UJNR 4th Meeting

November 6-8, 2002

at Metropolitan Morioka New Wing, Morioka, Japan

Seismic Risk Management of a Structure Fully Utilizing Recent Seismological Knowledge

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Armen DER KIUREGHIAN: UC Berkeley, USA

Alfredo H-S. ANG: UC Irvine, USA

Topics

1.

2.

3.

4.

5.

Topics

1. Seismic risk management

2.

3.

4.

5.

Topics

1. Seismic risk management
2. Formulation of life-cycle cost
3.
4.
5.

Topics

1. Seismic risk management
2. Formulation of life-cycle cost
3. Application to a building in Tokyo
4.
5.

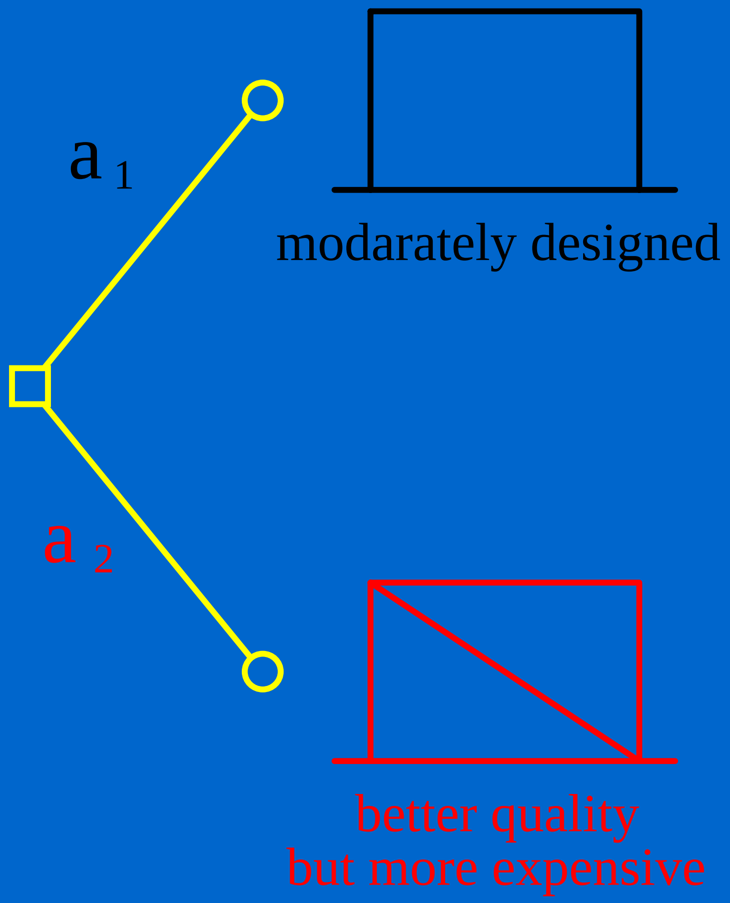
Topics

1. Seismic risk management
2. Formulation of life-cycle cost
3. Application to a building in Tokyo
4. Conclusions
5.

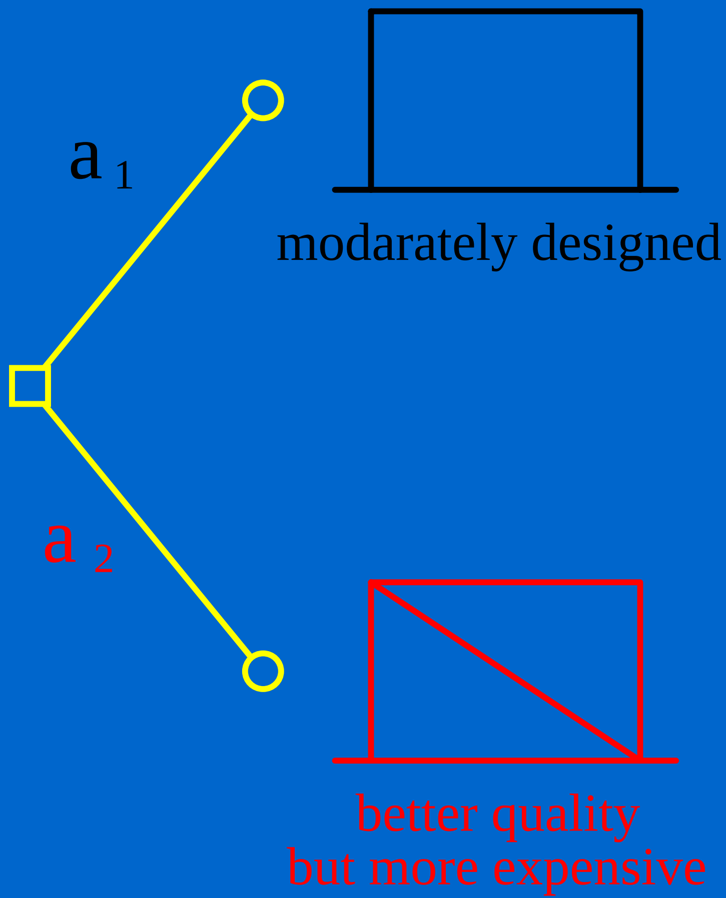
Topics

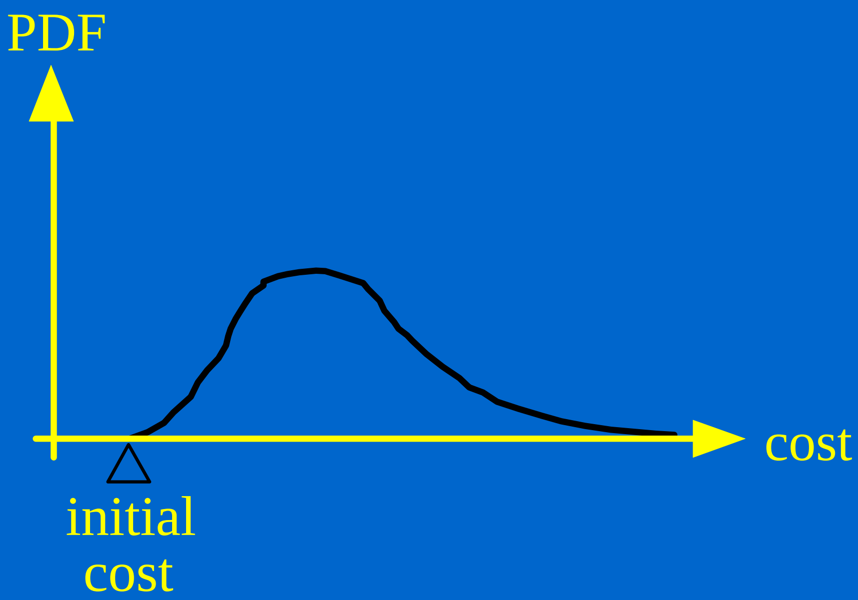
1. Seismic risk management
2. Formulation of life-cycle cost
3. Application to a building in Tokyo
4. Conclusions
5. Current study

