)/1+(0.05)/1.18 =0.9924

S_{sludge} = 1/0.9924 =1.007 (or Density of sludge = 1.007*1=1.007 Kg/L)

Volume of sludge = Mass of sludge/Density of sludge

For 1 Kg mass of solid, volume of sludge (V1) = 1/ (solid content*density of sludge)

= 1/ (0.02*1.003) = 49.85 liters (initial volume of sludge per Kg mass of solid with 98 % water)

After solid waste treatment, water content is 95% (i.e., 5% solids).

For 1 Kg mass of solid, volume of sludge (V2) =1/ (0.05*1.007) = 19.86 liters

So % volume reduction = [1-(19.86/49.85)] *100 =60%

So, now, we are able to solve the problem.

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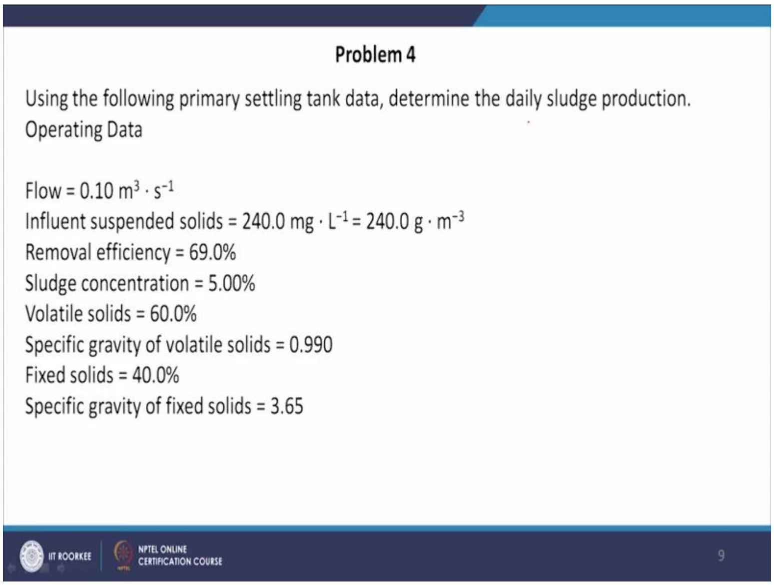

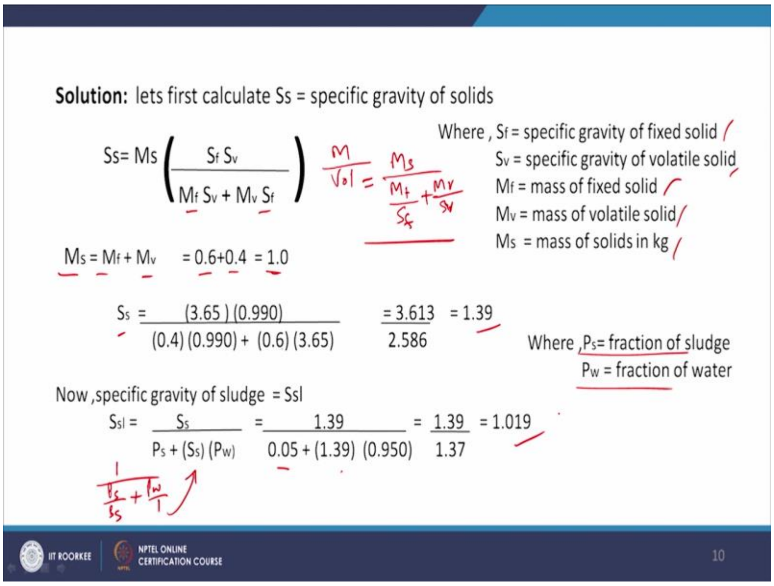

Then problem number 4, statement each using the following primary settling tank data determined the daily sludge production. Operating data are given. Flow 0.10 m^3/s, influent suspended solids 240 mg/l or 240 g/m^3, removal efficiency is 69 %, sludge concentration 5 %, volatile solids 60 %, specific gravity of volatile solids 0.990, fixed solids 40 %, specific gravity of fixed solids 3.65, so this is the problem statement, we have to solve this.

