

ESTIMATING EXCAVATION REVISED

By Deryl Burch

Revised by Dan Atcheson



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Contents

1 Get Started Right.....	5	6 Roadwork Take-Offs	125
Why Calculate Quantities	6	Plan and Profile Method	125
Reading Plans and Specifications	8	Understanding Surveys	127
Accuracy Is Essential	12	Plan and Profile	
Record Keeping.....	16	Cross Section Sheets	128
Understanding Plan		Cross Section Method.....	132
or Drawing Measurements.....	18	Calculating the Scale Factor	139
What If You Don't Have Plans.....	20	Mass Diagrams	143
2 The Site Visit	21	7 Irregular Regions &	
Review the Plans First.....	21	Odd Areas	151
Make the Visit Productive	22	Finding Area Using	
Site Visit for a Sample Project.....	32	Compensating Lines	153
Site Visit Checklist	35	Finding Volume Using Total	
Don't Forget Overhead	35	Area and Average Depth	154
3 Properties of Soils	43	Finding Volume Using	
Soil Classifications.....	43	Compensating Lines with a	
Pre-Construction Field Testing.....	46	Coordinate System	159
Soil Testing in the Lab.....	50	Finding Volume Using the	
Compaction Fundamentals.....	55	Trapezoidal Rule.....	167
4 Reading Contour Maps.....	65	8 Using Shrink &	
Planimetric and Topographic Maps	65	Swell Factors	177
Understanding Contour Lines.....	68	Soil States and Their	
Benchmarks and Monuments.....	73	Units of Measure	177
5 Area Take-Off		Using Shrink/Swell Factors	
from a Topo Map	75	in Earthwork Estimates.....	178
Comparing the Contour Lines	75	Ground Loss	181
Estimating with a Grid System	78	Estimating the Number of	
Calculating Cut and Fill Areas	90	Haul Trips.....	182
Using Worksheets in a Take-Off.....	102	Material Weight Factors.....	183
Shortcuts for Calculating Quantities ...	109	Pay Yards.....	185

9 Topsoil, Slopes & Ditches	187	13 Earthmoving Equipment:	
Dealing with Topsoil	187	Productivity Rates and	
Calculating Net Volumes		Owning & Operating Costs.....	281
for Earthwork	193	Machine Power	282
Slopes and Slope Lines	197	Machine Speed.....	287
Estimating Trenches.....	202	Machine Production	293
Drainage Channels	202	Productivity Calculations	
Utility Trenches	205	for a Simple Dirt Job	296
10 Basements, Footings,		Equipment Production Rates	302
Grade Beams & Piers.....	211	Owning and Operating Costs.....	309
Estimating Basement		Calculating the Overhead	313
Excavation Quantities.....	211	Adding the Profit	316
Finding Volume — Outside		Bid Price per Cubic Yard.....	316
Basement Walls.....	213	14 A Sample Take-off.....	317
Calculating the Total Volume		General Specifications.....	318
for Basement Excavation	222	Doing the Take-off.....	320
Sample Basement Estimate.....	228	15 Costs & Final Bid for	
Sheet Piling	238	the Sample Estimate	415
Estimating Ramps.....	239	The Bid Preparation Process.....	416
Grade Beams and Piers.....	244	Overhead.....	420
11 All About Spoil & Borrow	249	Machine Selection	420
Underlying Costs of		16 Computers & Computer	
Spoil and Borrow	250	Estimating Programs.....	515
Spoil and Borrow Volume		Computers and Earthwork	
Calculations	251	Programs.....	515
Calculating the Volume		Taking off an	
of a Stockpile.....	253	Earthwork Project.....	517
Finding the Volume of a		Working with Plans on	
Stockpile of Unknown Height.....	256	Separate Sheets	533
Calculating Volume for a		Importing CAD Drawings	533
Stockpile of Set Area	261	Additional Programs	535
12 Balance Points, Centers of		Solving Complex Earthwork	
Mass & Haul Distances	265	Problems with Software.....	537
Balance Points to an		In Conclusion.....	539
Excavation Estimator.....	265	Index.....	541
Balance Points to an Engineer	266		
Reducing Haul Distances	267		
Calculating Haul Distances	270		

1

Get Started Right

Construction cost estimating is demanding work, no matter what type of construction is involved. But I think estimating earthwork is the hardest of all. Why? For two reasons: First, excavation has more variables and unknowns — you don't know what's down there until you start digging; second, you have to rely on information from many sources — some of which may not be accurate.

That's why every earthwork estimator needs special skills:

- The ability to read plans and specifications
- An understanding of surveying and engineering practice
- A facility with mathematical calculations
- The ability to anticipate environmental and legal issues
- An abundance of good common sense

If you can bring common sense to the task, this manual will show you how to do the rest. I'll help you develop all the skills every good earthwork estimator needs.

Of course, I can't cover everything on every type of job. But I'll include the information most earthwork estimators need on most jobs. Occasionally, you'll have a job that requires special consideration. But if you understand the principles I'll explain here, you should be able to handle anything but the most bizarre situations.

A couple of subjects I think are important to cover here are the "by hand" approach to many earthwork problems, as well as the basics of computer earthwork estimating software. Both are meaningful topics for the earthwork estimator today. I've met many younger estimators who do earthwork take-offs with a computer who can't even

describe what the existing or proposed surfaces of the project would look like in the real world. Finding the centerline of a sloping surface in a basement requires knowledge based on the experience of doing “by hand” or manual earthwork take-offs. Those who’ve calculated earthwork take-offs on paper will make better use of their software. So, even though computers are used more and more for earthwork project take-offs, having a background in the math involved in project calculations will improve your capabilities when using a computer program. While computer programs generally don’t make mistakes, it’s very common for a mistake to be made by the person feeding the data into the computer. If you haven’t a reasonable idea of what the result should be, you won’t know if the software has given you a completely wrong answer. No software is a substitute for good judgment and sound estimating experience.

In this first chapter, I won’t do much more than touch on a few important points you should understand:

1. why you have to estimate quantities
2. the importance of plans and specs
3. working accurately
4. keeping good records

After making these points in this chapter, I’ll describe a step-by-step estimating system, from making the site survey to writing up the final cost summary. I’ll teach you a process for making consistently accurate earthwork estimates. Part of this process is calculating the cubic yards to be moved. That’s the heart of every earthwork estimate. I’ll cover quantity estimating in detail. Then I’ll explain how to find labor and equipment costs per unit. We’ll also consider soil and rock properties and how the equipment you use affects bid prices.

Why Calculate Quantities?

In the past, many smaller dirt jobs were bid on a lump-sum basis rather than by the cubic yard. Dirt contractors based their bids on guesses: What equipment will I need and how long should it take? Making estimates this way overcame a big problem for many of these excavation contractors — they didn’t know *how* to estimate soil and rock quantities.

I think those days are over. Today, fuel and labor costs are too high and the competition is too intense to risk “seat-of-the-pants” guesses. A few mistakes and a couple of surprises and you’re going to be looking for some other type of work. Only the best survive for long in this business. And most of the survivors know how to make accurate bids by the cubic yard. Fortunately, making good quantity estimates isn’t too hard once you’ve mastered a few simple skills. I hope that’s why you’re reading this book.

I've found that all good earthwork estimators are also good at calculating earthwork quantities. Here's why:

No one's going to do it for you. You have to do it yourself or it's not going to get done right. Many engineers, architects, and even some builders know how to figure soil and rock quantities, but few take the trouble to do it. Instead, they depend on the earthwork estimator to do it. If the engineer calculates quantities, he'll give the numbers in cubic yards, but won't specify what types of cubic yards are being presented. I've know some engineers who don't understand the concepts of soil swell and shrinkage. They simply give the cubic yards based on length \times width \times depth calculations and leave it up to the estimator to convert those quantities into loose and compacted cubic yards for the cut and fill quantities, respectively. I've also found that engineers make mistakes in calculating the quantities. There's an old estimator's saying: "An engineer does not an estimator make." These are two totally different professions.

Today, most owners, engineers and architects request excavation bids based on the cubic yards moved. That's now the accepted procedure for most projects, from single-family homes to roads and commercial jobs. Some projects are still bid lump sum, but those are the exceptions. It's common for the actual amount of dirt moved to be more or less than expected, so the best way to protect your business is to bid by the cubic yard. If it turns out you have to move more dirt than the plans show, instead of having to eat the extra cost, you'll get paid for it. It's as simple as that.

General and Special Quantities

If you agree that excavation bids should be based on quantity estimates, the next step should be obvious. Every estimate must start by figuring the quantity of soil to be moved.

I recommend you begin any project estimate, no matter how large or small, by dividing the excavation into two categories: general quantities and special quantities.

General quantities include any work where you can use motorized equipment such as scrapers, hoes and loaders at their designed production rate.

Special quantities include anything that requires special care or lower production rates. Examples are most rock excavation, nearly all hand excavation, and backhoe work around sewer lines, underground utilities, or existing structures. Naturally, prices for special quantities are higher than prices for general quantities.

Keeping these two quantities separate protects you. Most excavation contracts have a clause that covers extra work. Unanticipated rock deposits, special soil problems and unusual trenching problems are extra work that you should be paid extra for. If you've bid a higher price for special quantities, you'll get paid at that price per cubic yard for the additional work. Otherwise you could end up chipping out rock at the price of moving sand.

Calculating Cubic Yard Cost

Here's the basic formula for costs per cubic yard: Labor and equipment cost per hour multiplied by the hours needed to complete the work, divided by the cubic yards of material to be moved, or

$$\text{Cost per CY} = \frac{\text{Cost per Hour} \times \text{Total Hours}}{\text{Total Cubic Yards}}$$

Does that seem simple? It's not. You may know your hourly labor and equipment costs right down to the last penny. But estimating the time needed is never easy. And calculating volumes for sloping and irregular surfaces is very demanding work.

Here are a few things about the formula for computing costs per cubic yard that you should take note of.

1. It's based on labor and equipment costs for your business. That's important and I'll have more to say about it later.
2. It assumes you know the quantity of soil or rock to be moved. That's going to take some figuring.
3. Even after you've calculated the cost per hour and quantity of soil, you're not finished. You need to estimate the time needed. Usually that's the hardest part. To do that, you have to decide on the equipment (method) to use.

Of course, the quantity of material (yardage) is a very important part of our cost formula. But the excavation method (type of equipment) also has a major influence on cost. The most expensive equipment (cost per hour) will usually be the most productive (move soil at the lowest cost). But the machine with the largest capacity isn't always the best choice for every overhaul. I'll explain why later. For now, just understand that making good equipment selections helps reduce costs.