Seismic risk management

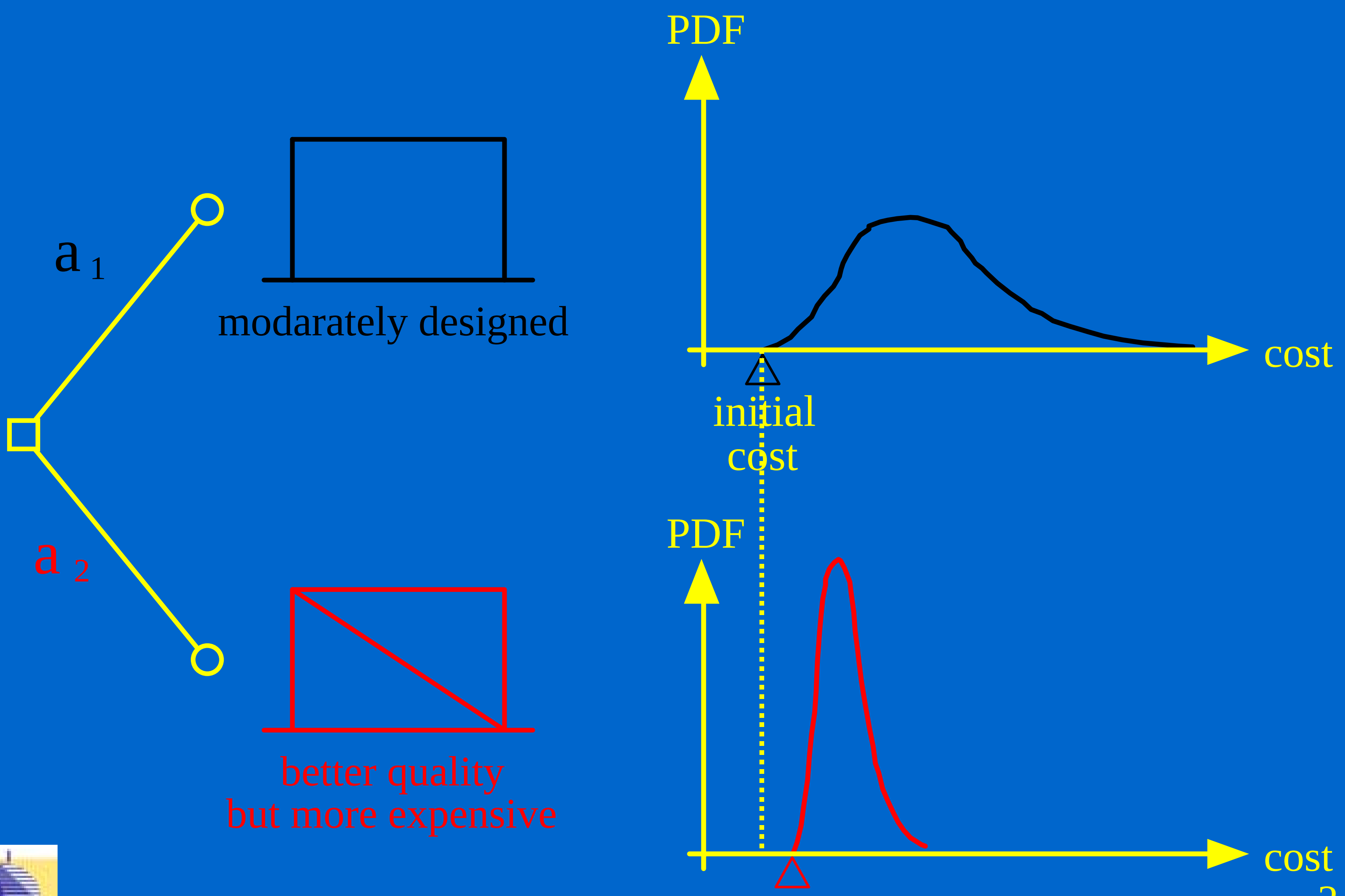


Seismic risk management

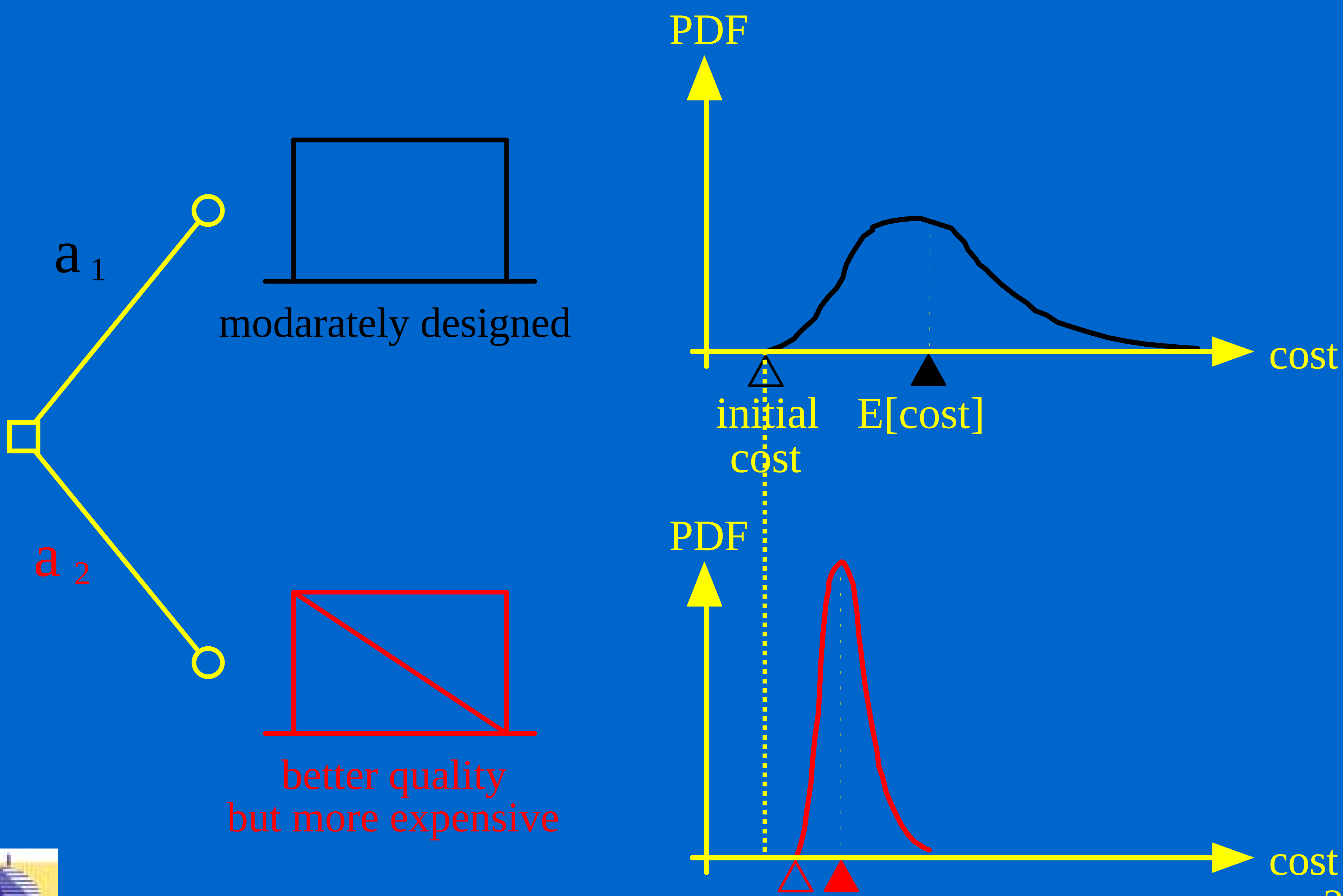




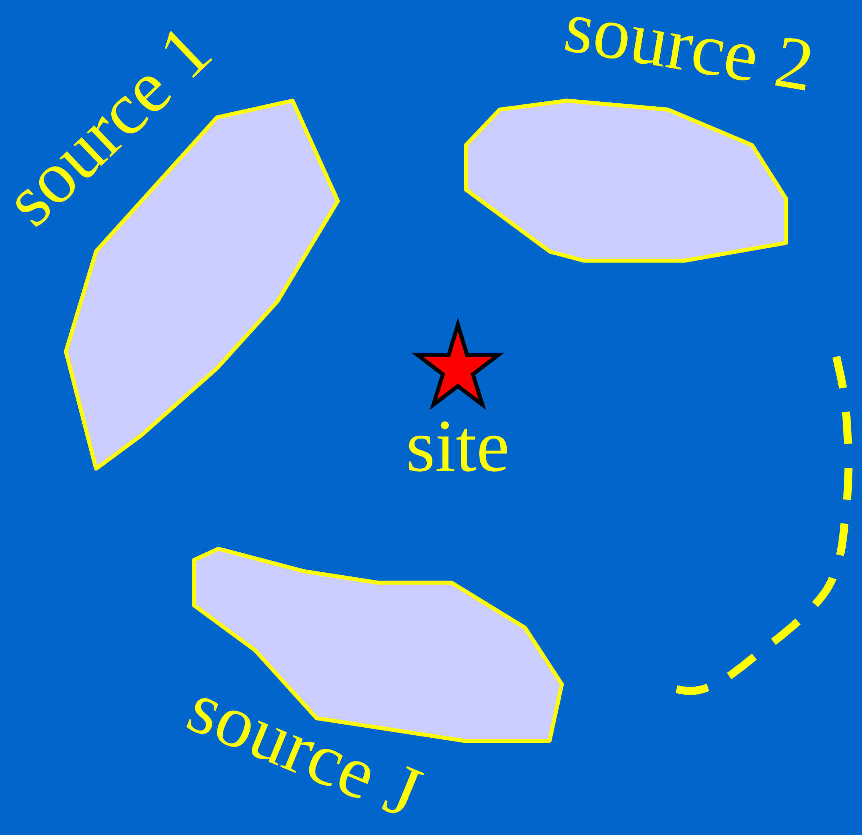
Seismic risk management



Seismic risk management



Formulation of expected life-cycle cost



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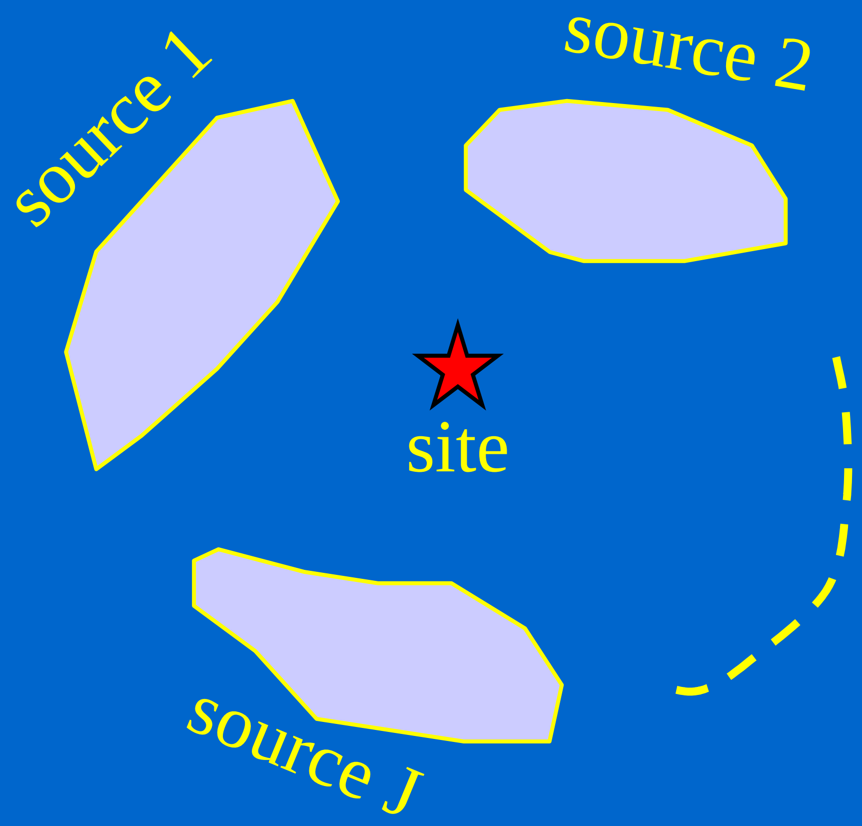
