Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 26-37

1522-8150/99/$3.00/Educational Practice Manuscript

Practical Business Application of Break Even Analysis in Graduate Construction Education

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The recent trends in the competitive global market dictate that construction management students must manage at higher levels of sophistication. This is especially important at the graduate level where the focus of education is on "management". One potential discipline, which can aid in producing more sophisticated managers, is economics. However, many of the economic tools are unfamiliar to the construction graduate because agriculture and business disciplines traditionally dominate economic analysis. As a result, construction students who enroll in economics courses are taught agricultural or business terms with no application being germane to construction. In an attempted to supplement the traditional disciplines, this paper will examine and demonstrate one of the typical economic analytical tools, Break-even Analysis, in a construction business context. This is to provide the graduate educator with a teaching tool that can be used to assist future construction professionals in the nuances of operating a construction business. Included are the theoretical underpinnings of break-even analysis and a hypothetical case study, which applies this economic concept to the business operations of road construction firm.

Key Words: Break-even Analysis, Profit Contribution Analysis, Economics, Construction Management, and Construction Graduate Education

Introduction

The cornerstone of financial decision-making is economic analysis. There are several evaluation tools currently available to construction managers, including present worth analyses, benefit/cost analysis, equivalent annualized costs, rate of return on investment, cash flow analysis, and break-even (Barrie and Paulson, 1978). At the undergraduate level, the typical student will probably not be expected to produce these sophisticated economic analysis as a part of their initial job responsibilities. However, the graduate student is likely to be initially employed in a position which does require sophistication of management methods, including economic analysis. While most graduates may have heard of some of these tools, they probably could not effectively utilize them within a construction firm's analytical framework.

Why is this? One possible answer -- predominant disciplines utilizing these decision making tools are agriculture and business colleges. Cows and widgets are used as the units for evaluation -- not square feet, board feet, or cubic yards. In most cases, if students take a business course outside of their respective construction department, they are not exposed to economic decision making scenarios or case studies involving construction. Construction is a relative newcomer to economic analysis and a review of the literature confirms this, with very few references being made toward economic analysis as a function of construction.

To help make economic analysis a part of the construction manager's knowledge base, one economic tool, Break-even Analysis, is scrutinized for the construction instructor and student.

This article evaluates an agriculture/business economic tool and places it in a construction business context by outlining the fundamental components, steps, and limitations of break-even analysis. The evaluation is followed by a hypothetical case study, which demonstrates how break-even analysis can be utilized as a useful managerial tool for the construction graduate.

Break-Even Fundamentals

Traditional break-even analysis is a relatively common managerial tool used in a wide variety of purposes for nearly all types of decision-making. Break-even analysis (sometimes called profit contribution analysis) is an important tool, which allows comparative studies between costs, revenues, and profits (Pappas and Brigham, 1981). This analytical technique facilitates the evaluation of potential prices, the impact of price changes and fixed/variable costs on profitability (Powers, 1987). This analysis can also be used to expedite decisions on investment return criteria, required market shares, and distribution alternatives (Kotler, 1984)

Break-even is the sales volume at which revenue and total cost are equal, resulting in no net income or loss. It is typical to graphically depict break-even as the point where a firm's total cost and total revenue curves intersect. This is the sales point where both variable and fixed costs are covered by the sales volume for the relevant range. If the break-even point is not achieved, that business will (or should) eventually go out of business (Casavant et. al, 1984).

Break-even Components

To fully appreciate the break-even theory and related graphical depictions, it is necessary to have a basic understanding of the concepts related to cost, revenue and profit. In order to facilitate this, one must first know the following components of break-even:

- Total Cost
- Total Revenue
- Net Profit
- Fixed Cost
- Variable Cost
- Semi variable Cost
- Contribution Margin
- Relative Range

Total cost is the sum of fixed cost and variable costs. *Total revenue* is that amount of gross income received from product sales or a service rendered, and is equal to the price of a unit times the number of units sold. *Net profit* results when total revenue exceeds total cost.

