CHAPTER 14

COST ANALYSIS

14-1. Cost Optimization. Engineering is a science that has as its purpose satisfying the wants and needs of people. In accomplishing this objective, the aim of the engineer should be to attain maximum results in the most economical manner. This cost optimization should provide the basis for selecting a project level of protection or evaluating alternative designs once project functional adequacy and safety are assured. In other words, only after design criteria have been achieved (minimum level of protection) can cost optimization be applied.

14-2. Elements. The elements that are to be considered in an economic optimization or life cycle analysis are:

a. Project economic life.

b. Construction cost for various levels of protection.

c. Maintenance costs for various levels of protection.

d. Replacement costs for various levels of protection.

e. Benefits for various levels of protection using probability analysis.

14-3. Effects of Protection Level. The construction cost will generally increase as the level of protection increases. Maintenance generally decreases as the level of protection increases. Replacement is less frequent and present worth annual costs are less as protection level increases. Benefits generally increase as protection level increases because frequency of losses (both time and property) decreases.

14-4. Economic Life. A Corps of Engineers project economic life is generally 50 years; however, some projects such as cofferdams or temporary sheet-pile locks can have shorter project lives. Once the economic project life is selected the level of protection to design for is needed. This level of protection or condition to design for is related to the occurrence of physical events such as river discharge, wind speed, or ice thickness. The severity or magnitude of these events has a statistical distribution that can be ordered into a frequency of occurrence. The frequency is converted to exceedance probability and plotted against the level of protection as shown in figure 14-1.