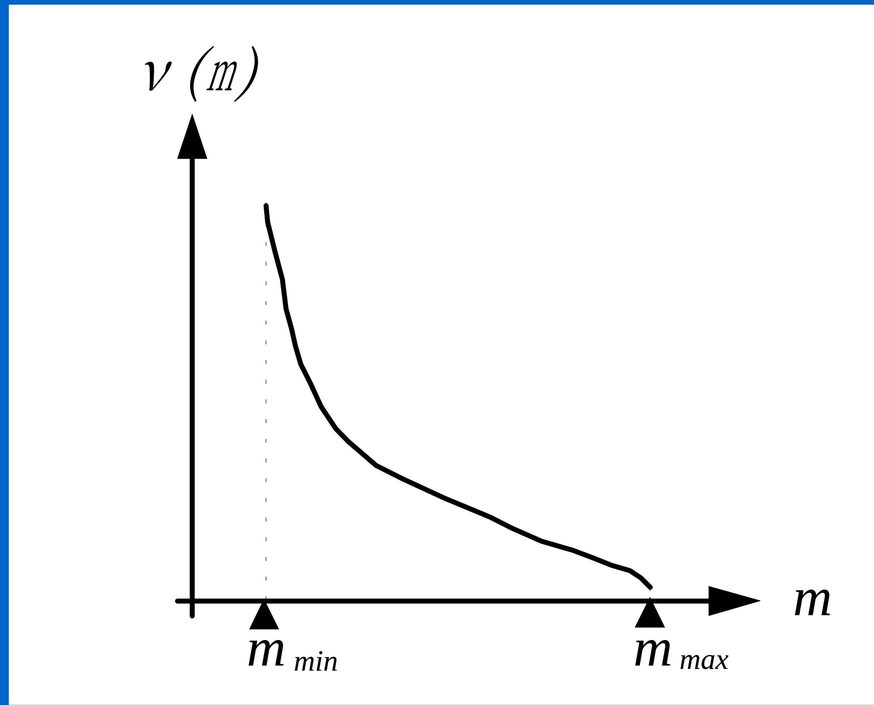
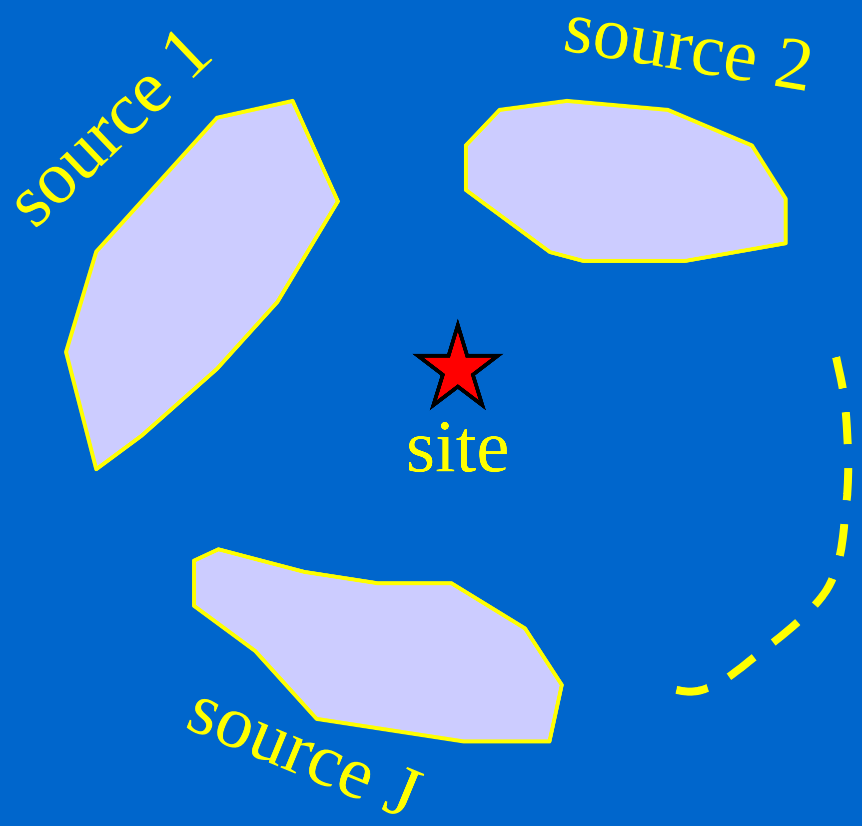
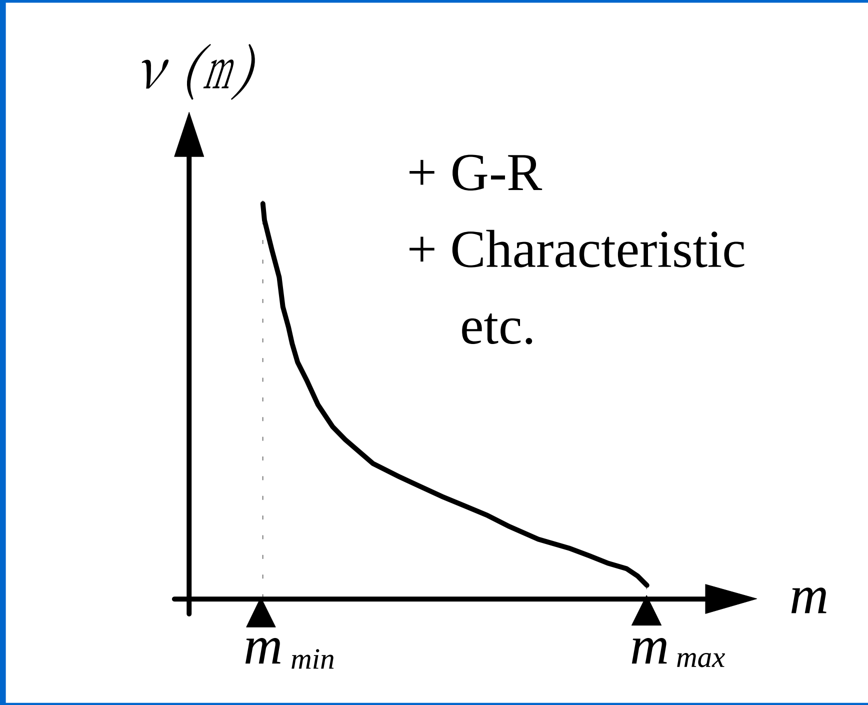




magnitude – annual rate

Formulation of expected life-cycle cost





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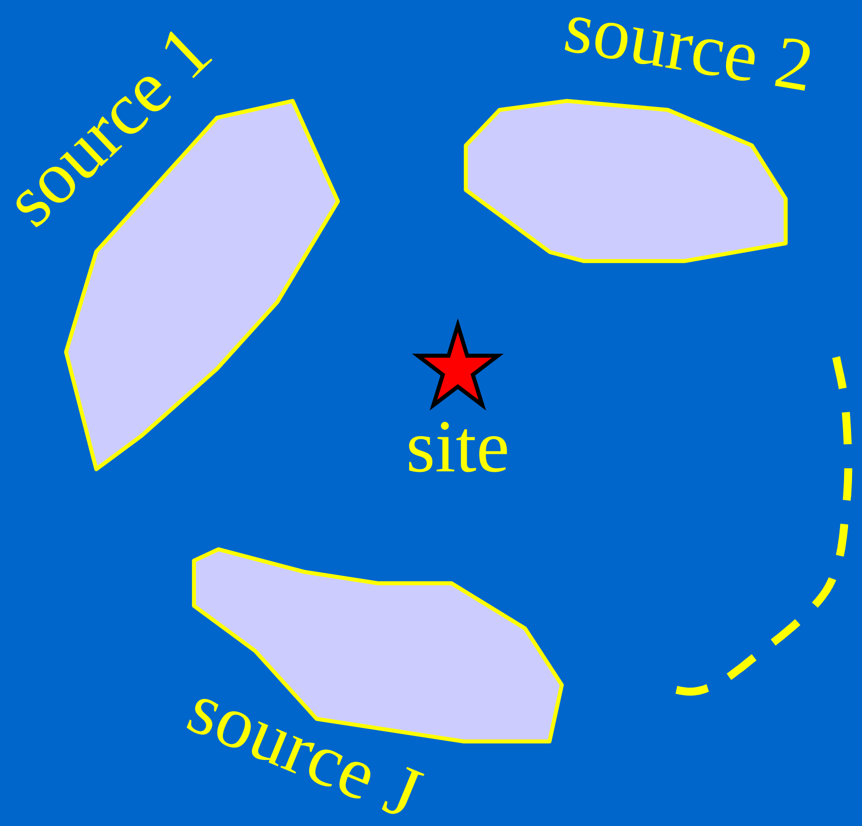

