Reading Assignment

Chapter 4:
Landfills

Course Learning Outcomes for Unit III

Upon completion of this unit, students should be able to:

1. Outline the necessary steps for constructing a landfill.
2. Describe the major components of a landfill design.
3. Explain the role of leachates in landfills.
4. Analyze some benefits and problems to reusing the land from closed landfills.

Unit Lesson

Unit III consists of Chapter 4 - *Landfills*. As with Unit II, this unit involves concepts as well as numerical computations. The lecture will focus on computations and will help you prepare for the numerical assessment questions. Please understand the examples in Chapter 4.

Page 105, of your textbook, describes the method for computing the overall bulk density of waste from the bulk densities of its components.

Example 4-1 presents an example of bulk density calculations. In the example, the percent by weight of each component is provided. This is similar to saying that if the total weight of the components is 100 lb, then miscellaneous paper comprises 50 lb, garden waste comprises 25 lb, and glass comprises 25 lb.

Example 4-2 describes the method for computing landfill volume where the volume includes the compacted waste volume and the daily soil cover. The total landfill volume (T) is given by the equation:

$T = 0.25\ T + 3.59 \times 10^6$. In the equation, 0.25 is the decimal version of 25% and indicates that 25% of the landfill volume is occupied by the daily cover. The value of 3.59×10^6 is the compacted waste volume in cubic yards (yd^3). If the equation is solved for T, then: $T = 3.59 \times 10^6 / (1-0.25) = 4.79 \times 10^6\ yd^3$ as shown in the example.

Example 4-3 explains the computation of percolation rate.

Example 4-4 presents a computation of landfill gas production. The landfill gas emission constant in the example is given as 0.0307 yr^{-1}. The symbol "yr^{-1}" means "inverse years" or "per year" and could be written as 0.0307 per year or 0.0307/yr. In the equation, "e" is the exponential button on calculators which is probably the button labeled "e^x" on your calculator. For practice, note that $e^{3.2} = 24.53$ and $e^{-(0.094)(5.7)} = 0.5852$.

Example 4-5 computes leachate collection system pipe spacing. It uses the equation in the middle of page 127 which is footnoted 27. Page 154 lists reference 27 as a publication by Richardson and Zhao. In the example, the 8.2 inch design storm has a duration of 24 hours and is converted to 0.00024 cm/s by:

Design storm = (8.2 inch / 24 hr)(1 hr / 3600 sec)(2.54 cm / inch) = 0.00024 cm/s

In the equation for P in the example, the symbol $\tan^2\alpha$ would be more clear if it were written as $(\tan \alpha)^2$ since $\tan^2\alpha$ means to take the square of $\tan \alpha$, but mathematical convention is to write it as $\tan^2\alpha$. The slope of the drainage system is $\tan \alpha$. Typically the leachate drain pipes are resting on the liner and both have the same downward slope.

Example 4-6 and pages 133-136 express pressure in several somewhat confusing ways. Page 134 says ΔP is pressure drop in ft and page 135 says ΔP is pressure drop for a gas expressed in ft of water. Further down page 135, P is expressed in lb/ft^2.

Look at the equation on the bottom of page 133:

$\Delta P = \rho f L v^2 / (2 g D)$	
where:	
	ρ = gas [or liquid] density, lb/ft^3
	= friction factor, u it-less
	L= length of p pe, ft
	v= velocity, f /s
	g= acceleration due to gravity, 32.2 ft/s^2
	D= p pe inside diameter, f

Check the units of the equation:

ΔP	$= \rho f L v^2 / (2 g D) = (lb/ft^3)(ft)(ft/s)^2 / [(ft/s^2)(ft)]$
	$= lb * ft * ft^2 * s^2 / (ft^3 * s^2 * ft * ft)$
	$= lb * ft^3 * s^2 / (ft^5 * s^2)$ $= lb/ft^2$

The book says that ΔP is "pressure drop, ft" but actually it is pressure drop in lb/ft^2. In your textbook, please change the wording from "ΔP = pressure drop, ft" to "ΔP = pressure drop, lb/ft^2".

Often pressure is expressed as psi (which means lb/in^2).

As an example, to convert 5 psi to lb/ft^2:

Pressure	$= (5 lb/in^2)(12\ in/ft)^2$
	$= 720\ lb/ft^2$

Using the equation on page 133 to solve Example 4-6.

Note: 4.026 inch	= 0.3355 ft:
ΔP	$= \rho f L v^2 / (2 g\ \ )$
	$= (0.0613\ lb/ft^3)(0.016)(800\ ft)(94\ ft/s)^2 / [(2)(32.2\ ft/s^2)(0.3355\ ft)]$
	$= 321\ lb/ft^2$ = 2.23 psi

It is recommended that you use the equation at the bottom of page 133 noting that ΔP is in lb/ft^2 and avoid using the ΔP equation on page 135 which has a constant of 0.0096 in the numerator. The equation at the bottom of page 133 is valid for both gases and liquids. The density equation in the middle of page 135 is correct.

Please take some time to look over the examples in Chapter 4, and let your professor know if you have questions. Study hard!