Fixed and *variable costs* represent the expenses incurred in making and selling the goods or services. Fixed costs are invariant costs that are not affected by production level or output. Such costs include interest on borrowed capital, rental expense, employee salaries, etc. In contrast, variable costs change with each marginal unit of production or output levels. Included are such costs as materials expense, depreciation associated with the use of equipment, utility charges, some labor costs, sales commissions, etc. (Pappas et. al, 1981). The easiest way to determine variable or fixed costs is to evaluate the expense versus the production level. For example, a project manager received a monthly salary. His salary expense to the company would be the same, regardless of the dollar amount of work completed by him, and therefore is a fixed cost.

Consider a framing carpenter who is paid per square foot of building. If no buildings are constructed, his cost to the company is zero. His cost varies as a function of the building size and number of buildings completed during a relevant time frame; therefore, this is a variable cost.

Semivariable costs often stay constant for a certain time period during production increases, then “step up” to a higher cost level at specific points of increased volume. An example of this is an insurance premium, which covers production to a certain level, which if exceeded, is changed to a new fixed level. To simplify the analysis process, semivariable costs are generally calculated and split into appropriate fixed and variable costs.

Contribution margin is that amount which contributes to the fixed costs of the company and to its profits, after deducting the variable costs. Total variable costs are subtracted from total revenue to yield the contribution margin. The contribution margin can be expressed in total dollars, in dollars per unit, or as a percentage.

Relative range is the limit of production or output levels over which fixed costs remain constant. Above the relative range cost evaluations and respective relationships are no longer applicable. For instance, if a construction firm’s work doubled or tripled, the company would have to hire more people, rent more office space, and acquire more equipment -- thus increasing fixed costs and altering the entire break-even cost and revenue structure.

Basic Analysis Steps

Once the definitions and their respective applications are mastered, it is then matter of performing the three basic steps of the break-even analysis:

1. Conduct a cost/income analysis of the construction firm to determine:
    1. Fixed costs
    2. Variable costs
    3. Total costs
    4. Total revenue

2. Calculate contribution margin and perform break-even analysis (Powers, 1987):

$$CM = P - V \qquad\qquad Q = F / CM$$

whereas:

CM = Contribution Margin
Q = Break-even point in units
P = Price per unit sold
V = Variable cost per unit (total)
F = Fixed cost per unit (total)

There are variations of the traditional break-even formula that calculate the market share required to break-even alone or to break-even and cover a profit requirement. This can be seen as follows:

Variations of break-even:

$$Breakeven\ with\ Profit\ Requirement = \frac{F + Profit\ Requirement}{Contribution\ Margin}$$

$$Market\ Share\ Required\ to\ Breakeven = \frac{Breakeven\ Point}{Market\ Size}$$

In all of these formulas, any type of appropriate unit can be used. Units in total dollars, dollars per unit, and percentages are commonly used. An example could be the market size of residential home construction -- units could be in total market dollars or in the total number of homes being built.

3. Create chart (optional)

A break-even chart is constructed using the above data. The break-even components are graphically depicted in Figure 1. Graph A illustrates fixed costs and graph B illustrates variable costs along with semivariable costs. Graph C combines both fixed and variable costs to equal total costs. Note that variable costs have to be considered in addition to fixed cost and are represented by beginning at the origin of the fixed cost at the y axis. Also, note that the semivariable costs have been reclassified into appropriate fixed and variable cost components for Graph C. Graph D illustrates sales revenue proportionate to the units sold. In Figure 2, all of the break-even components are synthesized to demonstrate the overall cost and revenue relationships. The difference between total sales and total costs to the left of the break-even point is loss and to the right is profit.