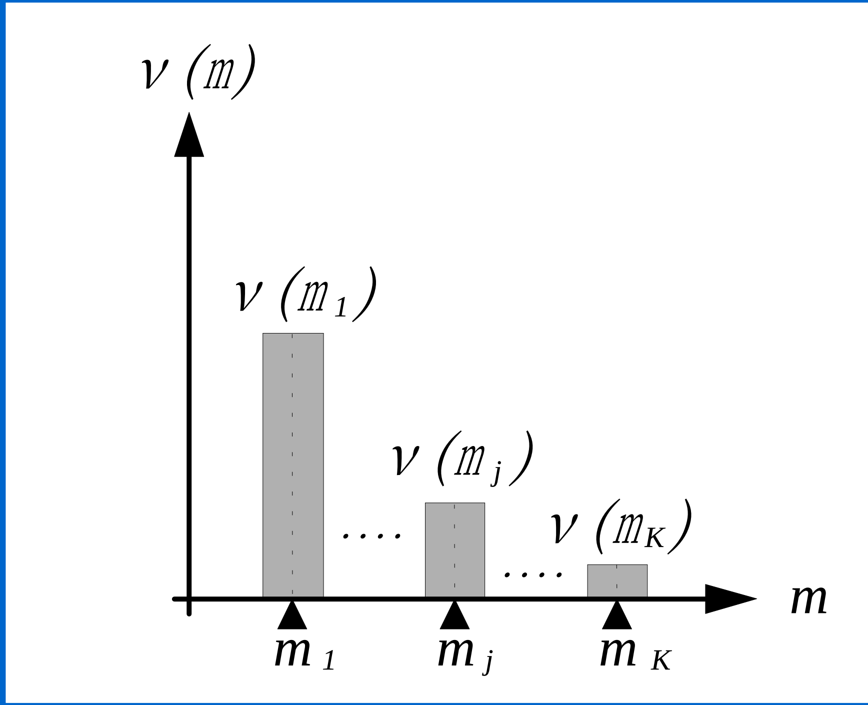

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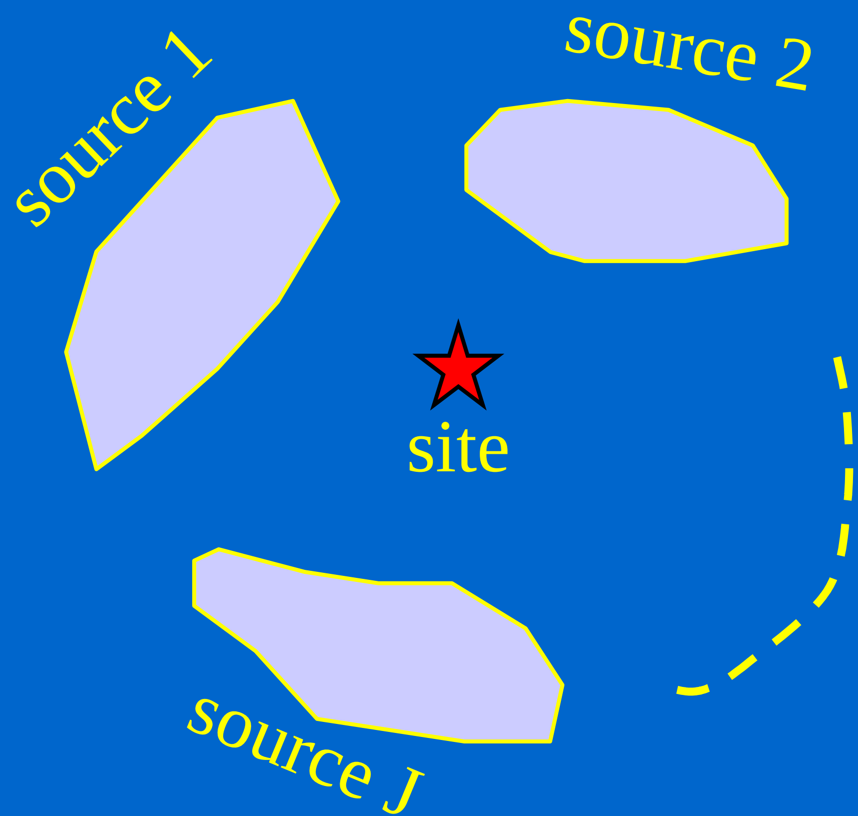
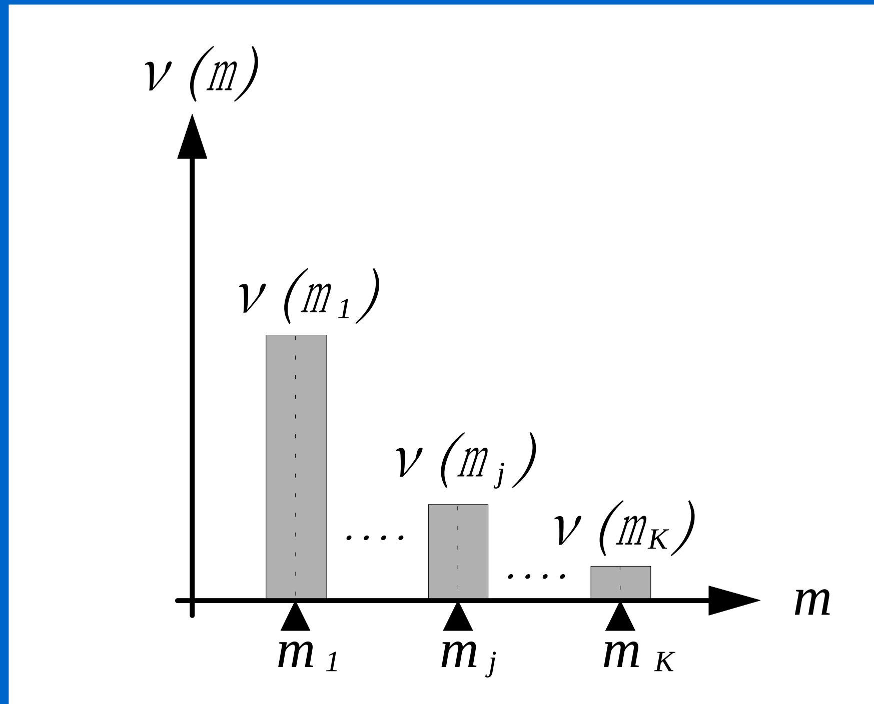
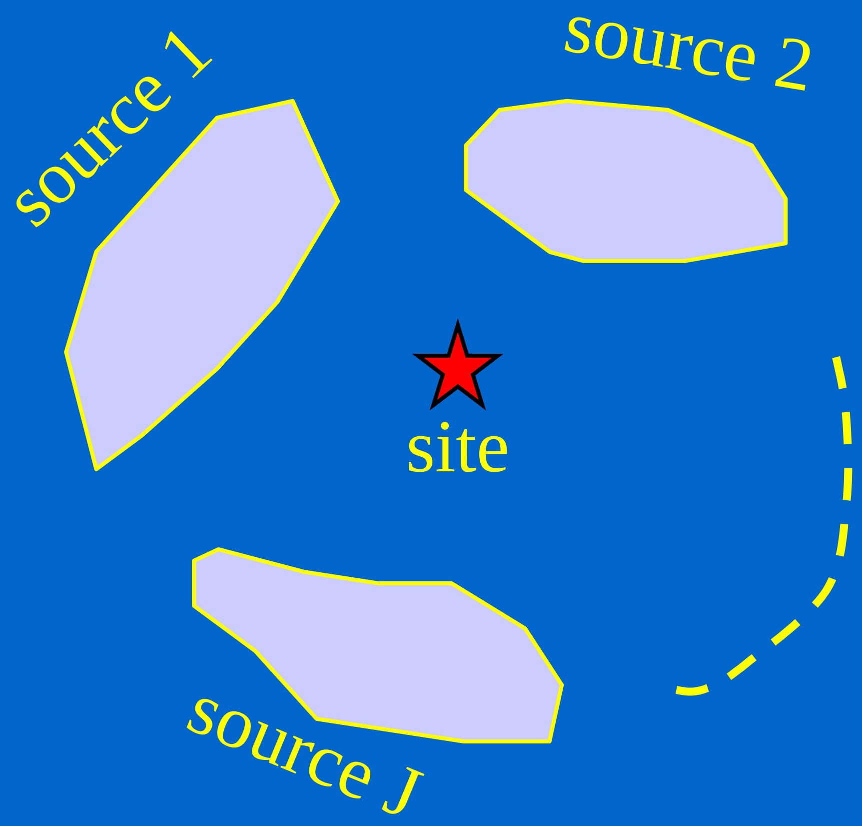