Reading Plans and Specifications

Many excavation projects let out for bid are based on a set of plans. Plans are scale drawings that show the finished project. Plans are supplemented with written descriptions called specifications (or specs). Specs explain in words what the plans can't or don't show. Ideally, the plans and specs, read together, should answer every question about the job. They shouldn't leave anything up to interpretation. The better the job done by the engineer or designer, the more likely the plans will be clear and complete.

Plan reading is an important skill for every earthwork estimator. But this isn't a book on plan reading. If you need help with reading plans or you don't understand the plans and drawings in this book, pay a visit to your local library or search the internet. You'll find there are several manuals that explain basic plan reading.

Look for Notes on Special Problems or Conditions

As an excavation estimator, you're expected to understand every detail in the plans and specs for the jobs you bid. Read these documents completely. They're worth careful study. Note everything that affects your excavation work. Some engineers and architects aren't very well organized. They can put instructions and notes almost anywhere on the plans. Read every page carefully, regardless of what you think it's about. Use a yellow highlighter and mark anything in the specifications that affects your work, such as the type of compaction required for the fill material. That'll make it easier to find later if you need to look it up.

Utility Lines

Pay particular attention to notes that spell out the contractor's responsibility. For example, you may find a note somewhere on the plans that relieves the engineer or architect of responsibility for damage to utility lines. It may say something like this:

NOTE: While every precaution has been taken to show existing utilities in their proper location, it is the contractor's responsibility to determine their actual location. No assumption should be made that no other utility lines fall within the limits of construction.

That means that if you break a pipe, such as a water main or a gas line that wasn't marked on the plans, it's entirely your fault and you have to shoulder the costs. So if you suspect utility lines may be a problem, ask the utility companies to locate their lines for you. Most will be happy to do that at no cost. But they may want ample advance notice.

Changed Conditions

Also pay attention to notes on natural obstacles (such as rock) or anything that's buried on the site. Is there an abandoned underground storage tank or old basement in the area to be excavated? The plans may also mention drainage problems and unsuitable soil deposits, probably in the cross-section drawings or special provisions of the specs.

A.I.A. contracts, and most federal government contracts, spell out what happens if you encounter *changed conditions* at the jobsite. An example of changed conditions would be if the soil type isn't what was indicated in the contract documents, or isn't normal for the type of work you're doing. In that case, you're entitled to extra pay for dealing with those changed conditions.

Owners and engineers have written volumes of contract language excusing themselves from liability for test borings and other information they provide to bidders. Some contracts even say that you're responsible for conditions at the site, if those conditions aren't as indicated in the bidding documents. That's ridiculous. To protect your business, be sure there's a *changed conditions clause* in the contract so you'll get extra pay if conditions aren't what the test borings showed, or conditions are very unusual for the type of work being done.

Other Costs

Search the plans and specs for everything that may affect cost. That's always your starting place. But it's not the end of your search. Many cost items won't show up in either the plans or specs. For example, you'll have to find out from the city or county building department what permits will be required. Also, city, county or federal law may set minimums for wages, employee benefits and insurance coverage.

Here's another pitfall to watch for: Who pays to have the project staked out by a surveyor or engineer? In most cases, the designer will pay for surveying — the first time. If you knock over any survey stakes during actual work, you'll probably have to replace them at your own expense. Work as carefully around the stakes as possible. But if job layout makes it impossible to avoid moving stakes, allow enough in your bid to pay for another survey.

Make sure you understand how you'll be paid. On larger projects, you're usually paid per cubic yard, based on the difference between the original soil cross section and the cross section when work is finished. We'll talk more about cross sections later in this book.

On many smaller projects, your payment may be based on the engineer's estimate of yardage. If that's the case, look for a provision in the specs that gives you an option to have final cross sections made at your own expense. Experience will help you decide if a final set of cross sections is to your advantage. But I recommend that you always take off quantities yourself. Don't assume the plans are right. Anyone can make a mistake, but you could end up paying the price.

Undercutting

Undercutting is removing additional dirt from an area below the finished grade line. There are several situations where this is necessary. The most common is where clay or a rock ledge is close to, but not above, the finished grade line. Figure 1-1 shows a typical situation with a rock ledge below the surface. Most structures can't be built directly on rock. If the rock weren't there, you would excavate to the finished grade line and be done. But because the rock is just below finished grade, you have to cut deeper. That's the undercut. Then you have to backfill the undercut with a suitable material, such as select sand. The sand provides a buffer between the rock and the foundation.

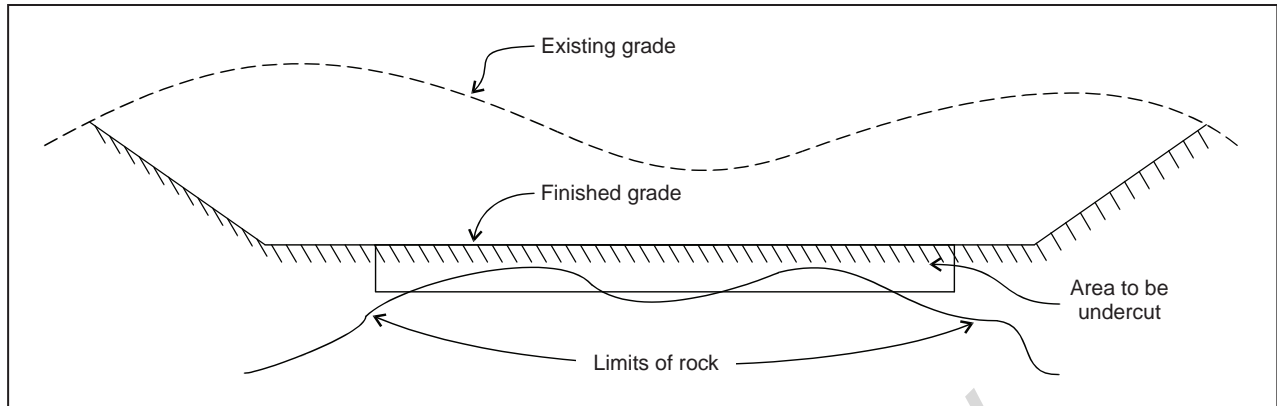


Figure 1-1
Undercutting for rock

There's probably nothing in the specifications that gives you the right to collect for undercutting and backfill. But it's expensive work and the cost shouldn't come out of your pocket. Where undercutting may be necessary, include it in your bid as a separate item on a per cubic yard measure.

Undercutting is also needed when trenching for underground utilities, such as storm drains and sanitary sewer lines. The undercut makes room for bedding material to be placed under the pipe. Most plans will show only a designated flow line elevation.

But based on the plans and your good judgment, you'll have to decide how much and what type of bedding to install below the pipe. Each cubic yard of bedding requires a cubic yard of undercutting. Some engineers specify this, and others don't. Figure 1-2 shows an example. Undercutting may also be required on roads, parking lots and sidewalks — anywhere there's a load on the soil.

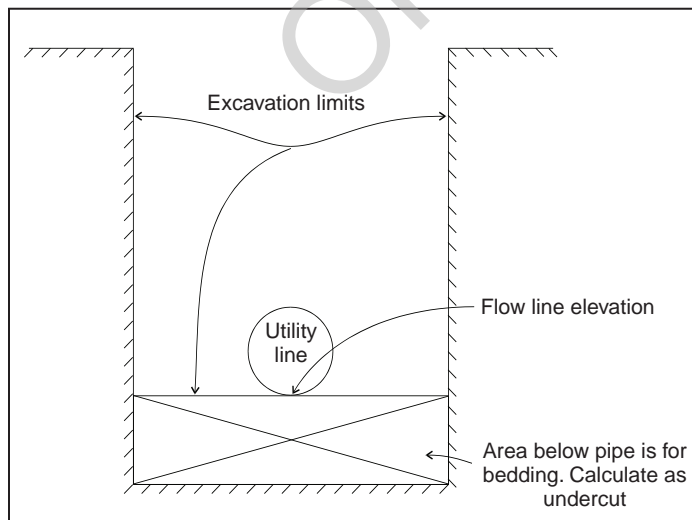


Figure 1-2
Undercutting for pipe bedding

Overfilling is the opposite of undercutting. When backfilling a large area, you can usually bring the backfill right to grade without cutting away excess backfill. But in a small area, it's usually easier to bring the area

above the final grade line by 2 to 4 inches, then cut off the excess. This is still called undercutting. Of course, you can't expect to get paid for removing the 2- to 4-inch excess. But it's still a cost of the job.

Accuracy Is Essential

Accuracy is the essence of estimating. If you can't work accurately, you're in the wrong business. But don't get me wrong. I don't mean that you have to account for every spadeful of soil on every estimate. On small projects, there are times when you can ignore small differences in elevation. On most jobs these small plus and minus areas will average out to almost nothing. But a 1-inch mistake in elevation over the whole job can cost you thousands of dollars. Even a $\frac{1}{16}$ -inch error over a few acres can hurt you.

Here's an example. Assume you're bringing in fill on a city lot measuring 125 feet by 150 feet. Because of a mistake in grade, your estimate of imported soil is wrong. It leaves the entire site 1 inch below the specified finished grade. How much more soil will be needed to correct the 1-inch mistake?

Here's the formula for volume:

$$\text{Volume (in cubic feet)} = \text{Length (in feet)} \times \text{Width (in feet)} \times \text{Depth (in feet)}$$

In this example, you know the length and width in feet, but the depth is only 1 inch. To use the formula, convert 1 inch to a decimal part of a foot. You can either refer to the conversion chart (see Figure 1-3) or divide 1 by 12, since 1 inch = $\frac{1}{12}$ foot. Either way, you'll find that 1 inch equals 0.0833 feet.

Now you're ready to use the formula for volume:

$$\begin{aligned}\text{Volume (CF)} &= 125 \times 150 \times 0.0833 \\ &= 1,561.88\end{aligned}$$

How many cubic yards is that? Since there are 27 cubic feet in a cubic yard, divide the cubic feet by 27:

$$\begin{aligned}\text{Volume (CY)} &= \frac{1,561.88}{27} \\ &= 57.8\end{aligned}$$

Trucking in almost 58 cubic yards of soil won't be cheap. If imported soil costs you \$25 a cubic yard, your 1-inch mistake is a \$1,450 error. That could make the difference between profit and loss on this job.