Limitations

The power of this tool to accurately reflect useable results can be limited due largely to the definition of fixed and variable costs. It is difficult to determine and categorize costs as fixed or variable. Most businesses have a combination of the two resulting in semivariable costs. Other costs are questionable and cannot be easily classified (Sinclair and Talbott, 1986). As a consequence, the usable results are limited by the structure of the formula, which defines all cost as either fixed or variable (Powers, 1987). Also, along with this cost analysis is a certain degree of difficulty in determining relevant ranges. Most companies that have been in operation for just few years have not yet experienced their maximum operating capacity. Difficulty arises when a company has never reached their maximum output and are uncertain of their limits as a function of their relevant range.

Management is sometimes deterred from using break-even analysis because of these complexities and the inherent imprecision to exact measurements. However, it is important to remember that break-even analysis is often used as a measure to determine general guidelines for business decision making (Pollack, 1995).

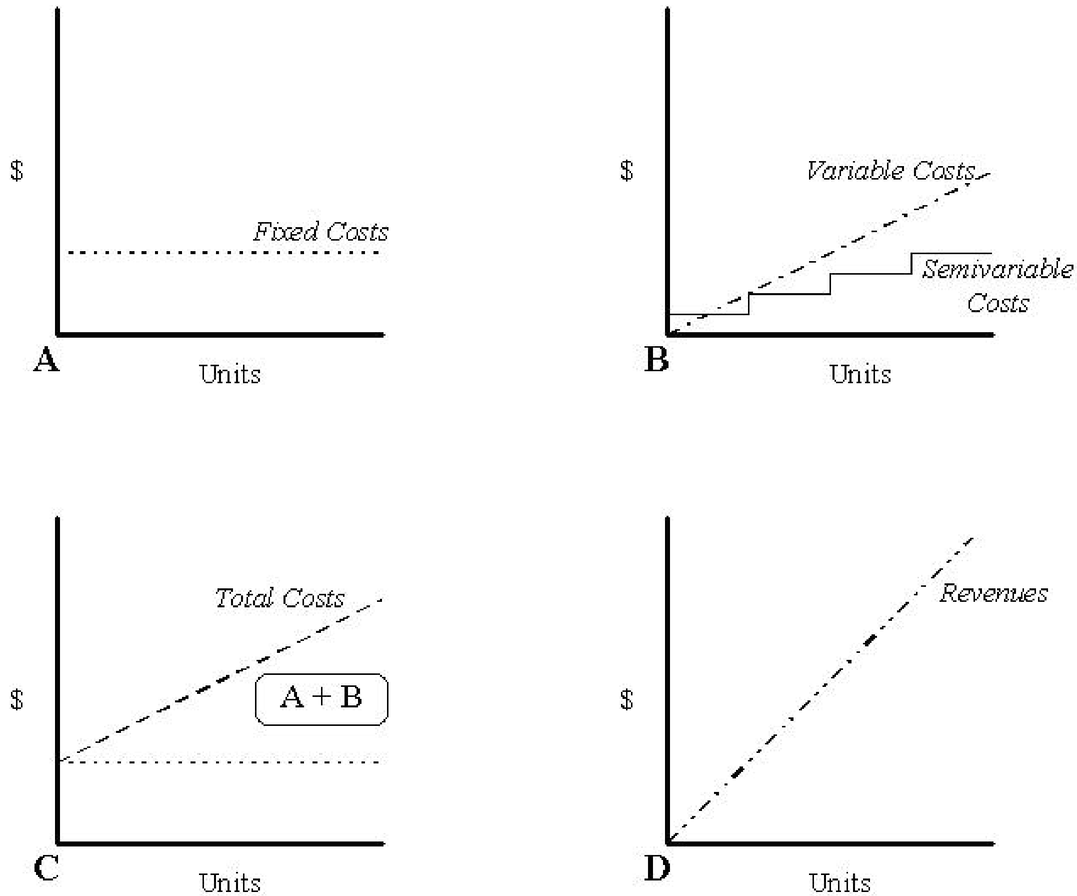

Figure 1. Break-even Components

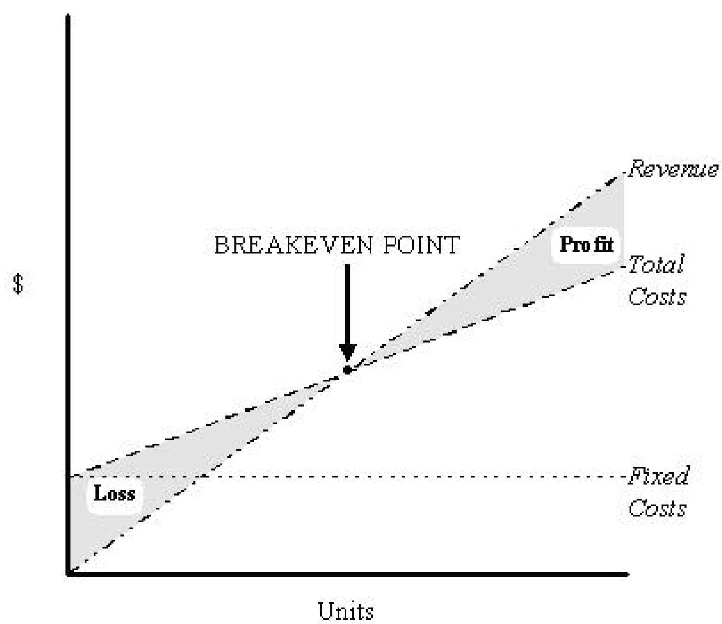

Figure 2. Graphical Break-even Analysis with Break-even Point

Practical Application of Construction Break-Even Analysis

The following hypothetical case study is presented to demonstrate the practical application of economic break-even analysis to the discipline of construction management. The information provided can be used by educators as a lecture/discussion aid. As an alternate, the instructor can give the student only the hypothetical background information (presented below) along with the expense/income sheet (Appendix A) and request that the students generate their own economic break-even analysis. Another option is to utilize the tutorial (web site still under construction) on the Internet as part of the classroom instruction (see Figure 3).

Hypothetical Case Background

Jack Lignite, president of Smooth Roads, Inc., is contemplating whether or not to place his bid on a large State construction contract, which involves approximately 6000 tons of hot mix asphalt. To competitively bid such a large volume, Jack would have to lower his standard construction price of $50 a ton to $45 a ton. This price includes labor, materials, and equipment for a turnkey asphaltic road system. Jack's main concern is that if he is awarded the contract, he won't make a profit. If this happened, Smooth Roads, Inc. could be out of business. Jack decides he can run a break-even analysis to answer his questions.

Currently, Smooth Roads, Inc. has a maximum construction capacity of 200,000 tons. Increasing the highway construction volume above this number results in increased fixed costs to the company. This 200,000-ton limit is the top of Jack's relevant range. It is a ceiling limit on the amount of roads the company can build without requiring more equipment and manpower.