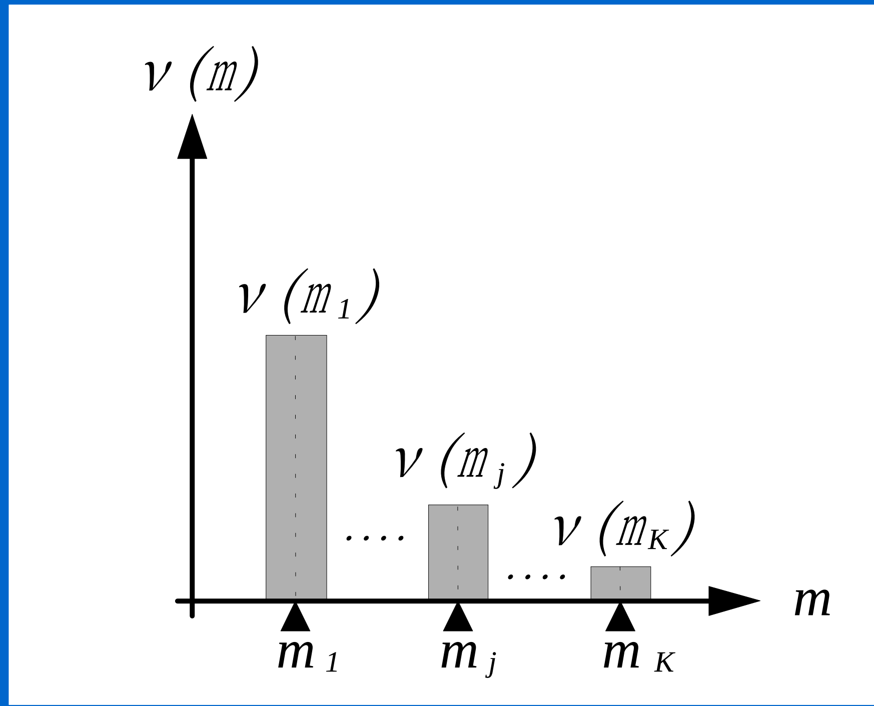


magnitude – annual rate

$$E\left[C_L\right] = \qquad E\left[C_D(m_j)\right]$$

Formulation of expected life-cycle cost





magnitude – annual rate

$$E\left[C_L\right] = \qquad \nu(m_j)\cdot E\left[C_D(m_j)\right]$$

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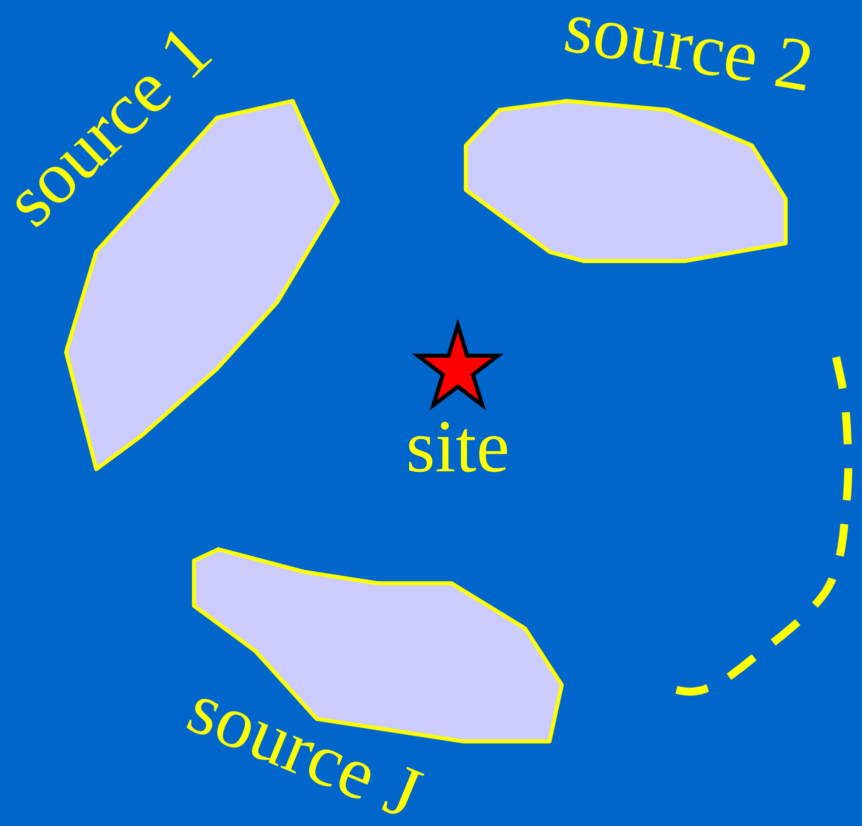
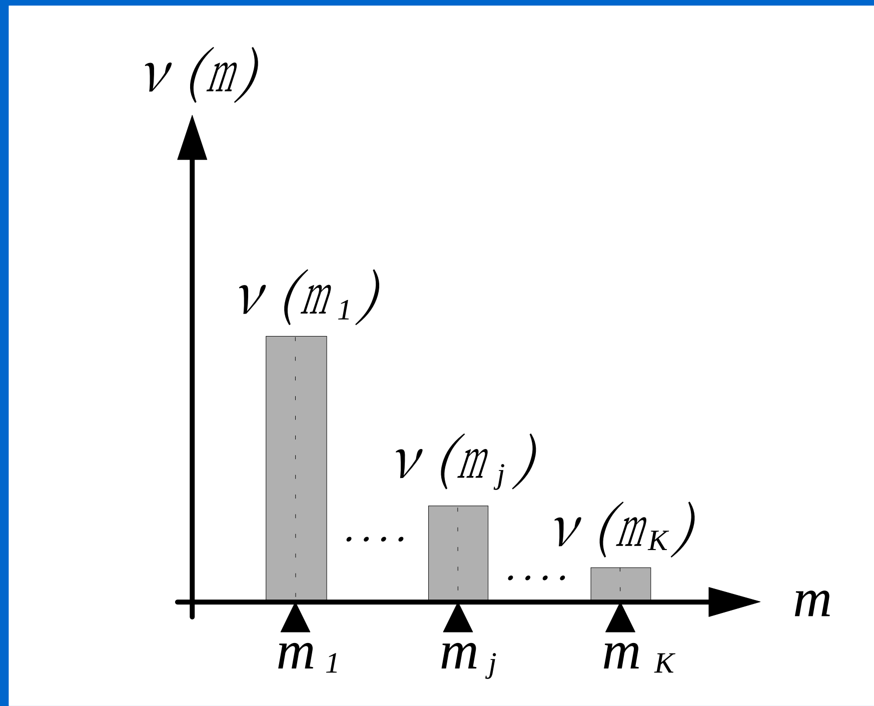
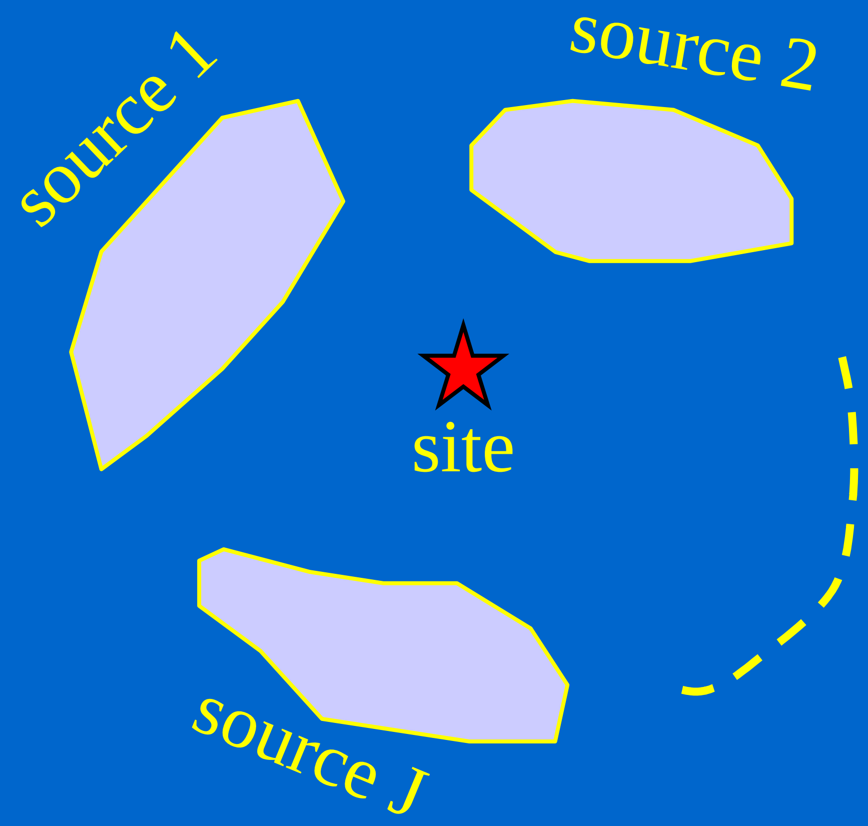