Inches	Decimal feet	Inches	Decimal feet
$\frac{1}{16}$	0.0052	$\frac{7}{8}$	0.0729
$\frac{1}{8}$	0.0104	$\frac{15}{16}$	0.0781
$\frac{3}{16}$	0.0156	1	0.0833
$\frac{1}{4}$	0.0208	2	0.1667
$\frac{5}{16}$	0.0260	3	0.2500
$\frac{3}{8}$	0.0313	4	0.3333
$\frac{7}{16}$	0.0365	5	0.4167
$\frac{1}{2}$	0.0417	6	0.5000
$\frac{9}{16}$	0.0469	7	0.5833
$\frac{5}{8}$	0.0521	8	0.6667
$\frac{11}{16}$	0.0573	9	0.7500
$\frac{3}{4}$	0.0625	10	0.8333
$\frac{13}{16}$	0.0677	11	0.9167

Figure 1-3
Inches to decimal feet conversion chart

Your Estimating Procedure

The more organized and logical your estimating procedure, the more accurate your estimates will be. If you have the tools, papers and information you need close at hand, you're off to a good start. Then you can focus your attention and concentration on producing an accurate estimate. If you're cramped for space in an uncomfortable office with poor lighting, and trying to work without all the equipment and information you need, errors are almost inevitable.

Work Area and Equipment

Start by organizing an efficient work area. It should be large enough so you can lay out all the plans on a table and still have room to write and calculate. Provide enough light to make reading comfortable, and keep the work area free of shadows. This is especially important when working with transparent overlays or other light-duty paper where you might mistake shadows for lines.

Although it's not essential, I like using a light table. You can place a drawing on it, overlay it with another paper, and see through both of them. It's great for working with plan and profile sheets, overlays on grid, or take-off sheets. It's a good idea to tape a sheet of drafting paper over a site plan. You can set up a grid and write all your calculations on the paper and file it away after the take-off is done. That way, you won't be marking up the drawings if you have to return them to the engineer. You don't want the engineer or anyone else to see how you did your take-off.

A large wall-mounted marker board is useful for showing, studying, or sharing an equation or idea, and can be a very handy addition to your work area.

A good calculator is a must. I recommend buying a calculator with both a digital and a paper printout. You need the printout to check your figures. Make sure you have an engineer's scale and drafting triangles for checking and drawing lines, a small magnifying glass, tape for holding overlays, and the normal collection of pencils, pens, erasers, and paper.

Later in the book we'll talk about using a planimeter to take off quantities. Although it's relatively expensive, a good planimeter will soon pay for itself. Take care to select one that's sturdy and has all the needed instructions and attachments.

A computer is even more expensive, but there are few estimators now who aren't using one. There are programs on the market that can handle anything from simple calculations to a complete estimating program, with cross sections, quantities and printouts. But no program is a substitute for a good estimator who understands estimating procedures and practices — which is the purpose of this book.

There are two advantages to using a computer. The first is time, an estimator's most valuable asset. A computer can help make your time more productive. Second, a computer makes it easier to keep cost figures for equipment and labor. Records from past projects and estimates can make current estimates more accurate.

If you don't currently use a computer in your work, don't jump in without first doing some research. There's tons of estimating software, thousands of different computers on the market, and hundreds of dealers. Take the time to make yourself familiar with the options. Talk to dealers. More important, talk to other estimators who use computers in their estimating. Read trade magazines, especially the ads for estimating software. And don't go out and buy a computer and then look for estimating programs to run on it. First, choose the estimating program you like, and then buy the computer that will run that program. Otherwise, you may find the computer you bought won't run the program you like.

The Work Process

When you've got your work area and equipment set up to work efficiently, you're on the path to accurate estimates. To stay on that path, it's important to approach the work with a logical and organized procedure. That speeds up the work and reduces mistakes. Let me describe the method that works for me. I think it'll work for you, too.

When starting a project, first read all documents describing the job. Take notes on any situation that's not a normal work requirement. Are there utilities that must not be disturbed? Do the documents indicate specialized material types from soil boring logs? Do they stipulate any arrangement for rock on the site? Watch carefully for the compaction and testing requirements. Testing is expensive and your project could be delayed while testing is being performed. Look for any special provisions set out by the designer. Then head out for a field visit. You'll find details about the site visit in the next chapter.

After returning from the field, review the documents again, looking for unusual situations that the site visit brought to your attention. Then make a complete written outline of all work that needs to be done, in the order in which it will be performed. Set up files for each separate section. Make a list of additional data such as quad sheets, local conditions, and any other information you need to gather.

Here's the order I usually use.

1. Consider any drainage, traffic or work zone protection that needs to be done. Are there any onsite streams that must remain open, or roadways to maintain? These would probably be lump sum items, not items you'd take off quantities for. Just make sure you don't miss any of these special items.
2. After studying the plans and the site, you should have a good idea if there's enough fill on the site, or if you'll need a borrow pit. Will you need a place to put excess material offsite? Begin now to make arrangements for needed borrow and storage sites, sampling of material for approval by the engineer, and purchase of any material that's needed. Also, check with heavy equipment dealers in the area to make sure any specialized equipment you'll need to do the project is available for rent. I've even heard of contractors who take a risk and rent equipment in advance in order to keep the competing contractors from getting the equipment.
3. Now consider the topsoil requirements. Review the material sample, the requirements for replacement, and availability of storage area on the site. Calculate the amount of usable material and the amount of waste that must be disposed of.
4. Will there be any special excavation, like rock work or the removal of existing structures or facilities? Make sure you include all work and any special equipment you'll need. Will you need to rent equipment? What about rock drills and saws, blasting material, or cranes?
5. Begin calculating the general quantities with the cut or fill work over the entire project. Start in the same place and proceed throughout the project the same way for every estimate. One way to make sure you cover the entire project is to set up a grid system with a corresponding file system. As you finish work in each grid, mark it off, file it, and move on to the next grid.
6. Next, calculate all the utility lines, keeping the figures for each area separate. Be especially careful in estimating the tie-in between new and existing lines. Allow a little extra time for lines that aren't exactly where the plans show them to be.
7. Then consider the roads, parking lots, and paved or special drainage ditches. Again, keep the quantities for each separate. One note of caution: Remember to consider the base and sub-base when figuring final elevations.

8. Buildings, basements, sidewalks and other similar structures are next. After you've calculated each structure separately, add them all together to get a structure total.
9. Finally, calculate the topsoil. And don't forget that if you've used a borrow pit, you may have to place topsoil there also.
10. Now you're ready to start putting together all that information to come up with a realistic quantity total for the complete project. Fill out the final quantities sheet. Remember to attach all worksheets, scratch paper and calculator printouts so you can recheck your totals.

Review your final sheet, looking for potential problem areas. If possible, have someone else check all your calculations and extensions. If that's not possible, set the estimate aside and go through it again a few days later. You'll have a fresh approach that may spot errors or omissions.

The last step is to go through all the documents and make sure they're in order. Then file them. Don't throw anything away — not even the scrap paper. Why are those records valuable? Keep reading; that's next.

Record Keeping

Once you've learned to read plans carefully and work accurately, there's still one more important step in good estimating practice: record keeping.

Think of your estimates as accumulated wisdom. Treasure them. Keep them handy. Make sure they're easy to understand. They should show how each figure was developed. Why? There are at least four reasons.

First, planning the work is a big part of every estimator's job. You can't estimate any type of earthwork without making decisions about equipment. Once you've selected equipment for estimating purposes, document your choice on the estimate worksheets.

If your bid is accepted, you'll probably want to do the work with the same equipment assumed in the estimate. What if months have gone by and you can't remember how the figures were developed? You have to start selecting equipment and estimating costs all over again. If the equipment assumed in your estimate isn't the same as the equipment actually used, comparison of estimated and actual costs may be meaningless.

Second, you're going to refer to most estimates many times over months or even years. You shouldn't have to guess about how each figure was developed. That wastes time and can exhaust your patience. I've seen estimators who should know better use

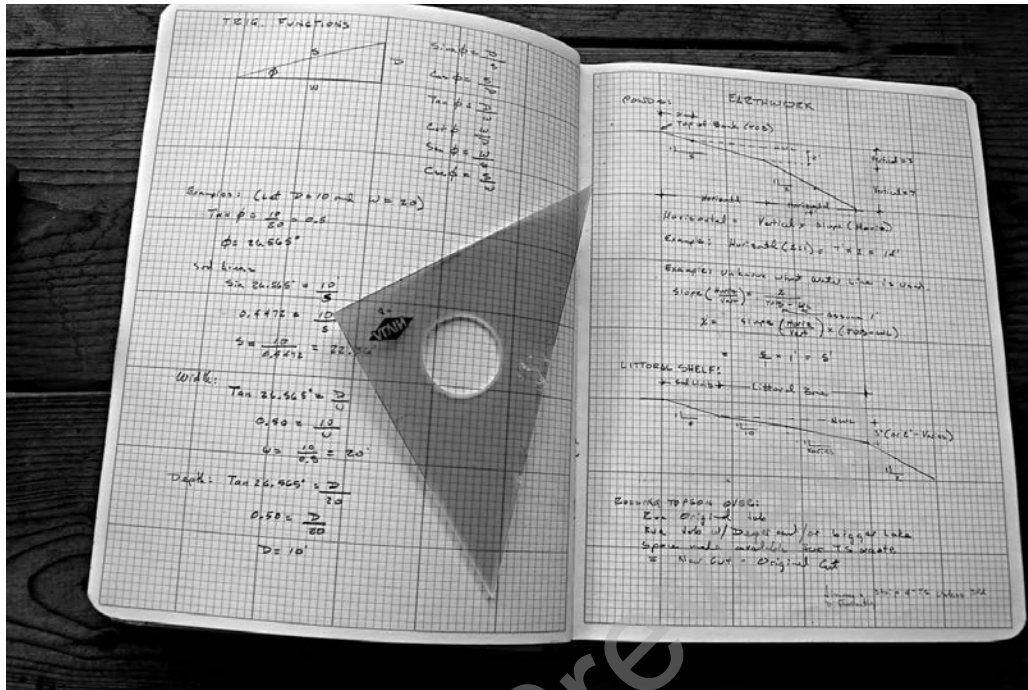


Figure 1-4
Formula book

the back of an envelope to figure special quantities. After entering the final cost, they discard the envelope. Later, if there's a question about the estimate, how can they verify the figures? They're gone!

When you write a calculation or create a drawing for possible future use, take the time to clearly describe the calculation and label each drawing very clearly. Over the years, I've created good ways to solve problems, and then later discovered that I didn't know how I came up with those solutions so I could duplicate them. Because I didn't make good notes or include well-labeled drawings, my solutions were one-time successes that I couldn't carry forward for future work. Now, whenever I find calculations that are needed over and over on different projects, I carefully draw diagrams and write out the equations, and then place them in a special book for future reference. (See Figure 1-4.)

