

Seismic Benefit Cost Analysis

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Hazard Mitigation Branch**

Governor's Office of Emergency Services

Overview of BCA

Generally required for all FEMA mitigation programs:

- **HMGP (404) and PA (406)**
- **FMA**
- **PDM**

Overview for BCA

The Law:

- **The Stafford Act requires that the President determine if projects are cost-effective.**
- **Federal Code of Regulations, Title 44 requires costs and benefits be computed on a net present value basis.**

OMB Instructions (A-94)

- **Count Net Social Benefits, not benefits to the Federal government**
- **Avoid multiplier effects or changes in regional economic output**
- **Cannot count tourism or costs of crime (looting)**

FEMA Policy PDM

- **Alternate Benefit-Cost Analysis methodologies must be approved before project submittal.**

Role of BCA

- **Determines whether a proposed mitigation project is eligible (BCR >1.0).**
- **Can be used to rank projects by the State or FEMA**

Role of BCA (continued)

- **A way to understand and use complex information to make decisions.**
- **Can be used to determine the best project among a range of alternatives**
- **Can be used to determine if a project is worth doing before a grant request is submitted.**

Role of BCA (continued)

- **Federal agencies are interested in the return on the investment for mitigation projects.**

BCA Basics

- **Every BCA needs to be credible and defensible.**
- **If estimates and techniques are not based on sound judgment, it will be difficult to defend an analysis.**

BCA Basics (continued)

BCA is conceptually pretty simple:

- **It's a comparison of *before* mitigation conditions to the *after* mitigation conditions.**
- **If damages are reduced after mitigation is implemented, then there are benefits to count.**

BCA Basics (continued)

- If the *benefits are greater than costs*, the project is cost-effective.
- Some things are more cost-effective than others.
- The benefit-cost ratio (BCR) is used to compare cost-effectiveness.

BCA Basics (continued)

- ***Benefits are more difficult to determine than costs.***
- ***Benefits happen in the future and must be calculated probabilistically (statistically).***
- ***Project costs are easier to determine because they occur up front and are determined by cost estimates for each project.***

BCA Methodologies

Best Data Analysis

- **An analysis that accurately and fully counts all of the significant benefits and costs of a project.**
- **Best data analysis is the ideal BCA.**

BCA Methodologies (continued)

Limited Data Analysis

- Can be used as screening tool**
- Cannot be submitted with application**

Frequency

- **Frequency refers to how often a particular event occurs (e.g., if you get paid every two weeks, the frequency of the checks is bi-weekly).**
- **All recurrent events can be assigned a frequency.**

Frequency (continued)

It's not possible to perform a BCA without a frequency or the probability of the hazard event.

The Concept of Risk

EQ Hazard and Risk

**EQ
HAZARD
(FREQUENCY
& SEVERITY)**

**Probability
of Damaging
EQ**

X

**PROPERTY
EXPOSED
TO EQ**

**Value and
Vulnerability
of Property
Exposed
to EQ Hazard**

=

**EQ
RISK
(DOLLARS)**

**Severity
of Threat
to the Built
Environment**

The Concept of Risk

- “*Value*” means that future damages are always expressed in terms of money.
- Risk is a simple term for the *monetary value of future damages*. Future damages are directly related to frequency of events.
- *Risk* is the single most important concept in mitigation planning and BCAs.

RISK Is Always The Key To Benefits (continued)

**When hazard events are infrequent or
minor:**

- **Damages and losses are low**
- **Low benefits**
- **BCRs are rarely > 1.0**

RISK Is Always The Key To Benefits (continued)

GOOD Mitigation Projects (high BCRs)

- Address high risk situations
- Are effective in reducing damages and losses

Cost-Effectiveness

Depends on:

- **The reduction of future risk**
- **Cost of project (including maintenance)**

Benefits

- **A benefit is an *avoided loss*.**
- **When a good mitigation project is implemented, damages that would have happened in the future are reduced or eliminated because of the project .**

Benefits

Benefit Categories:

- **Direct damages to structures, contents, and infrastructure**
- **Avoided deaths and injuries**
- **Avoided loss of function economic impacts**

Benefits – Loss of Function

- Usually the *largest single benefit* of projects that protect non-residential structures and infrastructure.
- *Least often counted benefit* by analysts.

Benefits – Loss of Function

- Occurs when a government facility, a road, a utility, or a business is interrupted by a natural hazard event.
- There is guidance in “*What is a Benefit?*” on counting these benefits.

Benefits - Avoided Casualties

- For earthquakes, deaths and injuries are a primary impact of disasters
- FEMA uses statistical values of \$3,000,000 million million per person for deaths, \$15,600 for major injuries, and \$1,565 for minor injuries.