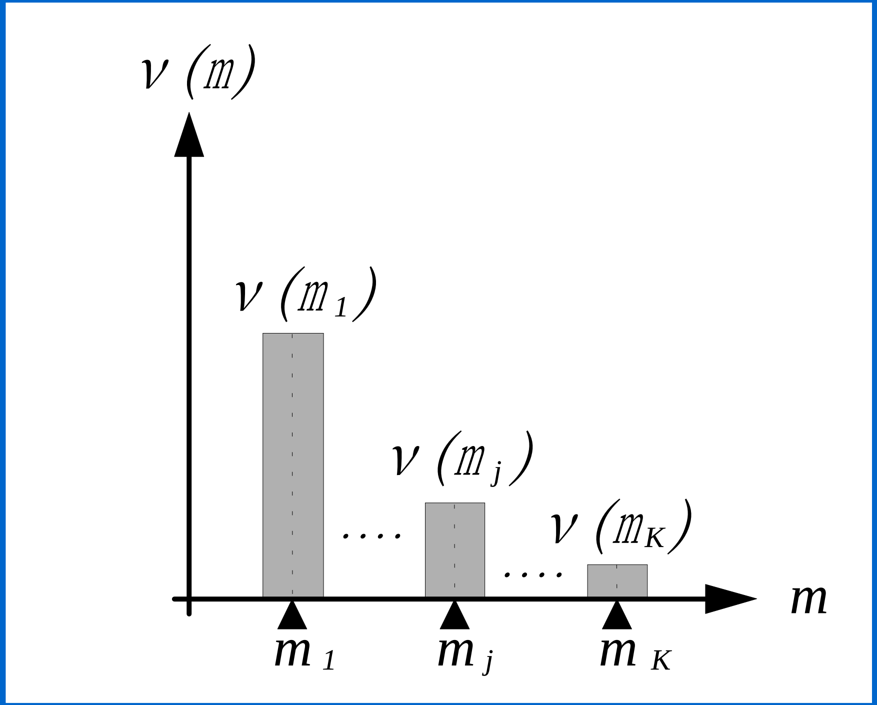


magnitude – annual rate

$$E\left[C_L\right] = \sum_{j=1}^{K} \nu(m_j)\cdot E\left[C_D(m_j)\right]$$

Formulation of expected life-cycle cost

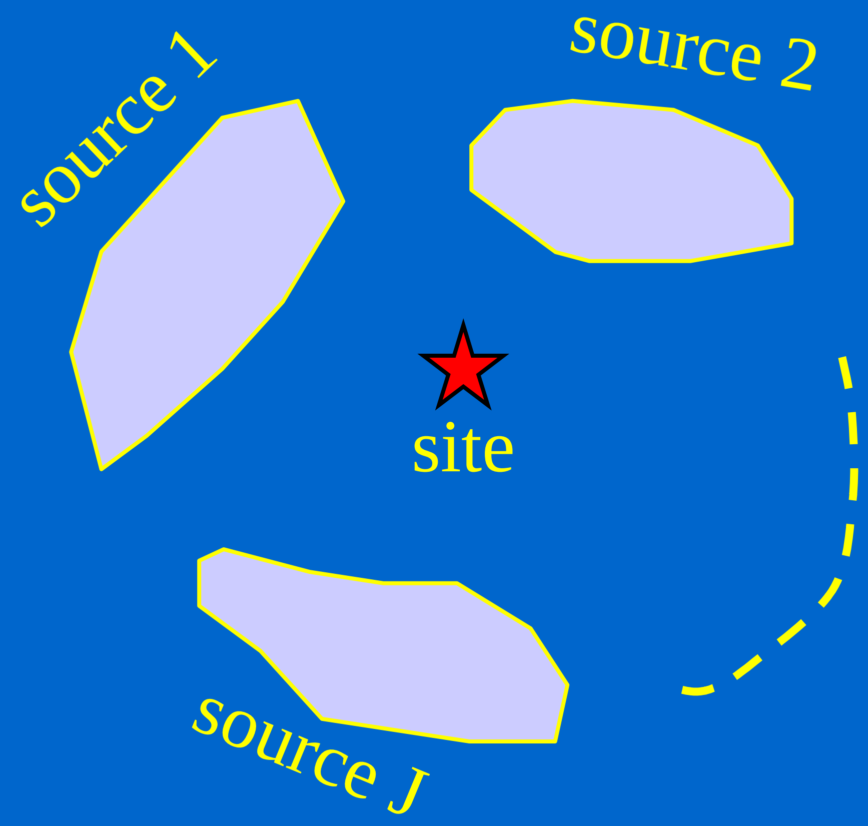


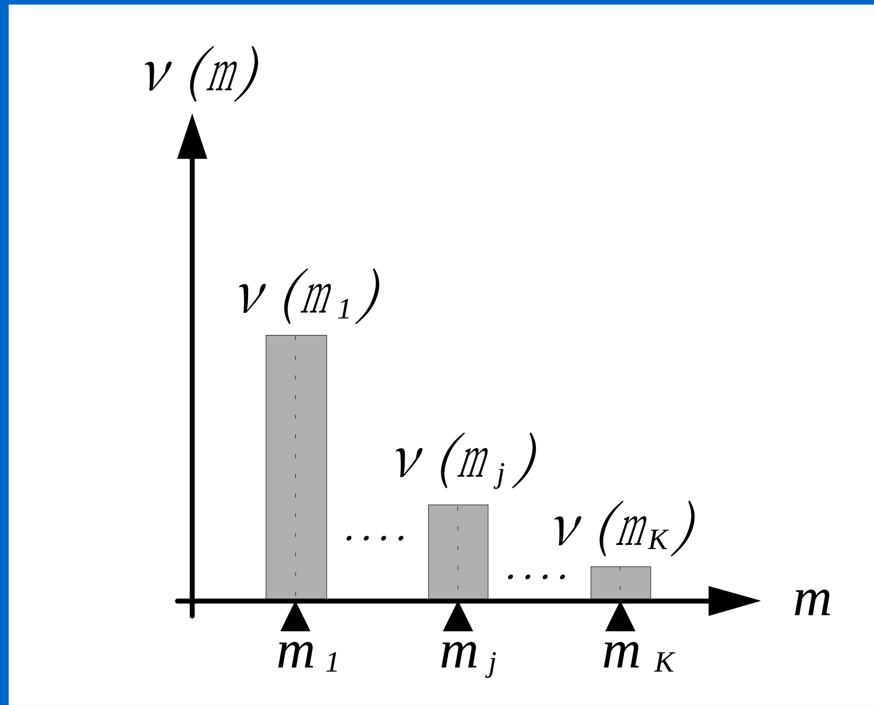


magnitude – annual rate

$$E[C_L] = \sum_{\text{all sources}} \sum_{j=1}^{K} \nu(m_j) \cdot E[C_D(m_j)]$$

Formulation of expected life-cycle cost

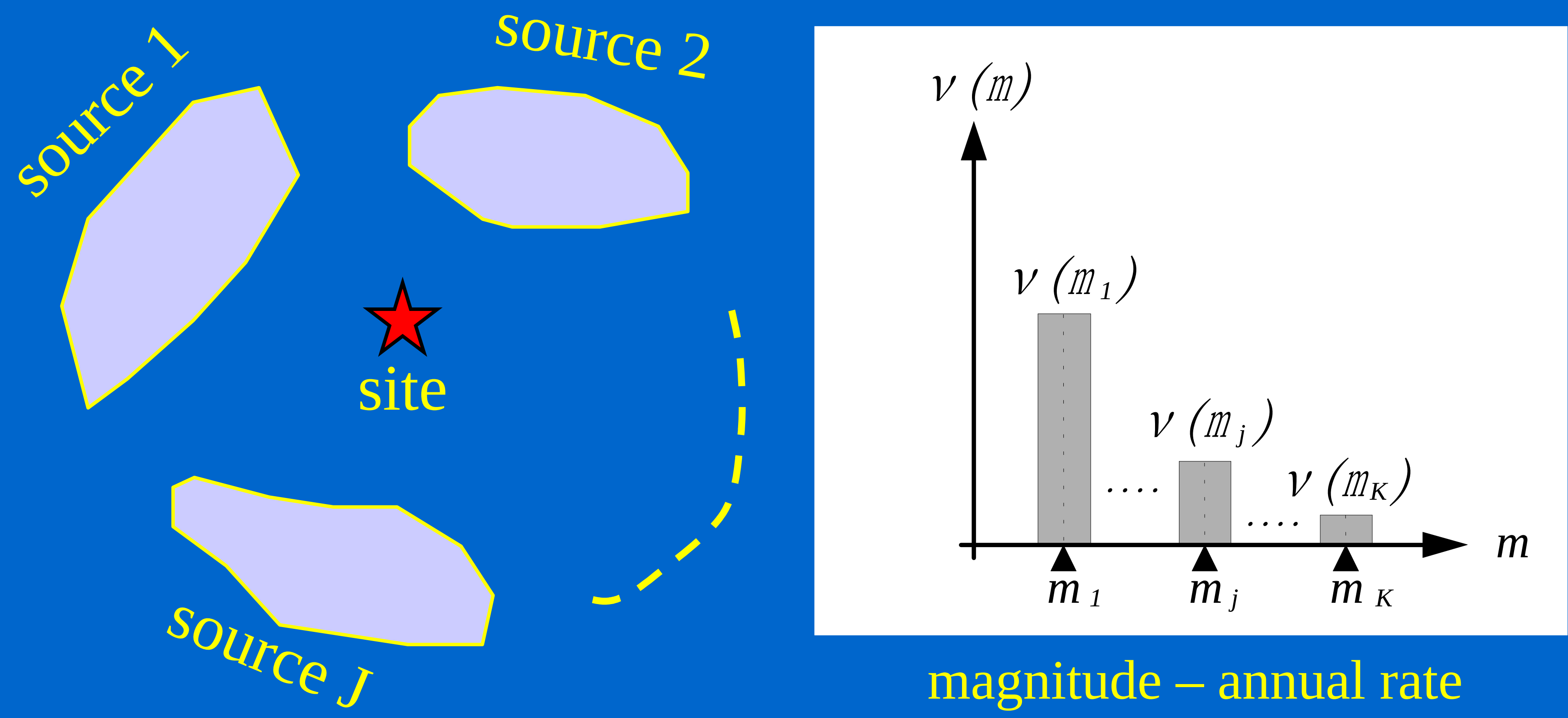




magnitude – annual rate

$$E\left[C_L\right] = \Delta T \times \sum_{\textit{all sources}} \sum_{j=1}^{K} \nu(m_j)\cdot E\left[C_D(m_j)\right]$$

Formulation of expected life-cycle cost



$$E\left[C_L\right] = C_I + \Delta T \times \sum_{all\ sources} \sum_{j=1}^{K} \nu(m_j) \cdot E\left[C_D(m_j)\right]$$

