TOPICS

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How to Use This Guidebook

This guide for the Construction AM Module and is intended to help walk you through studying for the Civil PE exam. You will find all of the study material needed for the AM construction portion of the exam. We have spent countless hours reviewing material from the Civil Engineering Reference Manual (CERM), the NCEES design standards, study guides, the internet, engineering textbooks to ensure that we have provided you with the most up-to-date and accurate resource available.

When you begin studying from this book use the following approach:

1. Print out e-book and place in 3" binder. Label the Binder Construction Engineering and tab each chapter.

2. Make sure the construction engineering cheat sheet is in the front of the binder. Add to it as needed.

3. Once you complete each chapter, solve as many problems as you can that relate to the chapter you just covered. Do at least three problems from other sources. If you have any questions on a technique or a concept, ask the question at either http://constructionengineering.ipbhost.com or www.engineerboards.com.

4. Place those problems inside the construction binder behind the chapter and make a tab labeled "Problems". If you use another reference manual when solving problems, make sure to tab them as well.

If you follow this approach, you will have solved multiple problems for every section and you will have all your references, notes pages, and problems fully tabbed so that you can easily reference them during the actual exam.

To report errors in this text, write to learncivilengineering2012@gmail.com

Basic Conversions

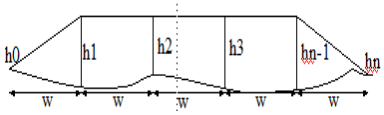
1 cubic yard = 27 cubic feet
1 cubic foot of Water = 7.48 gallons
1 gal of Water = 8.34 lbs
1ft of Water = 0.433 psi
2.31 Ft Head = 1 psi pressure
5,280 Ft = 1 Mile
43,560 ft^2 = 1 Acre
1 Board Ft = 144 in^3
1,440 min / day
1 liter = 1 kg

Basic Properties

Density of Water = 62.42 pounds per CF (pcf), 1,000 g/liter = 1,000kg/m^3
Economic Haul Distance; Large Dozer up to 3000 ft; Scraper 3000 – 5000 ft; Trucks > 5000 ft
Density = Weight (lbs) / Volume (cf)
Specific gravity = Density of material / Density of water
Density of Water = 62.4 lbs/cf or 1000 kg/cubic meter
lbs of concrete/sack of cement = 94 lbs

Earthwork Construction and Layout

Excavation and embankment



General Trapezoidal Formula: **Area = (h0/2 + h1 + h2 + …+ h(n-1) + hn/2) x w**
Average end area Method = **V = ((A1+A2)/2) * L**
Pyramid Method = **V = AL / 3**

Borrow Pit Volumes

Conical Spoil Pile = **Vol = (Ab x H) / 3; D = (7.64V / tan θ)$^{1/3}$; H = (D/2) tan θ** ; where Ab=base area; H=pile height;D=diameter; **θ** = angle of repose (deg)
Triangular Spoil Bank = **Vol = Cross section Area x L ; B = (4V/(L x tan Θ)$^{1/3}$; H = (B x tan Θ) / 2** ; V= pile volume; B= base width ; H = pile ht; L = pile length ; Θ = angle of repose (deg)
Density of Water = $\gamma_{water} = M_w/V_w$
Moisture Content (w) = M_w/M_s
Degree of Saturation (S) = V_w/V_v
Total or Wet Density of Soil (γ_{wet}) = M/V where $M = M_w + M_s$; $V = V_w + V_s + V_a$
Density of Solids = M_s/V_s
Specific Gravity = $G_s = \gamma_{solids} / \gamma_{water}$; or = $M_s/(V_s * \gamma_{water})$
Porosity (n) = V_v/V_t ; V_v = Volume of Voids = $V_w + V_a$; V_t = Total Volume = $V_s + V_w + V_a$
Void Ratio (e) = V_v/V_s
Dry Density of Soil (γ_{dry}) = M_s /V
Dry Density of Soil (γ_{dry}) = γ_{wet} / (1+w); (γ_{dry}) = ($\gamma_{water}*G_s$) / (1+(w/S)*G_s)
(γ_{dry}) = (γ_{water} * G_s)/(1+e)
Specific Gravity = S * e = G_s * w
Porosity (n) = e/(1+e)
Void Ratio (e) = n/(1-n)
$V_{Compacted}$ = V_{Banked} (1 – SHRINKAGE)
V_{Loose} = V_{Banked} (1+SWELL)

TOPIC I: Earthwork Construction and Layout

Chapter **Page**

Earthwork Construction and Layout

Introduction

The earthwork section is the typical starting point anyone starting to prepare for the Construction portion of the Civil PE Exam. The Earthwork section is a critical to know and there will be at least 3 questions on the exam directly covering these concepts. This topic covers three sections.

