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Economic analysis of a shopping center in seismic zone

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Abstract

Life cycle cost (LCC) is an important factor in economic analysis in order to cover all expected costs and benefits for an economic life. If a decision has to be made for investment purposes then damage cost incurred due to an earthquake should also be taken into account. Therefore, the total LCC of a structure in a seismic zone should be evaluated in terms of, not only its initial cost, expenditure and income but also earthquake damage cost. This paper provides an LCC analysis for economic evaluation of a shopping center located in a seismic zone. The effects of monthly income, recovery periods, initial cost, discount rate and occurrence time of an earthquake on total LCC are observed throughout the analysis period.

Keywords: Decision making; Life cycle cost analysis; Earthquake damage cost; Recovery cost; Investment projects

1. Introduction

Two earthquakes in Turkey in 1999 resulted in significant damage to houses, public facilities and infrastructure, and caused severe casualties. Most of the losses were caused by the collapse of structures because they were sited on liquefiable soil or along fault lines. Furthermore, most of them did not meet the design requirements of the code and did not include details that are earthquake resistant [1].

Earthquakes cause economic and social impacts in a society. However, this paper concerns only the economic aspect of earthquakes. The cost of damage caused by earthquakes to governments, businesses and families is very high. The money spent for the recovery from earthquakes is the money lost to economic development. USGS [2], EERI [3] and EQE [4] provide information about the impacts of earthquakes in the world. Table 1 shows economic impacts of some major damaging earthquakes in the last 20 years. Appropriate planning, design, and construction techniques can greatly reduce the cost due to earthquake. Siting of a structure is also important to minimize the effects of earthquakes. Governments, investors and individuals in seismic regions should be persuaded to deal more wisely with earthquake than they have done to date [5].

The decision to invest in measures that can protect property against possible damages from earthquakes is primarily an economic one. It should therefore be taken in the framework of the economic analysis, evaluating the costs and benefits of investing in mitigation. In selecting opportunities for earthquake mitigation, it is essential to remember that the most effective approach for reducing the long-term impact of earthquakes is to incorporate earthquake assessment and mitigation activities into the process of integrated development planning, into investment project formulation and implementation.

This paper presents a life cycle cost (LCC) approach for cost evaluation of a shopping center, which is constructed in a seismic zone for investment purposes so that it can be of assistance for decision makers.

2. LCC Analysis

LCC is a technique for economic evaluation, which accounts for all relevant costs during the investor's time

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Table 1
Economic impact of major earthquakes

Year	Location	Magnitude	Number of fatalities	Economic loss, US$ billion
2003	Bam, Iran	6.6	43,200	70
2003	Boumerdes, Algeria	6.8	2266	5
2001	Gujarat, India	7.7	20,023	5
2001	El Salvador	7.6	900	1
1999	Chi-Chi, Taiwan	7.7	2297	14
1999	Kocaeli, Turkey	7.4	19,118	20
1999	Colombia	6.2	1885	1.8
1999	Athens	5.9	143	4
1995	Kobe, Japan	6.9	5502	147
1994	Northridge, CA, USA	6.9	61	20
1993	Latur-Killari, India	6.2	9748	1.3
1990	Manjil, Iran	7.7	40,000	7.2
1989	Loma Prieta, CA, USA	7.0	63	6
1988	Spitak, Armenia	6.8	25,000	14.2
1987	Colombia, Ecuador	7.0	1000	1.5
1985	Michoacan, Mexico	8.0	9500	6

horizon and adjusting for the time value of money [6]. It should be noted that the concepts of LCC are not new. The principles are based upon economic theories, which have been used in investment appraisal in many areas of industrial and commercial activities. It should also be remembered that the technique is an aid to the decision-making process [7].

Arditi and Messiha [8] state that LCC analysis is a future-oriented methodology and there are many parameters used in the analysis such as future costs, future incomes, the analysis period, the useful life, the discount rate, the rate of inflation, agency cost (cost of construction, maintenance, rehabilitation, engineering and administration) and user cost (operation costs), hidden (cost due to detours, lost revenue to business, and lost tax dollars to government) and social cost (costs of controlling noise, vibration, and air pollution) in municipal organizations. The choice of the discount rate and the inflation rate have a major impact on the results of LCC analysis since a low rate favors long-term improvements with a large initial cost while a high rate favors short-term improvements. Knowing that the LCC analysis is not a deterministic method, the uncertainties involved in the parameters mentioned above can be eliminated by a sensitivity analysis, which helps decision makers to assess the effects of these parameters on the result. In recent years LCC has become a favored approach important in evaluating earthquake cost of facilities, as it comprises all the costs relevant to earthquake.

Investment decisions require economic analysis. In LCC all costs arising from an investment decision are of relevance. If the decision for investment purposes is on the construction of a structure in a seismic zone, possible earthquake damages should also be taken into account. The net benefit of a structure throughout its life cycle is therefore determined by the benefits (revenues) derived from its use, its construction cost, its operation cost and damage cost due to earthquake. So, the total cost of a structure in a seismic zone can be investigated at three levels:

- pre-earthquake cost,
- earthquake cost,
- post-earthquake cost.

2.1. Pre-earthquake cost

Pre-earthquake cost of a structure for investment is incurred regardless of the occurrence of an earthquake and consists of the initial cost, monthly expenditures and monthly income.

There are many parameters such as quality, size, resistance against earthquakes, soil conditions, and location, which affect the initial cost of a structure. The initial cost covers not only the construction cost but also costs of land on which a structure is to be constructed.

Monthly expenditure considers all the maintenance and operation costs, taxes, wages, etc. The total LCC includes not only the costs but also benefits, which refers to rent or income obtained from the building. The occurrence of an earthquake, depending on its magnitude and the resistance of the existing structures, will cause an economic loss and this will directly affect the total income.

2.2. Earthquake cost

The occurrence of an earthquake causes direct and indirect losses. Besides the physical damage, temporary business interruption causes economic loss. Depending on the size of the earthquake this loss may be heavy for a structure. In the event of a major earthquake, the focus of the first 24–48 h is exclusively on emergency response and relief: controlling fires, rescuing victims, providing medical assistance, and securing food and shelter for displaced victims. Earthquake cost can be referred to the costs caused by an earthquake such as emergency relief expenses, structural damage cost and business interruption cost. Ergonul [9] investigates earthquake cost of a town in a seismic zone under three headings: supply cost (health & temporary hospitals, emergency aids like food and temporary accommodation), physical damage cost and economic loss. In this study, the supply cost is not included in earthquake cost