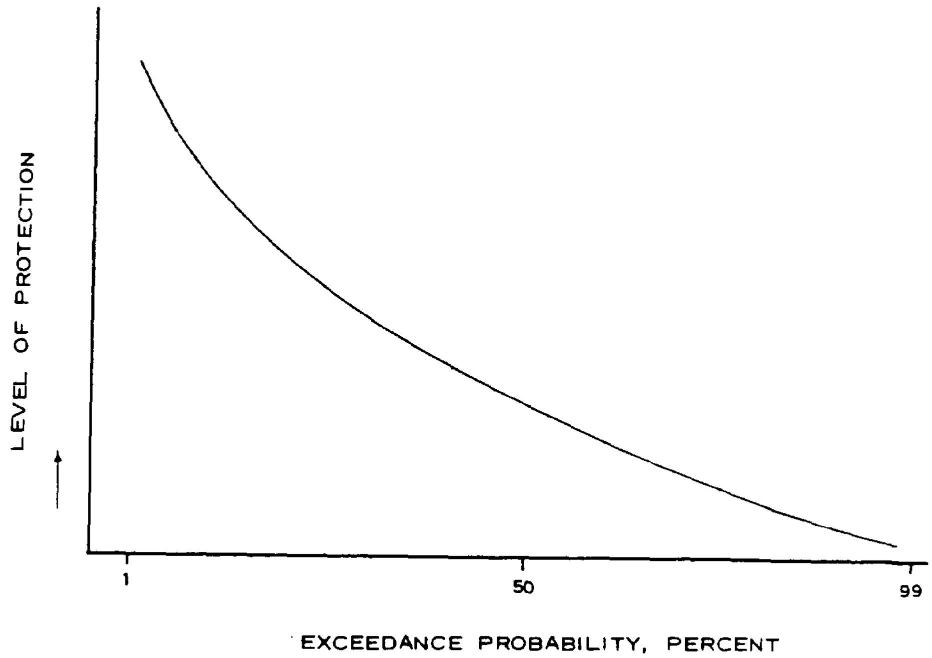

Figure 14-1. Probability versus protection level

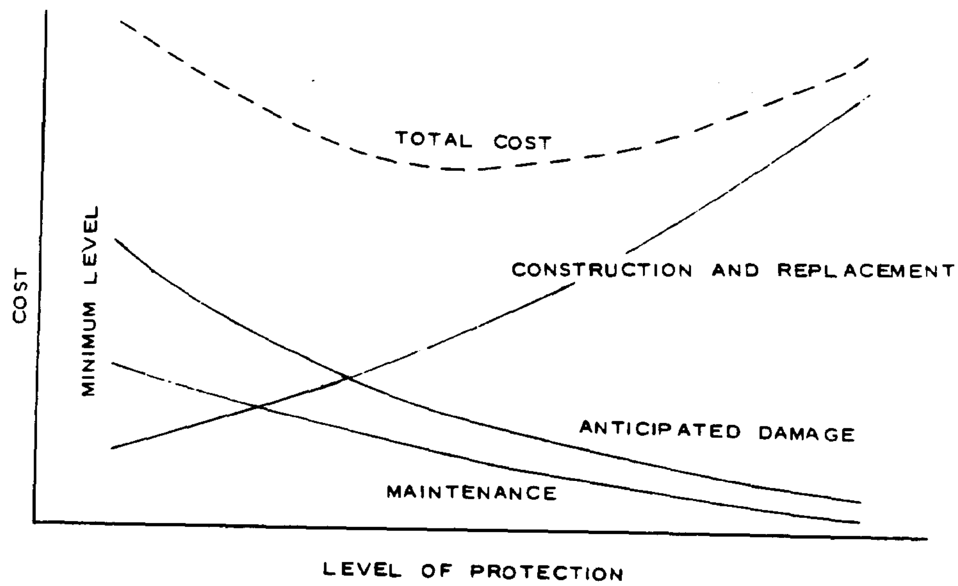

Figure 14-2. Project cost curves

14-5. Annual Damage. The expected annual damages are computed using standard methods. The anticipated annual damages can be computed by multiplying the expected annual damages by the annual exceedance probability for various levels of protection. This anticipated annual damage value is added to the amortized construction cost, annual maintenance cost, and present worth amortized replacement cost to obtain the total project cost. A series of these total project cost estimates for various levels of protection will provide a total cost curve as shown in figure 14-2. The optimum design is indicated by the lowest point on this curve.

14-6. Total Cost. The total cost curve may be fairly flat at the minimum point. If this occurs, it may be prudent to select a higher design level. A simplified life cycle cost analysis is presented in the following example problem.

Example Problem

Problem: Compare concrete side port filling lock with sheet-pile side flume filling lock.

Given:

a. 50-year project life.

b. 50-year life for concrete lock.

c. 25-year life for sheet-pile lock.

d. Lost benefits during replacement due to construction of adjacent lock $2,000,000/year for 4 years.

e. Sheet-pile filling time 20 minutes. Concrete lock filling time 8 minutes.

f. Average annual loss for slower filling is $1,500,000.

g. Interest rate 6 percent.

Find: Least annual cost lock using life cycle analysis.

Analysis:

Step 1. Estimate initial construction cost.

Step 2. Compute present worth of replacement (using initial construction as equivalent dollar value for replacement).

Step 3. Estimate lost benefits incurred during construction of replacement lock.

Step 4. Compute present worth of lost benefits.

Step 5. Total present worth cost and amortize for project life.

Step 6. Estimate annual maintenance cost including lost navigation benefits during downtime.

Step 7. Estimate lost benefits for slower filling time lock.

Answer: The concrete lock has the least annual cost.

The project cost computations are presented below.

<u>Concrete Lock</u>

Initial Cost	$60,000,000
Annual cost of construction (crf - 6 percent - 50 years)	3,806,400
Annual maintenance including lost benefits for downtime (50-year average)	50,000
Total Annual Cost	$ 3,856,400

Sheet-Pile Lock

Initial Cost	$25,000,000
Replacement after 25 years (in today's dollar value) = $25,000,000	
Present worth (pwf' - 6 percent - 25 years)	5,825,000
Present worth of loss during replacement construction ($8,000,000 - pwf' - 6 percent - 25 years)	1,864,000
Total Present Worth	$32,689,000
Annual Cost (cfs - 6 percent - 50 years)	$ 2,073,800
Annual Maintenance including lost benefits for downtime	500,000
Annual lost benefit for slower filling time	1,500,000
Total Annual Cost	$ 4,073,800

crf = Uniform annual series, capital recovery factor

pwf' = Single payment, present worth factor