Seismic Rehabilitation Grant Program Applications

What is Benefit-Cost Analysis?

Basic Concepts

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Benefit-cost analysis compares the costs of a seismic retrofit with the benefits of the retrofit. Retrofits that have benefit cost ratios greater than 1.0 are deemed cost effective—that is, economically justified. For the SRGP, a retrofit may be funded even with a benefit-cost ratio is less than 1.0, although the probability is likely lower than for retrofits with higher benefit-cost ratios.

Benefit-cost analysis is inherently probabilistic. The probabilities of future earthquakes with various levels of ground shaking at a given location is relatively well known from the United States Geological Survey's national seismic hazard mapping. However, when future earthquakes happen cannot be known in advance.

The level of earthquake hazard in Oregon varies markedly with location, depending on the USGS earthquake data, **and** on the Site Class at a given location.

Benefit-cost analysis of seismic retrofits estimates the average annual damages, economic losses and monetized statistical casualties by considering the full range of earthquake ground shaking levels and integrating the damage-probability relationship for two states of a building: the existing building and the building after seismic retrofit. The average annual benefits are the reduction in average annual damages achieved by the seismic retrofit.

The term "average annual damages" does **not** mean that such damages happen every year. Rather "average annual damages" is an estimate of the **average damages per year** over a long time period, such as 50 or 100 years. In most years there will be no earthquake damages. However, periodically, a given building will suffer varying levels of damage depending on the intensity of ground shaking in each future earthquake at the building's location.

The net present value of the reduction in average annual damages is then calculated statistically by taking into account the expected useful lifetime of a building (generally assumed to be 50 years) and a "discount rate" that takes into account the time value of money. That is, benefits that accrue 10 or 20 or 30 years in the future have lower present value than benefits that occur next year or five years from now.

The benefit-cost ratio calculated is the net present value of the reduction in average annual damages, losses, and casualties divided by the cost of the retrofit.

There are several key factors that govern the benefit-cost ratio for a given retrofit, including:

- The level of seismic hazard at a given location,
- The vulnerability (or fragility) of the building to earthquake damage,
- The cost of the seismic retrofit, and
- Several economic factors for the building:
  - Building replacement value,
  - Historical importance,
  - Contents replacement value,
  - Occupancy, and
  - Annual operating budget (a proxy for the value of services)

Given two identical buildings with identical parameters as listed above—except for location—the building in a higher seismic hazard location will always have a higher benefit-cost ratio. Thus, buildings in higher seismic hazard areas are more likely to have high benefit-costs ratios.

However, a building in a high seismic location may have a relatively low benefit-cost ratio, especially if:

- The building has relatively minor seismic vulnerabilities, and/or
- The retrofit cost per square foot is very high, and/or
- The building and contents replacement values and contents are high, and/or
- The occupancy is very low.

Conversely, a building in a relatively low seismic location may have a relatively high benefit-cost ratio, especially if:

- The building has profound seismic vulnerabilities with a high likelihood of collapse at a relatively low level of ground shaking, and/or
- The retrofit cost per square foot is relatively low, and/or
- The building and contents replacement values are high, and/or
- The occupancy is very high.