Third, old estimates are invaluable when compiling new estimates. Every estimate, especially if you actually did the work, provides a frame of reference for future jobs — even if labor and equipment costs have changed.

Fourth, every estimator makes mistakes. That's no embarrassment. But repeating mistakes is both foolish and expensive. The best way to avoid repeating mistakes is to preserve every scrap of estimating evidence — in a neat, tidy, well-organized file. Make notes on what worked and what didn't. Review those estimates and notes when estimating similar jobs.

Save everything. Good record keeping can come in handy as backup to justify a claim for extra work or as a means of proving your claim in court if a dispute goes into litigation. Also, someday you may want to write a book. I saved my notes and estimates and wrote a book. You're reading it.

Use Public Records

To the professional estimator, there's no such thing as too much cost information. Collect all the estimating data you can. It helps if you know where to look for it. I canvass city and county engineering departments, public works departments and maintenance departments for whatever information they can provide. They know about bid prices, soil conditions, abandoned streets, utility lines, sewer, and water problems. Use the resources available from your city and county government.

Aerial maps at the county tax office and contour maps from the United States Geological Survey offer clues to possible water and soil problems. There are USGS offices in most states. They're often located in the capitol, or in cities with universities. Check your local phone book or local engineering groups for the address of the nearest office. City, state and county highway departments will have information on soil problems they've found under highways in the area.

Understanding Plan or Drawing Measurements

There are three scenarios you may encounter with plans or drawings that will make your job as an earthwork estimator more difficult. They are: drawings that have been enlarged or reduced; a drawing that has only a measurable area; and being forced to measure a plan drawn in an engineering scale with a common ruler. Let's look quickly at how to deal with these three situations.

Determining the Actual Scale of a Plan

When a print has been reduced or enlarged, you can still use the given scale to measure plan dimensions accurately. The factor by which the plan scale has been reduced or enlarged can be determined by the following formula:

$$\text{Scale Factor} = \frac{\text{Printed Plan Dimension}}{\text{Scaled Dimension} \text{ (using original scale)}}$$

Example: You are given an original scale of 1" = 20'. Find the scale factor if a given plan dimension of 250 feet measures 55 feet at the original scale of 1" = 20':

$$\begin{aligned}\text{Scale Factor} &= \frac{250'}{55'} \\ &= 4.545\end{aligned}$$

You'll need to multiply any dimension scaled at 1" = 20' by 4.545 in order to obtain the correct length. Note: Never apply the factor to a printed dimension entered directly into your calculator. Apply the factor only to dimensions measured with your scale.

Some computer programs have a "compensate scale" feature that automatically determines the correct scale to use on any enlarged or reduced drawing; however, you can check your accuracy in setting the compensate scale feature by using the following formula:

$$\text{Actual Scale} = \frac{\text{Printed Dimension} \times \text{Original Scale}}{\text{Measured Dimension (using original scale)}}$$

Example: Determine the actual scale of the drawing discussed in the previous example.

$$\begin{aligned}\text{Actual Scale} &= \frac{250' \times 20'}{55'} \\ &= 90.91 \text{ feet per inch}\end{aligned}$$

Determining Plan Scale When Only Area is Given

In this situation you have a grading plan with a plan scale of 1" = 40'. The engineer has also given you the dimensions of the site, with an area of 5.76 acres. However, no other dimensions are given on the plan, not even a scale bar. Using the given plan scale provided, the work area measures 18.3 acres. Obviously, the plan has been reduced, making the given scale incorrect. What scale should you use to produce the correct results? Use the following equation to solve the problem:

$$\begin{aligned}\text{Correct Scale} &= \frac{\text{Given Scale} \times \sqrt{\text{Given Area}}}{\sqrt{\text{Site Perimeter Area}}} \\ &= \frac{40 \times \sqrt{5.76}}{\sqrt{18.3}} \\ &= 22.44 \text{ feet per inch}\end{aligned}$$

When You Have the Wrong Measuring Tool

Years ago, while visiting a friend, I was asked to measure the length of a line on a plan drawn at an engineering scale of $1" = 40'$, and all my friend had to measure the line with was a common ruler. The line measured at $3\frac{3}{16}$ inches long. To convert the length to the correct scale, I expressed my measured length as a decimal equivalent of inches and multiplied the result by the plan scale. The decimal equivalent of $3\frac{3}{16}$ inches is 3.1875 inches, so my calculation was:

$$3.1875 \text{ inches} \times 40 \text{ feet} = 127.5 \text{ feet}$$

To apply this principle to areas, convert each area dimension to its engineering dimension and multiply them together. For example, if an area measured with a ruler is $3\frac{1}{2}$ inches by $1\frac{1}{4}$ inches on a plan drawn at $1" = 40'$, it has actual dimensions of 3.5 and 1.25 inches in decimal form. Convert these dimensions to engineering scale dimension:

$$3.5 \text{ inches} \times 40 \text{ feet per inch} = 140 \text{ feet}$$

$$1.25 \text{ inches} \times 40 \text{ feet per inch} = 50 \text{ feet}$$

So the actual area at a 40-foot scale is:

$$140 \text{ feet} \times 50 \text{ feet} = 7,000 \text{ square feet}$$

What If You Don't Have Plans?

Up to this point, we've assumed that you're bidding the job from plans and specs provided by an architect or engineer. But you may be asked to bid on a small job that wasn't designed by an engineer or architect. Then you'll have to create your own plan. It may also be up to you to determine quantities and prepare a contract.

In any case, always figure soil quantities and get a written contract on every job, large or small. The responsibilities and liabilities are all yours, so plan and execute your bid with care. Use the procedures and guidelines in this book — even if there are no plans.

If the owner doesn't have a plan prepared by an architect or engineer, collect as much information as possible from the owner. Does he or she know of any soil problems at the site? Is it your responsibility to request the survey and staking? Are any permits needed? When should the job be completed? Where are the utility lines? What conditions might delay the work?

Whether the job is big or small, whether you've got no plan or a very complete plan prepared by the best engineering firm in the state, make a visit to the site as part of your estimating procedure. That's important — important enough to be the subject of an entire chapter. And that's the next chapter in this book.

Index

A

A.I.A. contracts, changed conditions..... 9
 Access, equipment..... 267
 Accessibility, jobsite..... 23
 Accounting fees, overhead..... 313
 Accuracy, rounding, effect on..... 84-85
 Actual scale, determining..... 18
 Adobe..... 45
 Aerial maps..... 18
 Altitude
 definition..... 290
 effect on horsepower..... 290
 American Association of State Hwy
 and Transportation Officials..... 55
 AASHTO 180-70..... 56
 AASHTO T99-70..... 56
 American Society of Testing Materials
 ASTM D-698..... 56
 ASTM D-1557..... 56
 American Soil Conservation Service
 (ASCS)..... 43
 Angle of repose..... 212
 finding..... 258
 forces on..... 259, 261
 stockpile..... 256
 Angle, reverse..... 256
 Annual costs, equipment..... 310
 Arc section..... 135, 137-138
 Area
 circle..... 122, 206
 compensating lines,
 using..... 152-154, 160
 coordinate system, using..... 162-163
 formulas..... 151
 irregular shapes..... 152
 jobsite, formula for..... 190
 oblique triangle..... 153-157
 section ends..... 132
 Trapezoidal Rule, using..... 167-168
 triangle..... 97
 worksheet..... 103
 worksheet, oblique triangles..... 155-157
 Area take-off, from topo map..... 75-123
 Areas
 available for stockpile..... 261-263
 demolition, computer estimating... 520-521
 naming, computer estimating..... 523-524
 ASCS (American Soil Conservation
 Service)..... 43
 Asphalt road, coefficient of traction..... 289
 ASTM D-698 and D-1557..... 56
 Atmospheric pressure..... 290
 Available power
 altitude effect on..... 290

machine..... 287
 traction effect on..... 288-289
 Average
 compactor operating speed..... 306
 end area, cross section..... 140-141
 grid elevation..... 106-107
 slope line..... 214
 Average depth
 cut or fill..... 118
 formula..... 89, 114
 triangular mound..... 158
 Average end area method
 cut and fill volumes..... 96-98
 formula..... 140
 trapezoidal prism..... 100
 volume formula..... 100
B
 Backfill, plans and specs..... 11
 Backhoe
 cycle time..... 512
 production rate..... 512
 Balance points
 engineers..... 266-267
 in excavation..... 265-266
 mass diagram..... 149
 Balancing site..... 125
 borrow and spoil on two jobsites..... 253
 computer estimating..... 528-530
 topsoil..... 192-193
 Bank cubic yards (BCY)..... 178-179
 Bank material
 approximate weights..... 183
 defined..... 178
 Bank run gravel..... 44
 Bank slopes, allowable..... 48
 Barricades, traffic..... 30
 Baseline
 horizontal..... 279
 vertical..... 279
 Basement excavation
 calculating total volume..... 222-228
 equivalent area..... 214-215
 estimating..... 211-243
 estimating ramps..... 239-243
 finding real depth..... 227-228
 sample estimate..... 228-234
 shortcut calculations..... 234-235
 slope angles..... 212
 wall dimensions..... 217-218
 work space allowance..... 212-213
 worksheet, volume calculations..... 224
 Basement wall dimensions..... 217-218

BCY (bank cubic yards)..... 178-179
 Bedding material
 calculations..... 206-207
 trench..... 205
 Bedrock..... 44
 Beginning station..... 142
 Bells
 net volume chart..... 247
 volume calculations..... 245-248
 Benchmarks..... 73-74
 staking elevations..... 129
 Berm, finding volume of..... 171-173, 175
 Bias tires, rolling resistance..... 282
 Bid
 pay yards..... 185
 price..... 316
 process..... 281, 416
 record keeping..... 16-17
 special quantities..... 7
 subcontracting excavation..... 415
 Bid preparation form, sample..... 423
 Bid, sample..... 415-513
 bid items..... 417-421
 cast iron pipe..... 419
 clearing and grubbing costs..... 417
 earthwork costs..... 418
 machine owner/operating costs..... 421
 machine selection..... 420-421
 manholes and catch basins..... 419
 mobilization costs..... 417
 office building footing and walls..... 420
 overhead..... 420
 shop building footing..... 420
 subcontracting excavation..... 415
 summary sheet..... 422
 topsoil costs..... 417-418
 utility trenches..... 418
 Bid sheet..... 417
 Blue Book values..... 309
 Boost time, pusher units..... 304
 Boring log..... 46-47
 Borings, soil
 computer estimating..... 531
 excavation, dissimilar soils..... 236-237
 locating ground water..... 539
 Borrow..... 249-263
 balancing between jobs..... 253
 definition..... 249
 hauling..... 250
 Borrow pit
 costs..... 250
 distance to site..... 23-24
 locating..... 267-270
 Bottom-of-lake contour..... 72