Project Costs

Items to consider:

- **Costs appropriate for the project**
- **Costs in present-day dollars**
- **Costs are well documented and from a credible source**

Project Costs

- **Construction costs are considered to be in the current year and no present value calculation is made**
- **Maintenance costs are computed on a present value basis and added to construction costs**
- **Anticipated Environmental costs**

Level One vs. Level Two BCAs

- **Level One Analysis uses either the default or standard data available in the full data module.**
- **Level Two Analysis uses data by the user that overrides the default or standard data in the full data module.**

BCA Documentation

- *Documentation is essential.*
- **Poorly documented projects may be eliminated from consideration.**
- **It is important to track, write down, and include in the application:**
 - **Data sources**
 - **Dates**
 - **Assumptions**
 - **Analysis procedures**

BCA Documentation

- Use data from *credible and reliable* sources (Federal, state, local agencies).
- Provide *complete technical support data*
- Explain and *provide justification* for any level two data or data that exceeds the FEMA defaults

BCA Documentation

- ***Organize the data via a list of attachments.***
- ***Cite the location of BCA relevant data within the support data (i.e., report name, page no., etc.)***
- ***Use the Seismic Data Documentation Template***

BCA Documentation

The test of good documentation

Someone other than the original BCA analyst can easily verify and re-create the data inputs and conclusions of the BCA.

Benefits in Seismic Module

- **Physical damages (buildings, contents, infrastructure)**
- **Casualties (deaths and injuries)**
- **Economic impacts (displacement, services, business and rental income)**

Sample BCA

- Using the frequency-damage method

Damages *Before* Mitigation

PGA (% of G)	Annual Probability	Scenario Damages and Losses	Expected Annual Damages and Losses
4-8	.033	\$0	\$0
8-16	.01	\$140,000	\$1,400
16-32	.0001	\$500,000	\$50
32-55	.00004	\$1,000,000	\$40
55-80	.0000006	\$5,000,000	\$3
80-100	.000000008	\$10,000,000	\$.08
Total Annual Losses			\$1493.08
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Damages *After* Mitigation

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32-55	.00004	\$ 0	\$ 0
55-80	.0000006	\$5,000,000	\$3
80-100	.000000008	\$10,000,000	\$.08
Total Annual Losses			\$3.08

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BCA Model

PGA	Expected Annual Damages <i>Before</i> Mitigation	Expected Annual Damages <i>After</i> Mitigation	Expected Annual Avoided Damages and Losses
4-8	\$0	\$ 0	\$0
8-16	\$1,400	\$ 0	\$1,400
16-32	\$50	\$ 0	\$50
32-55	\$40	\$ 0	\$40
55-80	\$3	\$3	\$0
80-100	\$.08	\$.08	\$0
Totals	\$1493.08	\$3.08	\$1,490
PVC (7% Discount Rate, 30 years)			12.41
Present Value of Future Benefits			\$18,490

BCA Results

Expected Annual Benefits		Present Value Coefficient (30 year)	Net present Value of Future Benefits	Costs	Benefit-Cost Ratio (BCR)
1490	X	12.41	=\$18,490	\$18,490	1.0

EQ Full Data Module

- **Pink cells are informational**
- **Green are data entry**
- **Yellow are calculated**

Discount Rate

- Represents the time value of money
- A real discount rate does not include inflation. This value is established by OMB A-94 at 7%
- The discount factor for a uniform series of benefits or costs over the life of a project is $\frac{(1+i)^n - 1}{i(1+i)^n}$ where $i=.07$ and n =project life

Building Type

- **16 building types**
- **Building damage functions are in the form of lognormal fragility curves that relate to the probability of exceeding a building damage state for a given PGA.**

Seismic Design Level

- **Differential between before and after mitigation should not exceed more than one step without documentation.**
- **URM buildings cannot be retrofitted above moderate code.**

Building Data

Building Replacement Value using Marshall and Swift

- Calculator Method
- Segregated Method

Building Data

Building Damages that would result in demolition

- **FEMA default is 50%**
- **Unreinforced masonry might be 30%**
- **Historic structures might be 90%**

Building Contents

- **Use 30% of replacement value as a default.**
- **Use a comprehensive equipment list if the contents exceeds 30%.**
 - **hospitals**
 - **museums**

Displacement Cost

- **Temporary building space**
- **Other displacement costs (utilities, equipment rentals)**
- **One time costs (move, build out, storage)**

Building Occupancy

- **A snap shot in time.**
- **High occupancy will result in a high BCR.**
- **Must be reasonable**

Value of Services

- **Annual Budget of Public / Nonprofit Agencies for the that would be impacted by the functional loss of the building.**
- **If rent is not included the module will provide a proxy rent.**

Value of Services

- **Post-disaster continuity premium is added only for police, fire and medical services critical to emergency response.**
- **Functional down time should be reduced if using a post-disaster continuity premium.**

Rental and Business Income

- For commercial business

Mitigation Project Data

- **Project description.**
- **Project costs inflation adjusted.**
- **Maintenance costs if applicable.**
- **Relocation costs during construction.**

Seismic Hazard

- **USGS hazard data by zip code gives probability of PGA at different levels.**
- **Soil selection must be based on geotechnical data.**
- **High seismic zones will not benefit from soft soils.**

Level Two Data

- **Seismic Damage Functions can be modified by a structural engineer due to specific performance criteria.**

Conclusion

- **The Full Data Module can provide a quick BCA if default values are used.**
- **Or can be used to generate a more detailed BCA by using Level Two Data.**
- **Credible sources and detailed documentation are essential for all data entered into the models.**
- **OES recommends using FEMA's data documentation template available on the BCA toolkit.**

Technical Assistance

OES Helpline 916-845-8150

FEMA Helpline 1-866-222-3580

bchelpline@dhs.gov

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