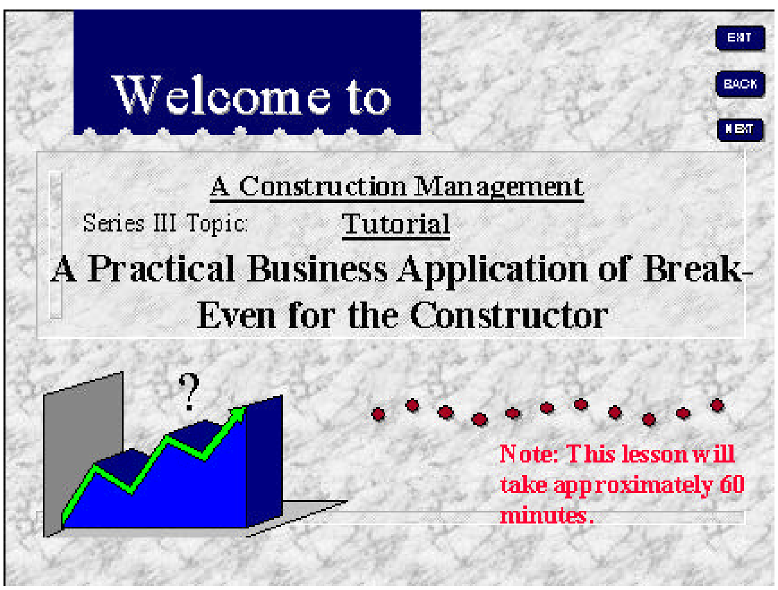

Figure 3. Introduction for Internet Tutorial

Analysis of Fixed and Variable Costs

Jack performed a detailed analysis of his fixed and variable costs. The semi-variable costs were computed using the "high/low" method to estimate individual cost components.

The "high/low" method (Powers, 1987) simply calculates the change in 1) a semivariable cost item and 2) volume of sales from one year to the next. The change in the cost (? C) is then divided by the change in volume of construction or sales (? V) from one year to the next to find the variable cost per unit. This result leads to the estimation of the variable component of the semivariable cost unit as follows:

Jack's repair and maintenance expenses were $25,200 in 1994 and $25,100 in 1993.

$$\Delta C = \$25,200 - \$24,100 = \$1,100$$

Jack's construction volume was 172,000 tons in 1994 and was 155,000 tons in 1993.

$$\Delta V = 172,000 - 155,000 = 17,000 \text{ tons}$$

To find variable cost per ton of hot mix asphalt from the semivariable repair and maintenance:

$$\Delta C / \Delta V = \$1,100 / 17,000 = \$0.0647 \text{ variable cost per ton}$$

To find the current variable portion of repair and maintenance, multiply the 1994 construction volume by the variable cost per ton:

$$172,000 \times \$0.0647 = \$11,130 \text{ variable cost}$$

The fixed and variable portion equal the total expense of repair and maintenance, therefore total cost less variable cost equal the fixed cost:

$$\$25,200 - 11,130 = \$14,071 \text{ fixed cost}$$

Jack applied this technique to all his semivariable costs. Once completed, he had successfully divided his expenses into fixed and variable (summarized in Appendix A). With a production level of 172,000 tons of hot mix asphalt, Jack found his total fixed expenses to be $1,278,110 and his total variable expenses to be $6,956,500.

Calculating Contribution Margin

Jack took the total variable costs and subtracted them from total revenue to acquire the contribution margin for the company as a whole (see figure 4). Jack discovered that he has $1,643,500 (contribution margin) towards his fixed cost. Subtracting the fixed cost from this number, indicates his profit, before taxes, of $365,390. Converting to a contribution ratio of 0.191 (by dividing contribution margin by total revenue) indicates to Jack that approximately 19% of every dollar of revenue will contribute to the fixed costs up to break-even, after that point, it will contribute to profit.

	$8,600,000	*Total Revenue*
−	6,956,500	*Variable Costs*
	$1,643,500	***Contribution Margin ($)***
−	1,278,110	*Fixed Costs*
	$ 365,390	***Profit Before Taxes***

$$\frac{\text{Contribution Margin} \quad \$1{,}643{,}500}{\text{Total Revenue} \quad \$8{,}600{,}000} = \mathbf{19.1\%} \ \textit{Contribution Margin (\%)}$$

Figure 4. Analysis of Contribution Margin

Break-even Analysis

Before Jack would turn his bid into the State, he needed to reassure himself that he could construct additional road systems at his current volume, and that his lower bid price covered both his fixed and variable costs (break-even point). To find the volume of construction (in tons) needed to break even, Jack divided the total fixed costs by the average contribution margin per ton (see Figure 5 for summary):

$$\text{Breakeven Point in Units} = \frac{\text{Total Fixed Costs}}{\text{Avg. Contribution Margin per Unit}}$$

Jack discovered that his break-even point was 141,228 tons. Multiplying this number by average price per ton gave Jack his break-even point in dollars -- $7,061,381. This meant that the company had to place 141,228 tons of hot mix and collect the respective construction revenues of $7,061,381 in order to cover total cost and yield a profit of zero. Construction in excess of this point will yield a profit because the contribution margin covers the fixed costs. Conversely, any amount below this point will result in a loss because the fixed costs cannot be covered by the contribution margin.