Boulders.....	44	Circumference, contour lines	122	Contour maps	
Boundary		Classification, soils.....	48	incomplete.....	71
lines	34	Clay	44, 47	reading	65
work	91-92	USCS definition.....	52	Contours, calculating	
Braking force, effect of grade	287	Clearing/grubbing costs, sample	417	hill/pond volume.....	118-119
Break-even point (BEP).....	272, 274	Coarse-grained soils.....	53	Contractor, bidding process.....	281
Bridges, haul route	24	Cobbles	44	Contractor's responsibility	
Brush, jobsite	25-26	Coefficient of traction	289	compaction testing	61
Bucket payload factors	511	Cohesive soils	55	specified in plans	9-10
Buggy (polar planimeter)	132	Color-code drawing,		Contracts	
Building and grounds, overhead	313	computer estimating.....	518	changed conditions clause.....	9-10
Bulldozer, production rates	305	Combi-roller	63	overcut payment clause.....	210
Burning vegetation	32	Combination ramp.....	240, 243	Controlling traffic	30
Business overhead	37-38	Compacted cubic yards (CCY)	178-179	Conversion chart	
C		Compacted material, defined.....	178	inches to decimal feet.....	13
CAD (computer aided drawing)		Compaction		shrink/swell factors	180
importing, computer estimating.....	533	equipment required.....	62-63	Coordinate system	
integrating proposed contours.....	534	fundamentals of.....	55	calculating area formula	162-163
Calculating earthwork quantities	6-8	ground loss.....	181-182	using to find volume.....	159-167
cubic yard costs.....	8	importance of soil moisture	56-58	variables, naming	162
end areas.....	132-143	requirements	28	Corner elevations	
keep formula book.....	17	soil	55-60	calculating.....	110-111
missing corner	116-117	specification requirements.....	59, 61	interpolating.....	82, 86-88
shortcuts	109-116	Standard Proctor percent	180	Corner volumes, excavating	219-221
special quantities.....	7	test diagrams	58	Corners, grid square	
using equivalent area	214-215	testing	55-59, 61	identifying.....	104, 110
Calculating travel time	24	Compactor		measured horizontal distance.....	105
Calculator, use in estimating.....	14	average operating speed.....	306	missing corner volume	116-117
Caliche	44	production rates	305-307	Cost, break-even point.....	272, 274
Carpenter's square,		Compensating lines		Cost factors, equipment.....	310-311
finding stockpile height.....	256	adding to contours.....	160-161	Cost information, collecting	16
Cast iron pipe costs, sample bid.....	419	area formula	160	Cost plus bids	316
calculations	464	defined	153	Costs	
Cast, soil	47	finding area with	152-154	calculating cubic yard, formula	8
Catch basins, sample bid	419	using coordinate system.....	159-167	controlling.....	38
calculations	447-450	Competitive bid process.....	281	direct overhead	35-36
CCY (compacted cubic yards).....	178	Computer estimating software.....	515-539	indirect overhead.....	37-38
Center of mass	265-266	requirements	516	job	35-36
depth not uniform	274	Computer, estimating tool	14	office	37-38
distance to edge	271-272	Concrete-lined ditch.....	203	soil testing.....	61-62
finding	270-272	Concrete road,		Cross section	
formulas	272, 277-278	coefficient of traction	289	average end area.....	140-141
profile, example	279	Concrete, utility lines in	207	estimating methods.....	132-142
vertical, finding.....	274	Condition of haul road,		payment based on.....	10
Center-to-center dimensions,		effect on cycle time.....	292	scale.....	128
wall.....	217-218	Cone, volume.....	263	sheets	128-130
Centerline profile	125, 128	formula.....	219	soil strata	532
take-off	131	stockpile ends	255	template	536
Centerline, road slope.....	201	Constant		view	526
Changed conditions		determining scale units.....	83	worksheet.....	144-145
plans and specs	9	planimeter.....	133-134	Cross-section method.....	88-90
contract clause.....	10	Construction material depth (TI)	197	volume.....	101
Channels, drainage	202-203	Construction scheduling, site visit.....	22	Cross-section software.....	535
Checklist		Contour area, formula for volume	122	Cross slope.....	201
direct overhead costs.....	35-36	Contour interval	70	Crown, roadway	201
indirect overhead costs.....	37-38	measuring planes.....	120	Cubic yard bank measure (CYBM)	185
Checklist, site visit.....	22	Contour lines		Cubic yard costs	
boundary lines	34	adding compensating lines....	153, 160-161	bidding process	281
road/highway conditions	32	characteristics.....	68-69	cost per	281
sample	39-41	circumference	122	estimates	6
site vegetation.....	32	comparing	75	formula for calculating.....	8
soil	33-34	existing, computer estimating.....	519	Cubic yards, converting to.....	97-98
utilities	33	find lake volume using	168-175	Cut and fill	
water problems	33	finding intermediate elevations	85-86	balance points	265-266
Check totals, computer estimating	528	grades	77-78	calculating, earthwork software.....	539
Circle		grid system.....	80	calculating quantities.....	109-116
area.....	122	intermediate	70	color map, computer estimating.....	527
area formula	151, 206	interval between	70	combining	195-196
center of mass.....	272-273	lakes and ponds	71-72	cross section.....	130
circumference formula	151	measuring length.....	121	cross-section worksheet	144-145
haul distance for	272	proposed, computer estimating	521	from centerline profile	131
		reading	80	mass haul diagrams.....	143, 147-150
		vertical dimensions.....	70	planning project.....	267-270

- prism calculations worksheet 113
 shortcut calculations worksheet 115
 under a structure 197
 Cut areas, calculating 90
 Cut depth, total, formula 193
 Cut volume 107
 calculations worksheet 113
 depth calculations 110-111
 Cycle time
 backhoe 512
 definition 291
 effect on cost 291
 equipment 291-292
 production rates 301
 pusher units 304
- D**
 Datum 65
 Day operations, efficiency factors 296
 Decimal feet, converting to 13
 Decimals, rounding 84
 Degree measurements 66
 Demolition areas,
 computer estimating 520-521
 Density, soil 55
 shrink/swell factor 177
 Depreciation, machine 309-310
 Depth
 average, formula 89, 114
 basement excavation 227-228
 calculations 110-111
 cut or fill 118
 Designer objectives 125
 Diagrams, mass haul 143, 147-150
 Diameter of circle, formula 122
 Difficulty, job 24-25
 Digital measuring device 120
 Digitize, meaning of 519
 Digitizer board
 color-coding drawings 518-519
 roll-up or solid 519
 secure to drawing to 517
 stylus take-off 516
 Dimensional systems 217-218
 Dipper cycles 304
 Direct overhead items 35-36
 Dirt job, sample 296-302
 Dirt road, coefficient of traction 289
 Disposal
 spoil 250
 tires 312
 Disposal site
 soil 28
 vegetation 32
 Dissimilar soils, excavating 236-238
 Distance
 edge to center of mass 271-272
 haul, effect on cycle time 292
 Ditches, drainage 202-203
 Downhill travel, total resistance 285
 Drain slope 201
 Drainage
 ditches, excavation 202-203
 jobsite 63-64
 planning for 63-64
 site problems 25, 28
 slopes 201, 197, 199
 Drainage channel
 estimating 202-203
 top of slab 203
 Drawbar pull
 altitude, effect on 290-291
 pounds of 287
- Drawing, profile 76-77
 Drawings
 merging, computer estimating 533
 scale factors 18-19
 Drive wheels, identifying 289
 Dry density, soil 57-59
 Dump site
 distance 23-24
 spoil 250
 Dump truck, production rates 303
- E**
 Earthmoving equipment
 Gradall excavator 203
 production rates 302-305
 repair factors 313
 track or wheeled 25
 trenching 208
 Earthwork
 calculating net volumes 193-197
 calculating quantities 6-8
 calculations, sample bid 432-441
 computer estimating 517-534
 costs, sample bid 418
 cubic yard costs 8
 embankment volumes 143, 147-148
 design 128-129
 estimating, skills required 5
 grid system estimating 78
 reading plans and specs 9
 roadwork estimates 125
 staking elevations 129
 Earthwork software 515-516
 balancing the site 528-530
 color-coding drawings 518-519
 determining rock blast areas 539
 existing contour lines 519
 existing elevations 519-520
 existing structure elevations 520-521
 locating ground water 539
 merging drawings 533
 naming areas 523-524
 opening project file 517
 problem solving with 537, 539
 proposed contour lines 521-522
 proposed structures 522-523
 setting scale and safety options 518
 strip and replace topsoil 523-525
 summarizing information 528-532
 top-of-curb elevations 522-523
 using cross-section programs 535-536
 using trenching programs 535-537
 verifying take-off 526-528
 Easements, jobsite 33
 Easy percolation test 49-50
 Efficiency factors
 estimating production rates 295-296
 productivity chart 296
 Electrical lines, marking 29-30
 Elevation
 between contour lines 86
 changes, cut/fill 193
 contour line 68
 exact 73
 proportionate readings 86-88
 real 74
 sea level, establishing 66
 Elevation points, computer estimating
 existing 519-520
 proposed 521-522
 parking lot 522-523
 sidewalk 522-523
- Elevations
 averaging 107
 existing and final grade 127
 finding intermediate points 85-86
 interpolating 82-88
 project 74
 recording on worksheet 104
 sloping 197
 staking at changes in 126
 Embankment volumes
 roadwork 143, 147
 soil shrinkage 147-148
 Empty weight
 calculating resistance 298-299
 speed and gear 300
 Encasement pipe
 calculating volume 207
 fill 207-208
 End area calculations
 arc sections, using 135, 137-138
 finding volume 140-142
 measuring strip, using 134-135, 136
 planimeter, using 132-134
 scale factor 139
 stockpile volume 255
 volume 262-263
 End area excavation, pond, formula 73
 Ending station 142
 Engineer
 balance points, using 266-267
 earthwork design 128
 soils 45, 47
 Engineer's scale 86-87
 Engines, effect of altitude on 290
 Equal depth contour method,
 worksheet 121-123
 Equipment
 access for 267
 compaction 62-63
 cubic yard costs 8
 cycle time 291-292
 depreciation 309
 evaluate site needs 24
 Gradall excavator 203
 hourly cost summary sheet 513
 load capacity 183-184
 maintenance 292
 operating cost factors 281, 287
 operating cost records 282
 operating speed and gear 300
 owning/operating costs 281, 309-313
 planning for 281
 power, effect on costs 282
 production rates 302-305
 production rates, effect on costs 293-296
 rolling resistance factors 283
 selection, sample bid 420
 soil weight load factors 183-184
 speed, effect on costs 287
 tire value 310
 track or wheeled 25
 trenching 208
 trenching calculations, sample bid 457
 weight on wheels 298-299
 work space allowance 213
 zones, mass diagram 149-150
 Equivalent area
 calculating excavation
 volumes 214-215, 217, 225
 finding width for 217, 225
 sample basement excavation 233