Expected damage cost

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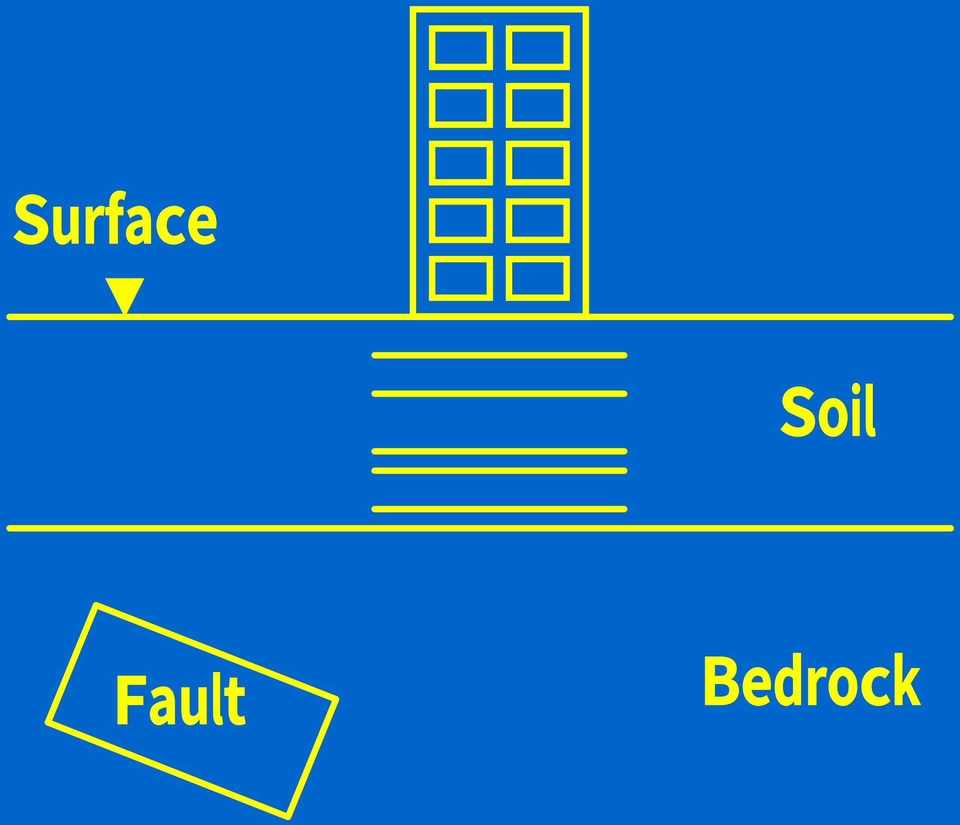

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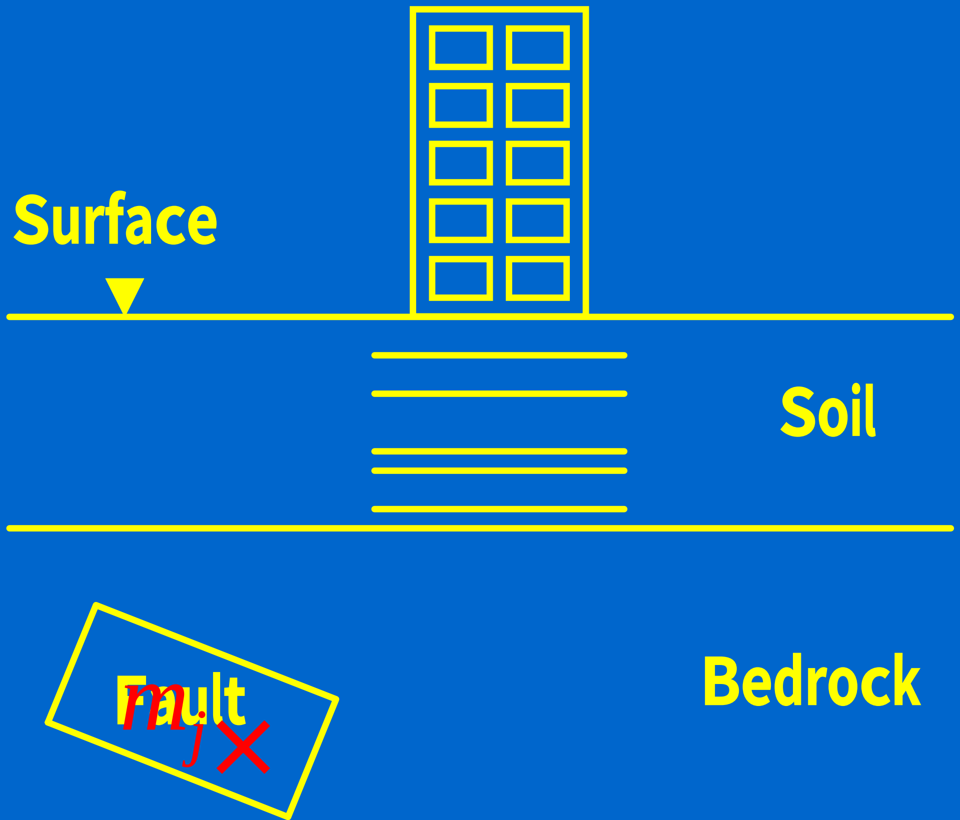

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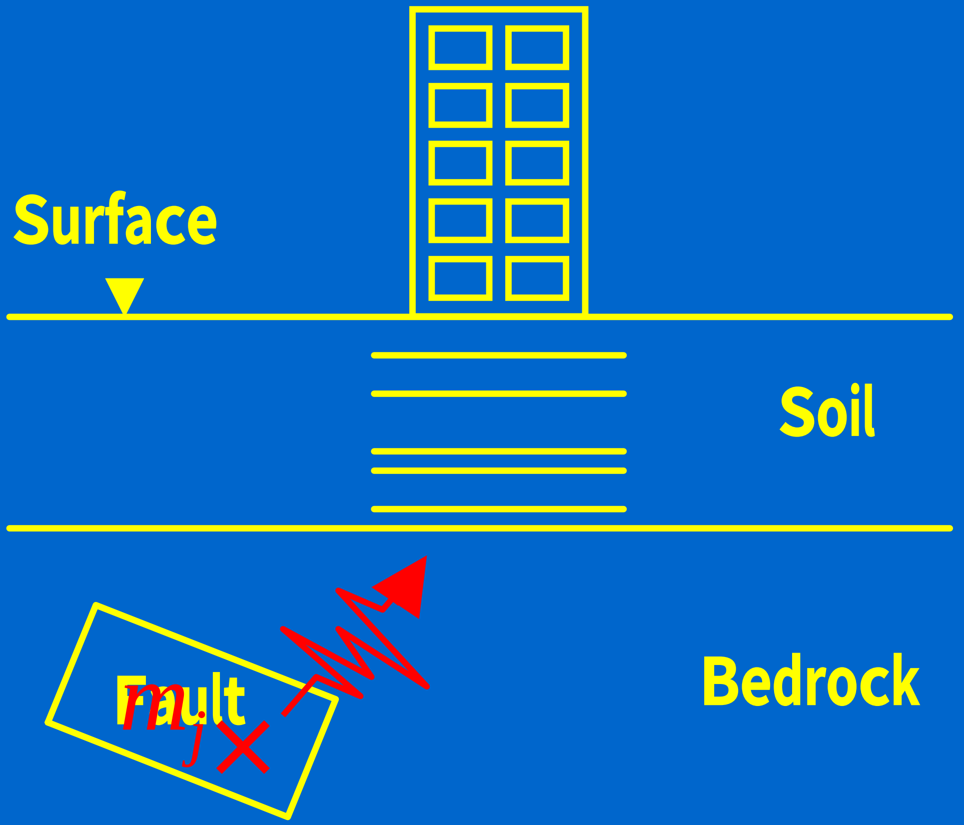

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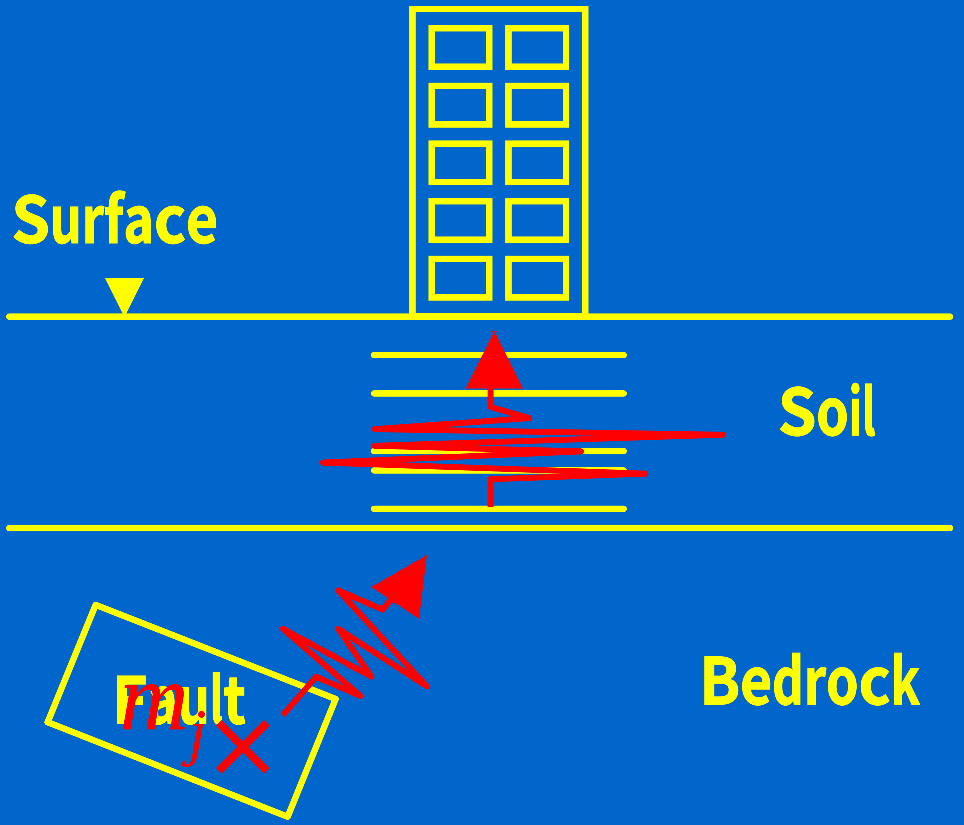