Charting for Visual Representation

From the break-even calculations, Jack constructed a chart to demonstrate the newly identified relationships. Using graph paper, Jack accurately plotted the values and located the break-even point (see Figure 6).

$$\text{Break-even Point in Units (tons)} = \frac{\textit{Total Fixed Cost} \Rightarrow \$1,278,110}{\textit{Avg. Contribution Margin per ton} \Rightarrow \text{average construction price per ton minus average variable cost per ton}}$$

$$\Rightarrow \$50 - \frac{\$6,956,500}{172,000 \text{ tons}}$$

$$\Rightarrow \$50 - \$40.5$$

$$\Rightarrow \$9.50 \text{ per ton}$$

$$\therefore \textbf{Break-even points in tons} = \frac{\$1,278,110}{\$9.05} = \textbf{141,228 tons}$$

$$\therefore \textbf{Break-even points in dollars} = 141,228 \times \$50 = \textbf{\$7,061,381}$$

Figure 5.Summary of Break-even Calculation

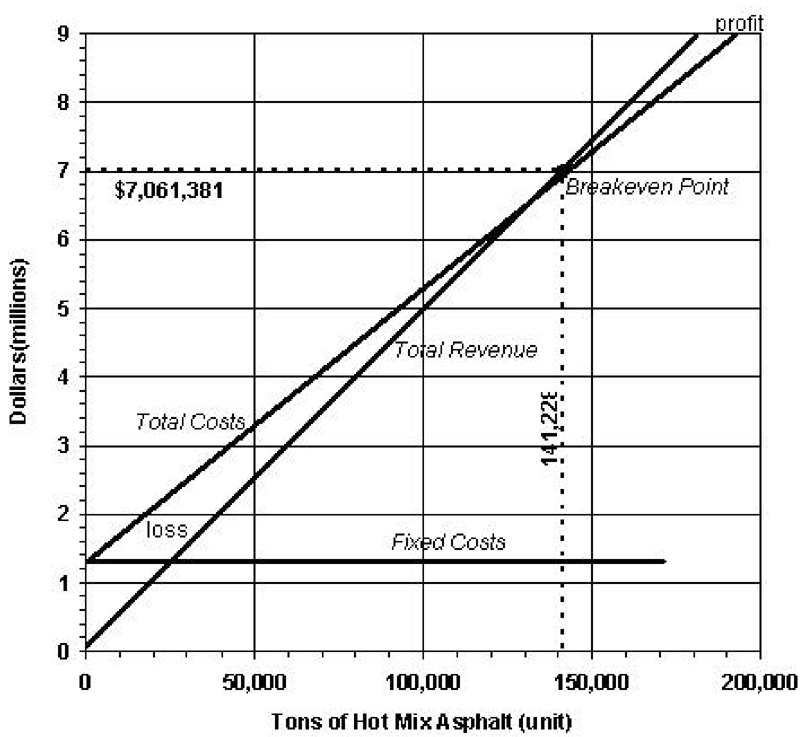

Figure 6. Smooth Road, Inc. -- Break-even Chart

Management Decisions

Jack has completed the break-even analysis and can now determine whether the company should take on the State's extra work at a lower competitive price. At this point, Jack believes that the company is able to construct the State road system without losing money. Further assessment is needed however before a final decision can be made:

1. Can Smooth Roads, Inc. places the additional 6000 tons without increases in the fixed costs (relevant range)?
2. Is each ton's (unit) variable cost covered by the reduced price?
3. Is the increased work beneficial and profitable?
4. Should Smooth Roads, Inc. definitely bid the project?