So, now, let us first calculate specific gravity of solids, the same formula we will be using. So, how can you get it?

$$S_s = M_s\left(\frac{S_f S_v}{M_f\, S_v + M_v\, S_f}\right)$$

Where, Sf = specific gravity of fixed solid

Sv = specific gravity of volatile solid

Mf = mass of fixed solid

Mv = mass of volatile solid

Ms = mass of solids in kg

$Ms = M_f + M_v = 0.6+0.4 = 1.0$

$$S_s = 1\left(\frac{(3.65)(0.990)}{(0.4)(0.990)+(0.6)(3.65)}\right)$$

$= 3.613/2.586 = 1.39$

Now, specific gravity of sludge = Ssl

$$S_{sl} = \left(\frac{S_s}{P_s+P_w\ S_s}\right)$$

Where, Ps= fraction of sludge

Pw = fraction of water

$$S_{sl} = \left(\frac{1.39}{0.05+1.39*0.950}\right)$$

$= 1.39/1.37 = 1.019$

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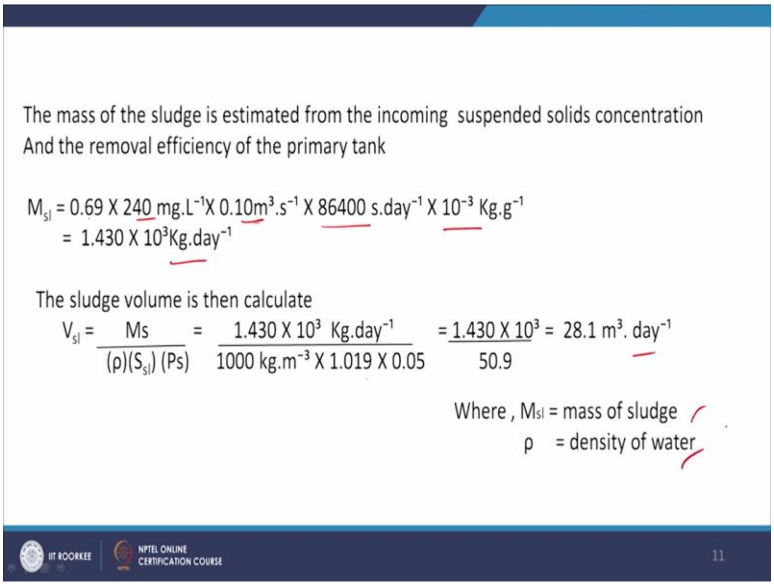

The mass of the sludge is estimated from the incoming suspended solids concentration

And the removal efficiency of the primary tank

M_{sl} = 0.69 X 240 mg. L^{-1}X 0. 10$m^3.s^{-1}$ X 86400 s.day^{-1} X 10^{-3} Kg. g^{-1}

= 1.430 X 10^3Kg.day^{-1}

The sludge volume is then calculated

$$V_{sl} = (\frac{M_s}{\rho S_{sl}\, P_s})$$

Where, Msl = mass of sludge

ρ = density of water

$$S_{sl} = (\frac{1.430 \text{ X } 10^3 \text{ Kg.day}^{-1}}{1000 \text{ kg.m}^{-3} \text{ X } 1.019 \text{ X } 0.05})$$

= 1.430*10^3/50.9 = 28.1m^3. day^{-1}

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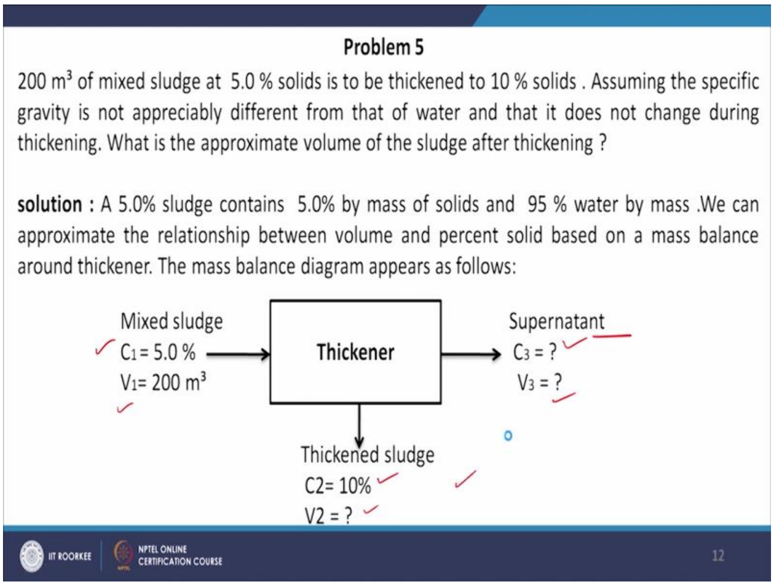
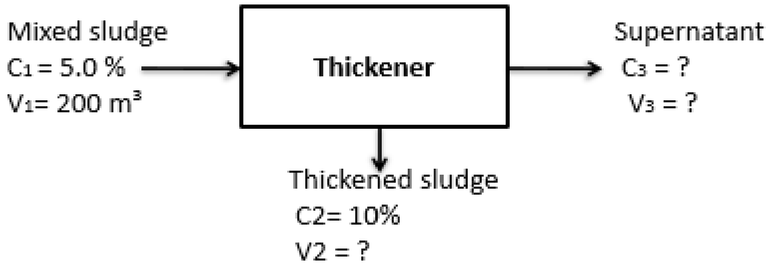


Next volume 5, the statement is 200-meter cube of mixed sludge at 5 percent solids is to be thickened to 10 percent solids. Assuming the specific gravity is not appreciably different from that of water and it does not change during thickening, what is the approximate volume of the sludge after thickening.