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- spoil volume 251
 tangent of an angle 258
 topsoil volume in CY 190
 total cut/fill 114
 total depth 114
 total resistance 285
 tree height 27
 tree volume 27
 trench volume 181
 triangle, volume 117
 V-in, V-out 222
 volume 12
 volume of equal depth contours 122
 volume of grid CY 82
 weight on drive wheels 289-290
 Four-wheeled tractor,
 weight on drive wheels 289
 Friction, effect on rolling resistance 282
 Frustum of a pyramid 98
 Fuel costs 312
- G**
- Gear ratio to machine speed 288
 General contractor bid 415
 General plan sheet
 project, sample 341
 storm sewer system, sample 392
 General quantities 7
 General specifications, sample 318-319
 Geology, study of 43
 Government contracts,
 changed conditions 9
 Gradall excavator 203
 Grade
 effect on cycle time 291
 finish 266
 Grade assistance,
 braking power needed 287
 Grade bank contour 72
 Grade beams, volume 244-246
 Grade line 127
 Grade resistance
 calculating 286, 298-299
 definition 282, 285
 formula 286
 negative 287
 Grader, motor, production rates 307-308
 Grades, before & after elevations 77-78
 Grades, soil 53-55
 Granular soils 55
 Graph paper, selecting grid size 159
 Graphic of contour 75-76
 Graphing, cut/fill areas 130
 Gravel 44
 definition, USCS 52
 pea 44
 Gravel road, coefficient of traction 289
 Green areas
 balancing the site 528-530
 estimating 523
 Green heads 29
 Grid overlay 78-79
 Grid square corners
 calculating depth 110-111
 calculating missing 116-118
 identifying 104, 110
 inside/outside measurements 105-106
 interpolating elevations 82, 86-88
 Grid system
 area take-off, basement 227-228
 calculating excavation volumes 323
 calculating volume 81-82
- drawing grid squares 78-79
 estimating with 78
 identifying grids 79
 interpolating elevations 82, 86-88
 reading contour lines 80
 scale 80
 subcontour lines 80-81
 take-off, sample 321-324
 worksheet 103
 Gross vehicle weight (GVW)
 on drive wheels 289
 Ground lines, cross section 130
 Ground loss 181-182
 Ground slope, determining 198
 Ground water, locating with 539
 Grubbing vegetation 25-27, 32-33
 Gumbo 45
- H**
- Half slope line (HS) 214
 Hardpan, definition 44
 Haul distance
 asymmetrical borrow pit 278-279
 average 272, 280
 calculating 271-272, 277-279
 center of mass 266
 finding center of mass 270-272
 improvements to shorten 272, 274
 mass diagram 149
 minimizing 270
 reducing 267-270
 symmetrical borrow pit 277-278
 Haul road
 calculating productivity 296-297
 specifications 297
 Haul road condition
 effect on cycle time 292
 effect on rolling resistance 283
 Haul trips, estimating 182-184
 Haul unit cycle time
 excavator 303
 pusher units 304
 Hauling units, production rates 303
 Heads, marker 30
 High-compressibility soil 54
 Highway conditions, site 32
 Hill volume, calculations 118-119
 Holding tank excavation, estimating 211
 Horizontal baseline 279
 Horizontal data, lakes and ponds 71-72
 Horizontal datum 65
 Horizontal distance
 plan distance 199
 run 198
 Horizontal scale
 calculating scale factor 139
 cross section 128
 Horizontal slice method 118-119
 Horsepower
 altitude, effect on 290-291
 available, equipment 287
 Hourly
 cost factors, machine 310-311
 operating cost, machine 316
 HS (half slope line) 214
- I**
- Ice, coefficient of traction 289
 Identifying grid squares 79
 Impact-rammer compactor 63
 Import, mass diagram 149
 Improvements, break-even point 272, 274
- Inches to decimal feet, conversion 13
 Indirect overhead items 37-38
 Inside corners, basement 219
 Inside grid elevation 105-106
 Inside ramp 240
 Inside-to-inside dimensions, wall 217-218
 Instructions, plans and specs 9
 Insurance, equipment 310-311
 Interest, on equipment 310-311
 Interim spoil 251
 stockpile, shrink and swell 252
 Interior dimensions, wall 217-218
 Interlocking sheet piles 238
 Intermediate contour lines 70
 Intermediate points, finding 86
 Internet, software requirements 516
 Interpolating elevations 82-88
 accuracy of 84-85
 Interval, contour lines 70
 Inventory counter 120
 Irregular shapes, area of 151
 ITT (interest, insurance, taxes) 310-311
- J**
- Job costs, overhead 35-36
 Job difficulty, evaluating 24-25
 Job efficiency factors, chart 296
 Job, planning cut and fill 267-270
 Jobsite
 accessibility, evaluating 23
 analyzing conditions 22-23
 balance borrow/spoil between jobs 253
 formula for area 190
 irregular shaped 151
 surface conditions 25
- K**
- Knox soil 44
- L**
- Labor, local 30
 Lake, finding volume of 168-170
 Layers, soil 47
 LCY (loose cubic yards) 178-179
 Legal fees, overhead 313
 Legends, topo maps 76
 Lift station excavation, estimating 211
 Lift thickness, topsoil, area per CY 192
 Light table 13
 Lines
 contour 68-72
 plotting elevation 130
 zero 90-94
 Liquid limit test 50-51
 Load factors
 equipment 183-184
 formula for 184
 Load time
 excavator 303
 pusher units 304
 Loaded weight
 calculating resistance 298-299
 speed and gear 300
 Loader, production rates 303
 Loading the bid 316
 Loam 45, 47
 Local soil information, importance of 43
 Loess 45
 Logs
 barricade 31
 boring 46-47

Loose cubic yards (LCY)	178-179
spoil volume	252
Loose material	
approximate weights	183
defined	178
Low-compressibility soil	54
Lowboys, overhead	313
Lubricant costs	312
Lump sum bids	6

M

Machine	
average hourly operating cost	315
hourly cost summary sheet	513
life span	309
operating costs, sample bid	475-510
production	293-296
retarder chart	511
selection, sample bid	420
speed, effect on costs	287
speed, weight effects	287-288
tire value	231
Machine owner/operating cost	309-316
chart	315
summary	314
Machine power	
definition	282
grade resistance on	285
rolling resistance	283-284
Maintenance, machine,	
effect on rolling resistance	282
Management, overhead	313
Manhole	
calculations, bid	451-452, 465-469
sample bid	419
template, computer generated	538
Manhole shield	210
Manufacturer data	
operating manual and spec sheet	287
percentage of GVW on drive wheels	289
travel time	301
Map roller	120
Maps	
aerial	18
contour	65, 71
locating and using	18
planimetric	65
problem areas,	
earthwork software	537, 539
scale	121
survey	127
symbols	76
topographic	65
using to verify take-off	526-527
Markers, survey type	29-30
Mass, center of	265-266
Mass diagram	143, 147-150
balance points	149
cross-section, software	536
equipment zones	150
Material	
borrow, matching with site	250
effect on machine production	293
jobsite storage	30
selling	252
spoil and borrow	249
thickness (TM)	197
weight in place	184
weights, chart	183
Measurements	
contour planes	120
converting scale	20
degrees, minutes, seconds	66

determining scale units	83
finding intermediate points	86
understanding scale	18-19
using arc section	135, 137-138
using measuring strip	134-136
using planimeter	132-134
wall dimensional systems	217-218
Measuring, cut/fill areas	130
Measuring tools	
engineer's scale	86
rubber band	85-86
strip	134-136
Merging drawings,	
computer estimating	533
Middle section, stockpile	253-255
Midpoints, horizontal & vertical	279
Minute measurements	66
Mobilization costs	417
Modified Proctor Test	56
Moisture content, soil	
effect on project cost	45
plasticity	51
problems	63
shrink/swell factor	177
testing	56
Moisture density curve	56-57
Monotypic soils	183
Monuments	73-74
Motor grader	
haul road maintenance	292
production rates	307-308
Mound, finding volume	152-158
Mountain contour lines	70
Mouse take-off	516
Muck	45
Mud	45

N

Naming areas,	
computer estimating	523, 524
National Geodetic Vertical Datum	66
Naturally-aspirated engines,	
altitude effect on	290
Net cut/fill depths	193-195
Net earthwork volumes,	
calculating	193-197
Night operations, efficiency factors	296
Notes, plans and specs	9
Nuclear density gauge	60

O

Oblique triangle	
finding area	153, 241
finding height and base	153-154
volume using area and depth	154
Obstructions, jobsite	24
Office building, sample	338-340
bid calculations	472-473
bid details	420
excavation details	411-413
Office expenses	37-38
Operating costs	
equipment	282, 287, 293
fuel and lubricants	312
repairs	312
tires	312
Operating gear,	
effect on available power	287-288
Operating speed, equipment	300
Optimum moisture content, soil	56-57
Organic matter, defined	52
Organic soils	45, 47

OSHA, slope safety	205
Outline work	15-16
Outside	
corners, basement	219
grid elevation	105-106
ramp	240
Outside-to-outside dimensions,	
wall	217-218
Overcut	
payment clause	210
trenching	208-210
Overfilling, plans and specs	11
Overhead	
calculating	313-316
direct	35
indirect	37-38
machine cost per hour	316
sample bid	420, 474
Ownership costs	309-316
depreciation	309
insurance	310-311
interest	310-311
overhead	313
Owning and operating costs,	
equipment	309-316
estimating	281
sample bid	421

