

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Department of Civil and Environmental Engineering  
1.133 Concepts of Engineering Practice

**PROJECT EVALUATION**

**Assignment 3b**  
**"Financing a CEE Project"**

Fall 2003  
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Assigned: September 17, 2003  
Due: October 1, 2003

**Financing a Skyscraper**

A simple cost model for the construction of a skyscraper could be based upon the following:

- a. The land area (acres) and the price of the land (\$0.1 to \$10 million/acre)
- b. The costs of clearing the land (\$10 to \$50,000/acre)
- c. The foundation (\$2-4 million/acre)
- c. The weight-bearing structure
- d. The exterior of the building, including windows, exterior materials, waterproofing, and insulation
- e. The elevators
- f. Heating, air-conditioning, ventilation
- g. Creation of a dramatic entry area and mini-parks
- h. Interior walls
- i. Interior finishing

For a CEE project, we are generally considering whether or not to begin a particular type of project. We probably have several basic design and location options plus numerous minor variations on these options, e.g. variations in size or quality of components. From the underlying logic of the project, we can develop a function that relates the project costs to the design and location possibilities. Separate functions can be used to estimate the initial investment costs as well as the fixed and variable operating costs. As engineers, it is our job to try to understand

what options are available, including new designs or construction techniques as well as "tried & true" approaches.

## **Revenues**

We also would like to estimate the demand for the services provided by our project, taking into account the quality of the service provided, the capacity of our project and competing facilities, and the price that we and our competitors charge. For a skyscraper, the revenues will be based upon the rental rates, commonly expressed as the annual rent per square foot. A skyscraper makes financial sense if the projected rents (net of any continuing expenses) will be sufficient to justify a mortgage sufficiently large to cover all of the costs of construction, including interest on a construction loan.

## **Timing and Cost Assumptions**

For this assignment, let's just consider the example described by Karl Sabbagh in "Skyscraper". This is a great book describing the people and the processes involved in constructing a 50-story office building in Manhattan. As is the case with most engineering books, the focus is on the technical rather than the financial matters. Hence, in addition to the information presented in the book, we need to make some additional assumptions to evaluate various options for the project:

- a. The time between land acquisition and beginning of construction is exactly 18 months. All of the engineering and architectural work is completed during this period.
- b. The time from groundbreaking until the time that tenants can move in is exactly 24 months (i.e. months 19 to 42 of the project if the project is completed on time).
- c. The permanent mortgage is obtained 3 months after the tenants move in (at the end of month 45 if the project is completed on time).
- d. The tenants have 4 months (to fix up the interior) before they make their first rent payment (at the end of month 46 if the project is completed on time).
- e. The fixed costs include the land acquisition, preparation of the case for development, the architects and engineers fees (assumed to be \$90 million of the \$145 million for fees and borrowing costs cited in the note), \$45 million of the construction costs (for the foundation, landscaping, entry, lobby and the roof), and \$5 million of the project management costs.
- f. The \$90 million architect/engineering fees were paid uniformly over the first 18 months of the project; the \$145 million construction costs were paid uniformly over the period of construction.
- g. The construction could have been stretched out over 3 years with a savings

in construction of \$5 million and essentially no chance of an overrun.

- h. The project costs were provided on a construction loan with interest of 10% per year charged from the point that costs were incurred.
- i. \$375 million of the permanent mortgage related to the office tower; the interest rate of this mortgage was 8%.
- j. All invoice and loan payments are made on the last day of the month.
- k. Additional space, if available, could likely be rented at \$30/sq. ft. per year or more.

## Questions

1. **Project Cost** (30 points) - Construct a spreadsheet that can be used to calculate the costs of construction, including interest costs on the construction loan. Structure the spreadsheet so that it shows the various cost categories across the top and the months (1 to 48 down the side). Have a column for total monthly cost and another column for the PW of the monthly cost (use discreet discounting compounded monthly). Have an area at the top of the spreadsheet where you can enter key parameters (including interest rate on the construction loan, length of the construction period, and the owner's discount rate) when doing sensitivity analysis. Use the spreadsheet to answer the following questions:

- a. What will the total project cost be as of the end of month 45 when - if all goes well - the permanent mortgage is secured (i.e. estimate the interest costs paid on construction and add it to the other costs to come up with a total budgeted cost comparable to the \$370 million shown in the note).
- b. What is the present worth of the total project cost as of the beginning of month 1 assuming a discount rate of 15%.

2. **Project Revenue** (20 points) - Assume that the project has one major tenant who pays \$26/sq. ft. for 600,000 sq. ft. and another who pays \$29/sq.ft for 200,000 sq. ft., while all other space is rented at \$30/sq.ft. (these are annual rates per square foot for long-term leases)

- a. Calculate the monthly revenue assuming that the building is fully leased from the outset
- b. Calculate the PW of the total revenue received over a 30-year project life as of the beginning of the first month in which rents are received (use the owner's discount rate of 15%)
- c. Calculate the PW of the revenue as of the beginning of month 1 (using the owner's discount rate of 15%)
- d. Compare the PW of the costs (from 1b) and the PW of the revenue (from 2c) and discuss whether this is a worthwhile project (from the owner's perspective).

3. **Refinancing** (10 points) - Once the building is up and rented, the owner can refinance the building at a lower interest rate, because the bankers now can see the completed building and the paying tenants.

a. Assume that the bank will provide a 30-year mortgage with the maximum amount equal to 80% of the net present value of the rents (calculated with a discount rate equal to the interest rate on the loan). What would the maximum amount of the mortgage be and what would the monthly mortgage payment be?

b. Considering the **owner's** cash flows and the **owner's** discount rate (15%), what is the project now worth to the owner (at the beginning of the first month), assuming that financing will be available?