From experience, Jack had previously determined that Smooth Roads, Inc. can place a maximum of 200,000 tons of hot mix asphalt without purchasing more equipment and acquiring more manpower. He would not incur additional fixed costs -- only variable costs such as labor, materials, and job related overhead. Smooth Roads current rate is 172,000 tons. An additional 6000 tons of hot mix asphalt can be placed without increasing the fixed costs. This indicates that the proposed level of production is within the company's relevant range.

Jack calculated earlier that $40.50 was the average variable cost per ton (unit). The reduced rate of $45.00 covered the variable costs by the contribution margin of $4.50 ($45.00 less $40.50). Since Smooth Roads, Inc. would already be operating past the break-even point, Jack concludes that the increased work would profit the company $27,000 (6,000 x $4.50). Jack realizes that his actual profits might be lower if the company has to put in overtime to complete the State contract. He is also aware that this would be a great opportunity for the company to acquire another client. Jack concludes that each ton's variable cost is covered by $4.50 and the work would be profitable and apparently beneficial.

Should Jack proceed with the bidding process and submit a Smooth Roads, Inc. proposal to the State? Based strictly on the economic issues of cost, revenue and profit, the answer would be.…Yes.

Discussion

This case study introduced construction to the business basics of economic break-even analysis. There are two primary beneficial uses for break-even analysis. These include techniques in company evaluation of desired profit levels and cost reduction impact analysis. Also, the decision making process can be enhanced by using break-even analysis in combination with other analytical tools such as Break-even Default Ratios (a sensitivity analysis on the limit of decreasing unit prices) and Degree of Operating Leverage (analysis on how a change in volume affects profits).

Inclusion of these tools to the graduate students' arsenal of analytical techniques assist in enhancing the critical thinking process. It also provides these future managers of construction with another tool to produce safe and sound managerial decisions, a typical requirement of graduate level students entering the workforce. Needed in the classroom is the connection between economics and construction. Once the association is complete, one can then teach the construction graduate students these simple managerial tools in *terms of construction* -- not in cows or widgets.

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Appendix A

Summary of Fixed and Variable Cost for Smooth Roads, Inc.

As Per Income Statement December 31. 1994					FIXED	VARIABLE
Revenue:						
172,000	@	$50.00		**$8,600,000**		
Cost of Construction						
Material			3,324,180			3,324,180
Labor - Main Office			1,830,500			1,830,500
Labor - Branch Office			827,350			827,350
Payroll Taxes			212,300			212,300
Equip. Depreciation			443,500		443,500	
Insurance			160,000			160,000
Bonding			412,000			412,000
Repair and Maintenance			25,200		14,070	11,130
Equipment Rentals			32,460		32,460	
Total Cost of Const.				**$7,267,490**		
Plant Expenses						
Auto expenses			14,000		10500	3,500
Depreciation			32,200		32,200	
Electricity			8,300		7,100	1,200
Insurance			15,680		15,680	
Misc. Expenses			65,200		58,200	7,000
Telephone			13,290		12,000	1,290
Plant Labor			102,550			102,550
Property Taxes			12,500		12,500	
Total Plant Overhead				**$263,720**		
General and Administrative						
Advertising			110,000		110,000	
Association Dues			15,000		15,000	
Bad Debts			18,000		18,000	
Computer Service			14,200		14,200	
Commissions			9,800			9,800
Interest expense			130,000		88,000	42,000
Legal and accounting			28,200		21,000	7,200
Salaries – Office			80,000		80,000	
Salaries – Field			145,000		145,000	
Stationary and Supplies			12,400		12,400	
Payroll taxes			30,100		30,100	
Telephone			22,500		18,000	4,500
Travel and expenses			88,200		88,200	
Total G & A				**$703,400**		
Total Costs				**$8,234,610**	**1,278,110**	**6,956,500**
Profit before Taxes				**$365,390**		