So, this is also a problem related to the thickening process. So, we will see the mass balance of this and if we have a thickener, so, here mix sludge we are having volumetric flow rate it is given and then concentration is also given. So, we are assuming that in the supernatant the concentration will be C_3 and V_3 and here in the thickened sludge the V_2 and C_2 that is C_2 is 10 percent and V_2 we have to calculate. What is the approximate volume the sludge after thickening and in this case, we can assume that after settling the supernatant which is going out that will not have any solid content that assumptions we will take.

A 5.0% sludge contains 5.0% by mass of solids and 95 % water by mass. We can approximate the relationship between volume and percent solid based on a mass balance around thickener. The mass balance diagram appears as follows:



The mass balance equation is then

$C_1V_1 – C_2V_2 - C_3V_3 = 0$

Let’s assume the supernatant concentration u much less than the influent and effluent

Concentrations (C_1 and C_2), then we can make the assumptions that $C_3 = 0$

$C_1V_1=C_2V_2$

and $V_2 = C_1V_1 /C_2$

In this case the volume of sludge after thickening would be

$V_2 = (0.05) (200)/ (0.1)$

$= 100 \text{ m}^3$

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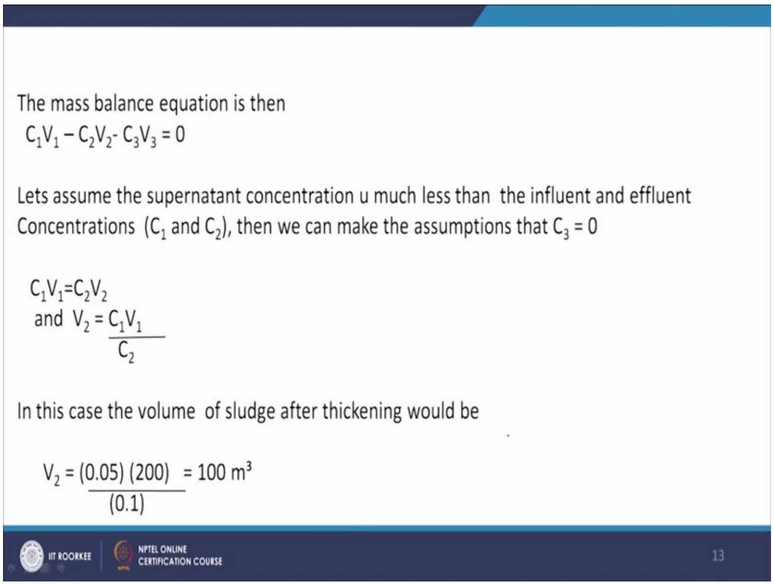

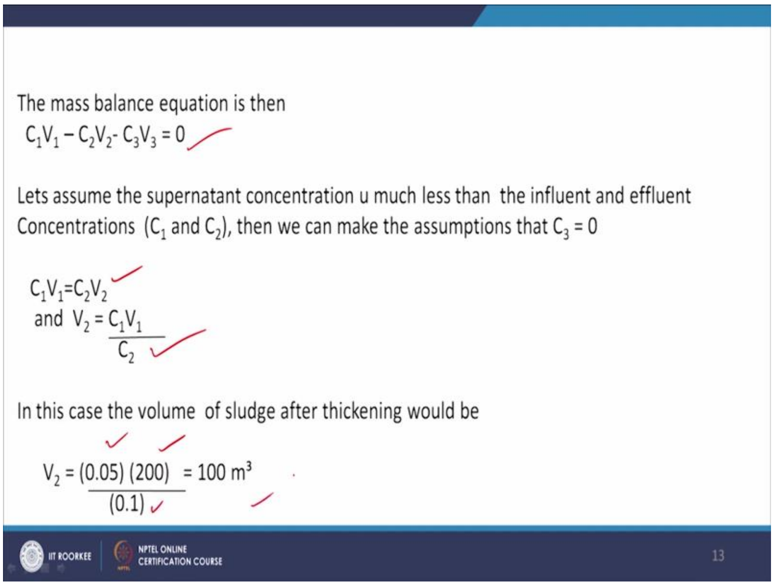

So, up to this in this class, thank you for your patience.