Section 1: Excavation and Embankment: This section deals with the removal and/or addition of soil to the existing terrain.

Section 2: Borrow Pit Volumes: There is some overlap with the section 1 and this section but this deals with taking soil from an existing location. The soil properties, volumes, and water content are known and you have to figure out how to solve for relevant information.

Section 3: Site Layout and Control: This section is for basic information on surveying and site preparation.

The Earthwork Construction and Layout topic area is very important and is the most difficult part of the construction AM portion. When studying this topic stay focused and make sure to master all the concepts and formulas. If you use common sense, deductive reasoning, and have the ability to deal with the question in a calm state of mind, you should be able to navigate this section and capitalize on these critical and necessary points.

There is an incredible amount of information out there discussing the Earthwork topics that can be found in the CERM, Goswani, and Ruwan. Also, internet searches typically render Power Point slides from various universities around the country discussing Earthwork. We have gone through most, if not all, of the above referenced materials and the goal here is to bring to you the pertinent information, the MUST KNOW information, regarding this topic for the exam.

1 Excavation and Embankment

Introduction

This section is the longest and is consider the most difficult topic area for the AM section of the Construction Engineering material. It is by no means impossible to learn, or really that difficult I just point that out so you do not get discouraged with this section and you bare down and focus on learning and mastering this section. Even though the NCEES syllabus states there will only be 1-2 questions on this topic there are other area that could use some of the concepts here to answer those questions too, for example in cost estimating they might need to know how much it will cost per truck load. To solve for that you need to be able to figure out how much soil needs to be hauled.

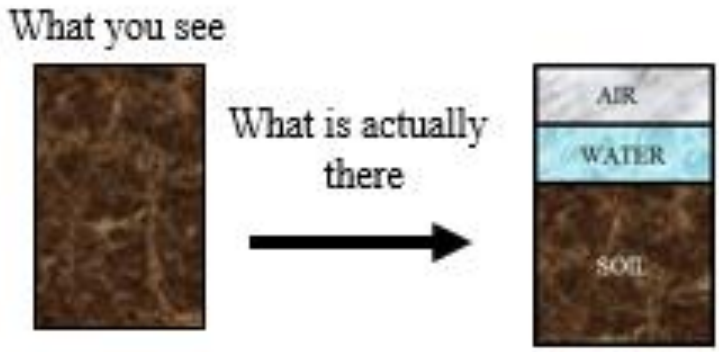
This topic will cover the following concepts.

1. Soil Phase Diagram: Basic understanding in Phase relationship in soil.
2. Bank/Loose/Compacted Volume Conversions using Swell and Shrinkage

Discussion

Soil Phase Diagram: Basic understanding in Phase relationship in soil.