P

Paper contractors	415
Paper, graph	130
selecting grid size	159
Parallelogram, area formula	151
Parking lot	
elevation points	522-523
estimating excavation	326
Pay yards	185
Payload	302
bucket, factors	511
truck	303-304
Payment for	
overcut	210
services	10
Payroll, overhead	313
PDF format	516
Pea gravel	44
Peat	45
Pebbles	44
Percentage of GVW, drive wheels	289
Percolation test	49-50
Performance records, importance	282
Permanent benchmarks (BM)	74
Permits	10
road right-of-way	32
Personnel, planning for	281
Phone lines, marking	29-30
Photographs, document site	22
Pick-up line	75-76
Pier	
net bell volumes	247
shaft drilling chart	246
volume calculations	244-246
Pipe	
bedding, undercutting for	11
calculations, sample bid	458
wall thickness, importance of	207
Plan and profile, take-off method	125-132
Plan and profile sheets	
earthwork design	128-129
examples	126-127
road project	275
sample	369, 377-380

Plan distance.....	199	Profile		Remote-controlled compactor	63
Plan view, basement excavation.....	229	end area calculations.....	132-143	Rental equipment, availability.....	30
Plan with contour lines	346, 368	existing.....	126	Repair cost, machine.....	312-313
Plan with grid squares.....	347	finish, balancing cut and fill.....	266-267	Replaced topsoil	
Planes		left, right and centerline	131	balance with topsoil stripped.....	192-193
existing elevation.....	88-89	proposed.....	127	calculating volume.....	192
proposed elevation.....	88-89	vertical regions	135	computer estimating	523-525
trapezoidal shape.....	100	Profile section		Repose, angle of	
Planimeter.....	120	calculating a slope	77	finding.....	258
constant.....	133-134	drawing	76-77	forces on	259, 261
determining areas.....	132-134	Profit.....	316	stockpile	256
estimating tool.....	14	Project		Resistance	
Planimetric maps.....	65	computer estimating	517-534	calculations	298-299
Planning slopes.....	199	costs, effects of soil on	45	data, machine	287
Planning team, contractor's.....	281	determining boundary.....	523-524	grade, definition.....	282
Plans		determining task time.....	295	rolling, definition.....	282
multiple sheets	533	elevations	74	Restricted space, excavating in	238
notes, special conditions.....	9	grid	68	Retarder chart.....	511
reading	8	planning cut and fill.....	267-270	Return time, pusher units.....	304
review for site visit	21	size.....	30	Reverse angle method,	
scale factors	18-19	summary sheet, sample project	414	stockpile height	256-260
understanding measurements	18	Properties of soils.....	43-64	Ribbon, soil.....	47
Plastic limit test.....	51	Property lines.....	34	Rimpull	
Plasticity, soil	49	Public records, using	18	chart, wheeled tractor.....	288
compressibility.....	52	Pull off.....	68	definition.....	287
index.....	51	Pull, pounds of		formula.....	290
Plumb bob, finding stockpile height	256	effect on machine speed	287	speed and gear	300
Pneumatic roller	63	traction.....	288	Rise	198
average operating speed.....	306	Purchase price, machine.....	310	basement perimeter slope	212
Point contour option.....	521-522	Push, pounds of, traction.....	288	River, jobsite.....	33
Point elevation, formula.....	107	Pusher units		Road profile, computer estimating.....	536
Point of optimum moisture	56	formula.....	304	Road, slope	201
Polar planimeter	132	productivity rates	304	Road surface	
Pond bank slope		Pyramid, frustum of	98	coefficients of traction.....	289
horizontal change	72	Pythagorean theorem	242	condition, effect on	
safety considerations	71	Q		rolling resistance	283
Pond volume, calculations	118-119	Quadrangle (quad) sheets	66-67	Roadway template.....	372
Portable document files (PDF).....	516	Quantities		Roadwork, estimating.....	320
Pounds of pull, traction	288	earthwork, calculating	7	centerline profiles.....	128, 131
Pounds of push, traction.....	288	estimating	6	plan and profile sheet.....	369
Power, machine	287	special and general	7	road sections	370-371
definition.....	282	take-off, basement excavation	230	take-offs	125
Pre-construction field tests	46	tracking overcut volumes.....	208-210	template	372
Price per cubic yard, bid.....	316	Quantities take-off sheet	146	Rock	
Prism		sample	224	locating blasting areas	539
stockpile middle section	253-255	summary sheet, sample project	414	undercutting for	10-11
trapezoidal	100	Quantity take-off worksheet	103	weathered.....	44
truncated.....	88-89	R		Rocks, road surface conditions.....	25
volume.....	262	Radial tires, rolling resistance	282	Roll-up digitizer board.....	519
Prismoidal formula.....	99	Ramps		Rolling resistance	
Procedures, estimating.....	13-16	combination	240, 243	calculations, example	298-299
Proctor tests.....	55	estimating	239-243	compactor.....	306
Production rate		inside	240	definition.....	282
BCY data tables	303	outside.....	240-243	estimating	282
calculating.....	293	RAW (Regions absent of work)	142	factors.....	283
efficiency factors	295-296	Real depth, excavation.....	227-228	formulas	283-284
formula.....	301	Real elevations	74	Rounding, effect on accuracy	84
keeping good data.....	294-295	Record keeping.....	16-17	Rubber band measuring tool.....	85-86
machine.....	293-296	Recorder of Deeds, checking with.....	33	Run	198
Production rates, equipment.....	281	Recording elevations.....	322	Run/rise ratio, slope.....	198
backhoe	512	Rectangle		S	
bulldozer.....	305	area formula	151	Safety, excavation	
compactor.....	305-307	center of mass	273	equipment	30
hauling units.....	303	Red heads	29	manhole shield.....	210
motor grader.....	307-308	Reference		sheet piling.....	238-239
pusher units.....	304-305	lines, graph	159	trench boxes.....	204
Productivity calculations		points, survey.....	73-74	trench slopes.....	204-205
cycle time	301	Regions absent of work (RAW)	142	Safety options, computer estimating.....	518
gear.....	300	Relief maps.....	65	Safety, public	31
haul roads	296-297	markings	66	Sample	
operating speed.....	300			bid.....	415-513
production rates	301-302			excavation estimate, basement.....	228-234
resistance	298-299			take-off	317-414
travel times.....	301				

Samples		Site size	30	Soil borings	
soil	56	Site visit		computer estimating	531
topsoil	189	checklist	39-41	excavation with dissimilar soils	236-237
Sand cone test	60	estimating process	15	locating ground water,	
Sand, definition	44	evaluate traffic control	30	earthwork software	539
USCS	52	importance of	21-22	Soil Conservation Service (USCS)	43-44
Sand surface, coefficient of traction	289	locate utility lines	28-30	Soils engineer, compaction testing	61
Sandy loam	45, 47	make checklist	22	Special conditions,	
Sanitary sewer lines		sample project	32-35	reading plans and specs	9
estimating	327-332, 375-391	soil conditions	28	Special quantities	7
plan and profile sheets	377-380	taking soil samples	48	Specifications	
Scale		temporary utility needs	29	compaction requirements	59, 61
actual vs. plan dimensions	276	Size, site	30	haul road	297-298
choosing	128	Skills needed, estimating	5	notes, special conditions	9
determining	18	Slab, effects on zero line	93-94	reading	8
distance, graph	160-161	Slope		sample basement excavation	233
grid system	80	angles, selecting	212	sample project	318-319
horizontal	128, 139	calculating degree of	198, 200	topsoil quantities	189-190
quad sheets	66	calculating volume of topsoil	199-201	understanding measurements	18
setting, computer estimating	518	effect on grade resistance	285	Speed, machine,	
using to interpolate elevations	82-85	run and rise, basement perimeter	212	effect on operating cost	287
value of scale unit	82-83	run/rise ratio	198	Spoil	249-263
vertical	128, 139	safety	204-205	balancing between jobs	253
Scale factor	139	total run formula	216	definition	249
formulas for	18-19	Slope line	197	disposal	250-251
Scaling elevations	321	drainage	201	dump site	250
Scheduling, equipment	281	estimating length, chart	200	interim	251
Scope of work		field distance	199	shrink and swell	252
bid summary	422	Slopes		stockpiles	252
reviewing	416-417	bank, safe	48	Square, area formula	151
Scraper, rolling resistance	283-284	lakes and ponds	72	Stability, soil	47
Sea level elevation	66	roadway	201	Staking project	
Second measurements	66	Snow, coefficient of traction	289	contractor's responsibility	10
Section line	75-76	Software		roadwork elevations	129
Security, jobsite	31	computer requirements	516	Standard drawings	
Segmented-pad roller	62	Internet requirements	516	office building	411
Self-propelled compactors,		Soil		road sections	370-371
average operating speed	306	allowable bank slopes	48	sanitary sewer lines	386
Semicircle		basic constituents	52	shop building footing	407-408
center of mass	272-273	calculating dry density	57-59	storm sewer system	393-395
haul distance for	272	characteristics	47	topsoil excavation	367
Setting scale, computer estimating	518	classifications	43-45	Standard life span, equipment	309
Sewage discharge	49	coarse grained	53	Standard Proctor,	
Sewer lines, jobsite	28	cohesive	55	compaction percent	180
Shaft, volume	245	compaction	55-60	Standard Proctor Test	56
Shale	45	compaction testing	61	Stations	
Sheepsfoot roller	62	density	55	beginning and end	142
average operating speed	306	determining moisture content	51	calculating volume	
Sheet piling	238-239	excavations, dissimilar types	236-237	between	140-142, 147-148
advantages/disadvantages	239	expansion/compression factors	529	intervals, alternative labels for	275
Shield, manhole	210	field testing	46-50	regions of absent work	142
Shop building footing, sample bid		fine grained	54	surveying	128-129
bid details	420	granular	55	Steep slopes, equipment for	25
calculations	470-471	hauling, cost of	267-270	Stockpile	
excavation details	407-410	lab testing	50-51	influences, soil pile behavior	261
specifications	336-338	liquid limit test	50	interim spoil	252
Shoring, trench slopes	204	loading, cost of	267	locations, topsoil	188
Shortcut		moisture, importance of	45	selling	252
calculating quantities	109-116	monotypic	183	Stockpile volume	
total cut/fill, formula	114	movement	64	calculation sheet	260
Shrink/swell factors	177-180	optimum moisture content	56	end sections	255
apply to fill	269-270	plastic limit test	51	height, reverse angle method	256-260
conversion chart	180	plasticity index	51	height, unknown	256-260
customize using materials weights	183	properties of	43-64	middle section	253-255
formula for	182	shrink/swell factors	177	set area	261-263
stockpiled topsoil	252	site samples	48-49	Storage, jobsite	30
Shrinkage, embankment soil	147-148	stability	47	Storm sewer lines	332-335
Sidewalk, elevation points	522-523	states	177-178	calculations, sample bid	453-456
Silt	44, 47	stockpiling	28, 31	jobsite	28
definition, USCS	52	type, matching	250	plan and profile sheets	396-398
Silt fence	33	types, maximum safe slope	204	plan sheets and calculations	392-406
Site plan, sample	342	unstable	28	Stream beds, jobsite	28, 33
Site problems, anticipating	22-23	USCS grading	53-55	Strip, measuring	134-136
		weight charts, obtaining	183		