4. **Other Issues** (30 points) to be presented in class

A. **Sensitivity to cost & revenue assumptions:** how would the total project cost (as calculated in part a) and the PW (as calculated in part b) vary if the:

1. Construction costs were higher or lower
2. Interest rates for the construction loan were higher or lower
3. The time required for construction were higher or lower
4. The owner's discount rate were higher or lower
5. Rents increased or declined over the 30-year life of the building

B. **Selling the building:** once the building is refinanced, the owners may get bored simply collecting rents and making mortgage payments. What price should they offer and what is the minimum price that they should accept?

C. **Redesigning the building:** - suppose that, early in the planning stage, the city planning department offers you a chance to increase the floor area ratio to 15 (which would allow you to add 3 stories and 100,000 sq. ft. of rentable space). All you have to do is provide an enclosed, all weather walkways to neighboring buildings as part of a "downtown mall" concept. How much additional cost would you be willing to accept to be able to get the added rentable space, assuming that the added work would delay the entire project for 2 months?

5. **Sustainability Issues** (10 points) - Identify three issues related to the social and environmental sustainability of a skyscraper. Discuss how the design of the project could be altered to make the project more sustainable. (max: 1 page)

## INSTRUCTIONS

*Here's how the Skyscraper Assignment would be done.*

a. All students will attempt Questions 1, 2, 3 & 5 individually.

b. Question 4 is a team assignment and has to be presented in class on October 1 2003, based on the following distribution:-

Team 1 - 4 Question 4A  
Team 5 - 8 Question 4B  
Team 9 - 11 Question 4C

c. Teams

We will have 11 teams of 3 students each. See attached table for grouping.

d. The presentation would be as follows:-

Question 4A	20 mins
Question 4B	20 mins
Question 4C	20 mins

15 mins for presentation and 5mins for discussion.

Each team will be required to prepare for a presentation, and any team could be asked to make a presentation on the spot. You could use overheads or Powerpoint presentations if you like.

e. Answers to all questions (individual and team assignments) have to be submitted in paper by 5pm October 1 2003, including all calculations and presentation slides.

*Data Summary and some useful hints (Prepared by Chu Eu Ho)*

**1. Costs (in millions)**

	Fixed	Variable	Total
Land	\$58	0	\$58
Preparation of case	\$5	0	\$5
Arch and Engr Fees	\$90	0	\$90
Construction costs	\$45	\$100	\$145
Project Management Fee	\$5	\$12	\$17

If construction scope has been increased, the variable cost will be adjusted accordingly, but fixed costs will remain the same.

Spread the total costs over the respective periods applicable.

**2. Space**

Usable land space 1.9 million sq. ft.

Rentable office space 1.6 million sq. ft.

**3. Time Frame**

a. Work Schedule

T = 0, Land acquisition

T = 1 to 18, Arch and Engr Design

T = 19 to 42, Site Construction

T = 43 to 46, Interior Work

Note that Project Manager gets involved from T = 1 to 45, while Arch/Engr input is only required from T = 1 to 18.

b. Rental starts from month 47 onwards indefinitely

c. Mortgage payment starts end of month 45 for 360 months

**4. Interest and Discounts Rates**

a. Construction Loan interest rate  $R = 10\%$  per annum over 45 months

b. Owner's Discount rate  $R = 15\%$  per annum

c. Mortgage Interest rate  $R = 8\%$  per annum over 30 years

Calculate all sums based on a monthly rate,  $i = R/12$

**5. Calculation of interest costs**

- a. Note that the Initial Cost for Land and Preparation of Case ( $C_1 = \$63\text{m}$ ) is borrowed at  $T = 0$ , i.e. at beginning of month 1. Therefore the interest ( $I_1$ ) accruing for this amount is payable at the end of month 1
- b. All other expenses are paid at the end of each month, for month 1 say  $E_1$
- c. The principal owing at the beginning of month 2,  $C_2 = C_1 + I_1 + E_1$ . The interest accruing at the end of month 2 will be  $I \cdot C_2$ . The steps are repeated up to the end of construction at month 42.
- d. Pay a little more attention to how you would set up the spread sheet to do this. Have a column for Accumulated Monthly Costs for each month ( $AMC = C + I + E$ ) and obtain the total construction cost (TCC) at end of month 42
- e. Convert total construction cost to its present value at  $T = 0$  using  $PV = TCC / (1 + i)^T$

## 6. Rental

Tenant 1, 600,000 sq ft @ \$26 psf  
 Tenant 2, 200,000 sq ft @ \$29 psf  
 Others, 800,000 sq ft @ 30 psf  
 3 optional new floors, 1000, 000 sq ft @ \$30 psf

Calculate monthly rental income (MRI) and annual rental income (ARI) based on the rentals.

## 7. Calculation for Variable Costs in QUESTION C

- a. When the additional 100,000 sq ft of rental space is included, the original usable space (1.9 million) has to be prorated upwards to account for the increased usable space, i.e. Ratio of New to Original Usable Area =  $(1.6+0.1)/1.6 \cdot 1.9 = X$  say
- b. The new variable costs ( $V_{\text{new}}$ ) can then be prorated accordingly i.e.  $V_{\text{new}} = V_{\text{original}} / 1.9 \cdot X$
- c. Calculate the new construction cost = Fixed Cost +  $V_{\text{new}}$

## 8. Financial Considerations

Remember that

- a. For a Bank to consider whether a mortgage is worthwhile, calculate the Capital Worth (Present Worth) of the annual income i.e.  $CW = \text{ARI} / \text{Bank interest rate}$
- b. For a Buyer to consider whether the project is worth buying, calculate the Capital Worth of the Net Cash Flow (NCF) = monthly rental income (MRI) – monthly mortgage payment, i.e.  $CW = \text{NCF} / \text{Discount rate}$