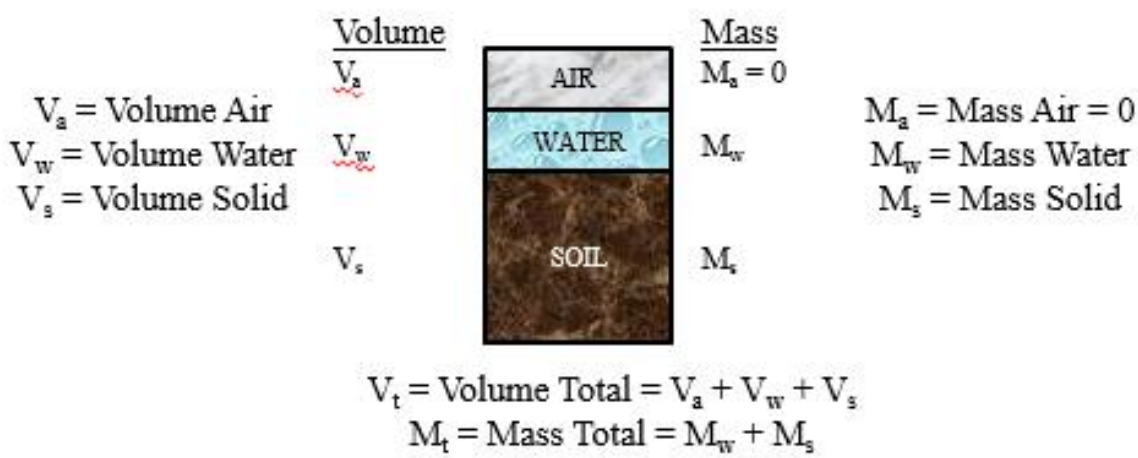
The first most important concept to understand with soil is the components which make it up. When you excavate soil, it is made up of solids which could be clay or sandy material. This part



of the volume of soil never changes so it is constant. The tricky part is that there is also air and water that is trapped between the soil particles which accounts for some of volume of the soil.

It is very important to understand that you will add air/volume to the soil by excavating and you can subtract air/volume from soil by compacting. Also you can add or subtract volume and weight to soil by adding or subtracting the amount of water content.

When thinking about soil it is most important to think about it as either by volume or a mass/weight. The total volume of any given soil is equal to the volume of Air + volume of the Water + the volume of Solid soil. The total mass of any given soil is equal to the mass of the water + the mass of the solid soil. Yes, air does have a mass, however compared to water and soil it is relatively zero for our purposes.



Unit soil weight is usually expressed in pounds per cubic yard or kilograms per cubic meters. The unit weight depends on soil type, moisture content, and degree of compaction. In soils natural state it will contain some moisture. The moisture content of a soil is expressed as a percentage that represents the weight of water in the soil divided by the dry weight of the soil:

$$Moisture\ content\,(\%) = \frac{Moist\ weight - Dry\ weight}{Dry\ weight} \times \quad 100$$

Bank/Loose/Compacted Volume Conversions using Swell and Shrinkage

<u>Bank Cubic Yards</u>

Bank Cubic Yards (BCY) is the <u>undisturbed state of soils in the ground.</u> It is sometimes referred to as "in situ" or "in place". Why do we use Bank Cubic Yards? Because massive road projects can sometimes mean that the project will require, say…1,500,000 BCY of earth excavation. It's much easier to deal with 1,500,000 BCY mathematically then it is to deal with 40,500,000 cubic

GUIDE TO PASSING THE CIVIL PE EXAM

CONSTRUCTION AM

FIRST EDITION

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Mark is an Engineer Officer in the US Army with currently over 13 years in service. He holds a Chemical Engineering undergraduate degree from Clarkson University and a Master's Degree in Environmental Engineering from University of Missouri S&T. All his work experience is in Civil Engineering and has worked for over six years as either a Project Engineer or Resident Engineer in the USACE construction office. This allowed him to sit for the PE exam in Construction Engineering. Which he did in April 2012 and passed. He took the PE Exam April 15th 2012 (in Germany on a Sunday), and I found out he passed on 30 May 2012 in Manas, Kyrgyzstan while heading over to Afghanistan for a year. Mark has a passion for teaching people about how to become an engineer and how to solve problems.

Jason is an industry professional specializing in bridge design and bridge construction namely in California and Arizona. He graduated from Arizona State University earning a Construction Engineering degree and upon graduating immediately went to work building, estimating, and designing bridges. All of his experience has been in the Heavy Civil – Construction Industry as either a Project Manager, Senior Structure Estimator, Estimator, Project Engineer, or Primavera Scheduler. As a Senior Estimator/Project Manager, Jason has competed and won several Hard Bid Contracts, Design-Build Contracts, and Construction Management at Risk Contracts. Jason is a civil engineer enthusiast and highly recommends studying for and passing the PE Exam. It is a noteworthy cause and upon passing, it will say volumes about yourself, your dedication to your craft, as well as your dedication to the civil engineer industry.

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