- Stripped topsoil..... 188-189
 balance with topsoil replaced..... 192-193
 computer estimating 523-525
 Structure area, calculating..... 191
 Structure elevations, computer estimating
 entering..... 520-521
 proposed subgrade..... 522-523
 Stylus take-off..... 516
 Subcontour lines, plotting..... 80-81
 Subsurface conditions..... 28
 Summary page, computer estimating
 required materials in CY..... 530
 site totals..... 528
 soil boring information 532
 soil expansion/compression factors 529
 trenching software 538
 Superelevation 201
 Superintendents, overhead 313
 Suppliers, local..... 30
 Surface conditions, jobsite..... 25
 Surface structures, cut/fill under..... 197
 Surface, road, effect on RR..... 283
 Survey
 maps..... 127
 markers..... 73-74
 stakes, contractor's responsibility..... 10
 USGS..... 18
 Survey ties..... 29-30
 utilities..... 33
 Surveyors
 earthwork design..... 128-129
 using coordinate system..... 159
 Swell
 factor..... 147
 spoil..... 251-252
- T**
- Take-off
 arc section..... 137-138
 from centerline profile 131
 from topo map 75-123
 grid square..... 321-324
 manual, importance of 6
 measuring strip 134-135
 office building 338-440
 organizing..... 102
 plan and profile method 125-132
 planimeter..... 133-134
 project grid pull-off..... 68
 project summary sheet 414
 roadways 125
 sample..... 317-414
 sample, plan sheets 341-342, 346-347
 sanitary sewer lines..... 327-332
 shop building footing..... 336-338
 storm sewer lines..... 332-335
 strip and replace topsoil..... 320
 Take-off calculations
 basement excavation volume..... 227-228
 calculation sheets 343-366
 entrance road..... 325
 grid volume..... 81-82
 quantities, basement excavation 230
 quantities, cross section..... 146
 worksheets..... 102
 Take-off, computer estimating
 earthwork project 517-534
 exporting to Excel..... 533
 mouse-type software 516
 stylus-type software 516
 verifying..... 526-528
 Tamping-foot roller..... 62
 Tangent of an angle
 formula..... 258
 table..... 259
 Tape measure, stockpile height..... 256
 Task time, motor grader..... 307-308
 Template, computer generated 75-76
 cross section..... 535
 manhole..... 538
 Template, roadwork..... 131
 Temporary benchmarks (TBM) 74
 Test borings..... 33-34
 Test hole, topsoil 189
 Test-hole data, dissimilar soils 236-237
 Testing
 compaction..... 55-59, 61
 cost factors..... 61-62
 field, soil density..... 60
 percolation 49-50
 Proctor 56
 scheduling work around..... 61
 shrink/swell factor..... 179
 soil 46-51
 USCS..... 52
 Theft, jobsite 31
 Ties, survey 29-30
 Till..... 44
 Tires
 coefficient of traction..... 289
 design, effect
 on rolling resistance..... 282-283
 hourly cost 312
 inflation, effect on rolling resistance..... 282
 replacement costs..... 312
 value..... 310
 Toe of slope..... 198
 Tools, make for measuring 85
 Tools and equipment, estimating..... 13-14
 Top-of-bank contour 71
 Top-of-curb elevations,
 computer estimating 522-523
 Top of slab 203
 Top of slope..... 198
 Topographical (topo) maps..... 65
 calculating shortcuts..... 109
 contour lines 68-72
 estimating quantities, using 120
 grid system estimating..... 78
 intermediate contour lines..... 70
 map scale..... 121
 project grid..... 68
 symbols 66, 76
 using to find lake volume..... 168-170
 volume, using to find 159-167
 Topsoil 187-197
 applying shrink/swell factors..... 252
 calculations, sample bid 417, 424-431
 disposal..... 188
 haul route, sample bid..... 424
 layers..... 187-188
 loam..... 45
 onsite storage..... 30
 quantities, calculating..... 190
 replaced, volume of..... 191-192
 stockpiling..... 188
 strip and replace, computer
 estimating..... 523-525
 strip depth (TO)..... 197
 stripped, effects on zero line..... 93
 stripped, volume of..... 188-190
 value of..... 250
 volume, slope 199-201
 Total depth formula..... 114
 Total resistance
 calculations 286-287
 example 299
 formulas..... 285
 Trace contour option 522
 Tracing
 green areas..... 523
 site perimeter..... 525
 Track equipment, efficiency factors..... 296
 weight on drive wheels..... 289
 Track equipment, slopes..... 25
 Track machines, pull ratings..... 287
 Tracks, coefficient of traction..... 289
 Traction
 coefficients of 289
 defined..... 288
 effect on usable power..... 288
 Tractor
 overhead cost 313
 rolling resistance 283-284
 weight on drive wheels..... 290
 Trade specialization 415
 Traffic conditions, jobsite 24
 Traffic control 30
 Transfer time, pusher units 304
 Trapezoid, area formula 151
 Trapezoidal prism 100
 Trapezoidal Rule
 avoiding pitfalls 174
 using to find area..... 167-168
 using to find volume..... 167-175
 worksheets..... 170-173
 Travel time
 calculating..... 24
 production rates 301
 Travel, total resistance factors..... 285
 Trees, jobsite 25-26
 calculating height 27
 Trench boxes 204
 Trenches
 calculating fill 206-208
 concrete lined..... 207
 estimating overcut..... 208-210
 excavation equipment 208
 formula for volume..... 181
 slope safety..... 204-205
 utility..... 205-208
 width factors..... 205
 Trenching equipment
 buckets..... 208
 Gradall excavator 203
 Trenching software..... 535-537
 trenchwork template..... 537
 Triangle
 area..... 97
 area formula 151
 center of mass..... 273
 finding volume..... 116-117
 volume calculations 117-118
 volume using area and depth..... 154-158
 Trips, production rates 300-302
 Truck
 dipper cycles..... 304
 hauling unit production 303
 rolling resistance 283
 Truncated prism 88-89
 Turbo trace..... 519-520
 Two-wheeled tractor,
 weight on drive wheels..... 289
 Tying down utility lines..... 29-30
- U**
- U.S. Coast and Geodetic Survey 73
 U.S. Geodetic Survey..... 73

U.S. Geological Survey (USGS)	66
contour interval listing	70
maps	18
Undercutting	10-11
Underground structure excavation, estimating	211
Unified Soil Classification System (USCS)	52
symbols and descriptions	54
Unit, scale	82-83
Unknown points, finding	86-88
Unstable slopes, equipment for	25
Unstable soil	28
Uphill travel, total resistance	285
Usable power	288
Usable topsoil	187
Utilities	
overhead	313-316
undercutting for	11
Utility easements	33
Utility lines	
excavating for	208
locating	9, 28, 33
marking	29-30
production cost calculations	459-463
set in concrete	207
Utility trench, sample bid	205
calculations	442-446
costs	418

V

V-in/V-out calculations, basement excavation	231-232
formulas for	222
Vandalism, jobsite	31
Variable time, definition	291-292
Vee ditches	202
Vegetation, jobsite	25-26
Vertical	
center of mass	274
datum	65
distance, rise	198
wall excavations	222-223
Vertical scale	
calculating scale factor	139
cross section	128
Vibrating-roller compactor	63
Visit, site	22
Void ratio	59
Volume	
average area	140-142
average end area	100
average end area method	97, 100
bells	245-248
cone	219-221, 255, 263
contour area	122-123

contour slices	118-119
coordinate system, using	159-167
cross-section method	88-90, 101
cut and fill, total	114
end area	262-263
end area calculations, using	140-142
end areas, combined	255
equivalent area, calculating by	217
exterior basement excavation	217, 225
formula	12, 82
formula, cross section method	90
formulas for solids	143
frustum of a pyramid	98
grade beams	244-246
hill	118-119
horizontal slice method	118-119
interpolating elevations	82
irregular areas	152
irregular shapes	167
jobsite vegetation formula	27
mound	152-158
mound, using average depth	154-158
mound, using compensating lines	166
net cut	196
piers	244-246
pond	118-119
prism	255, 262
prismoidal formula method	99
ramp	243
replaced topsoil	191-192
roadwork, mass diagram	143, 147-148
sample basement excavation	228-234
shaft	245
shortcut calculations	234-235
slope outside basement wall	213
sloping wall basement excavation	223-227
small lake	168-170
spoil	251
stockpile	253-255
stockpile of set area	261-263
stockpile of unknown height	256-260
stripped topsoil	189-190
topo maps, using	159
topsoil, slope	199-201
total cut/fill, formula	114
tracking overcut	208-210
trapezoidal prism	100
Trapezoidal Rule, using	167-175
trench bedding	206-207
trench, formula	181
triangular area	116-117
vertical wall basement excavations	222-223
worksheet	104

W

Wall dimensions, basement	217-218
---------------------------------	---------

Water	
drainage	63-64
jobsite	24, 33
problems	63
Water lines, marking	29-30
Water table, jobsite	28, 63-64
Water trucks	62
Weathered rock	44
Weight	
in-place material	184
machine, effect on speed	287-288
Weight on wheels	
calculating	286
drive wheels, formula	289-290
loaded/empty	298
Wheeled equipment	
efficiency factors	296
rim pounds of pull	287
rolling resistance factors	283
Wheeled scraper, grade resistance	286
Work boundary	91-92
Work space	
basement excavation	211-213
trenching overcut volumes	208-210
Workers, hiring local	30
Working elevation	193
Worksheet	
arc section take-off	137-138
area/volume, compensating lines	161, 164-165
areas of oblique triangles	155-158
cut/fill prism calculations	112
equal depth contour volume	121
existing contours	104
grid square and volume	103
grid square depth calculations	110-111
measured horizontal distance	105-106
proposed contours	104
shortcut for cut/fill	115
take-off	102
Trapezoidal Rule	170-173
volume calculations for lake	175
Worksite, visit	15
Worm test	51
Worm, soil	47

X, Y, Z

Yards, pay	185
Yellow heads	29
Zero line	
adjust for topsoil stripping	92
adjust for slab or paving	93
cut and fill quantities	109
determining path	94-95
locating	90-91
work boundary	91

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