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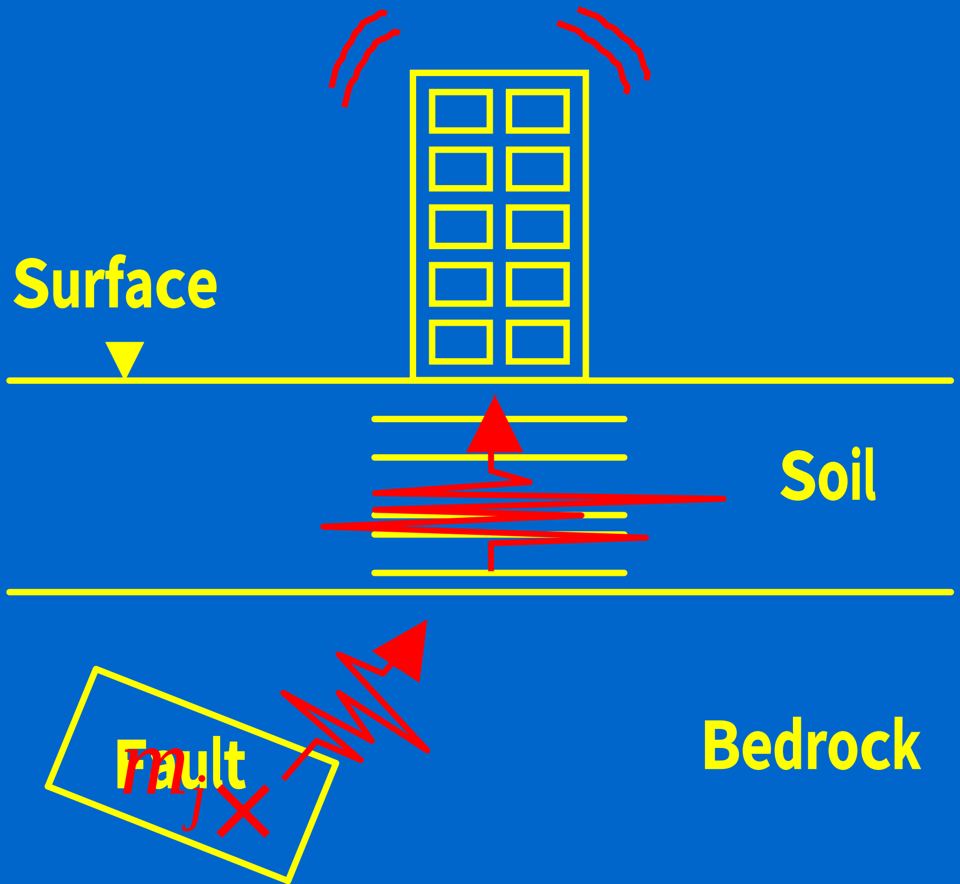

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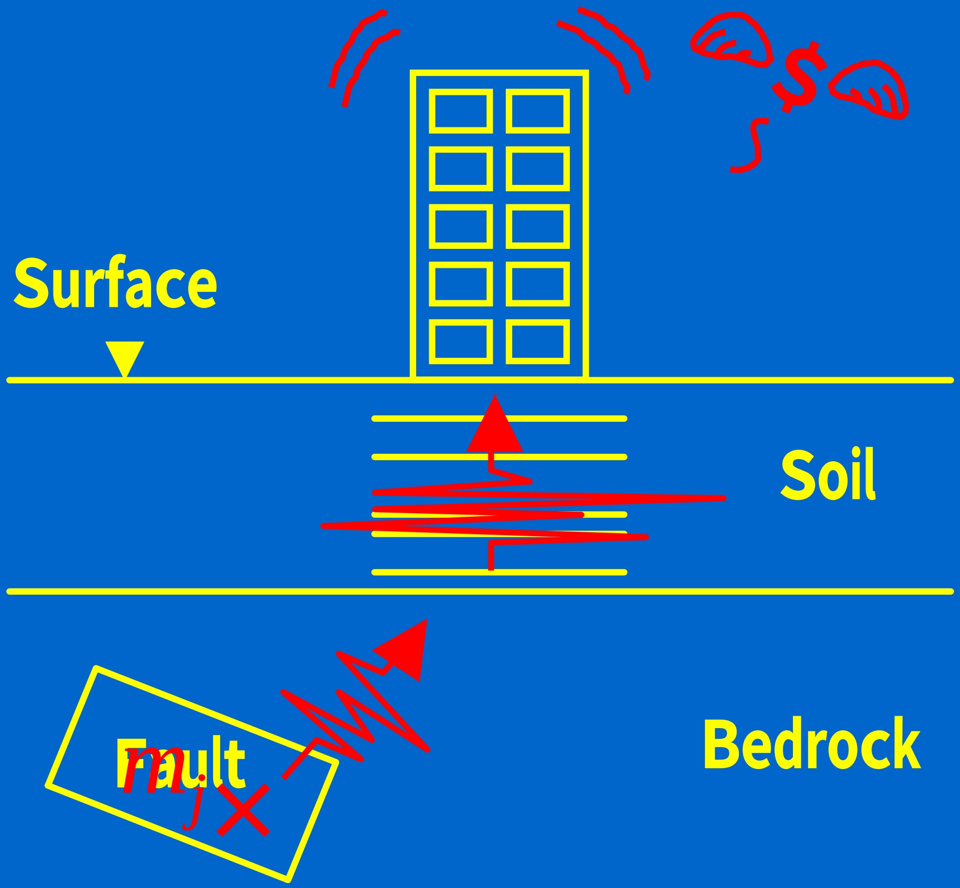

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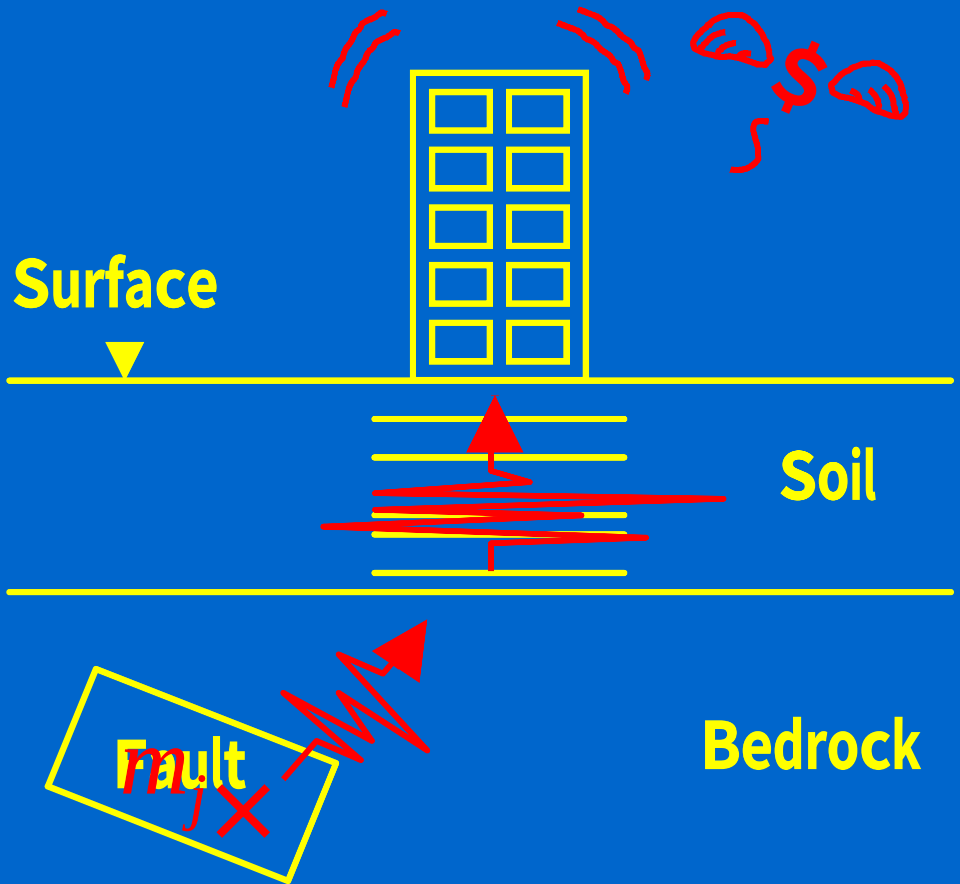

Monte Carlo simulation !

Seismological model

Finite-fault stochastic Green's function method

Seismological model

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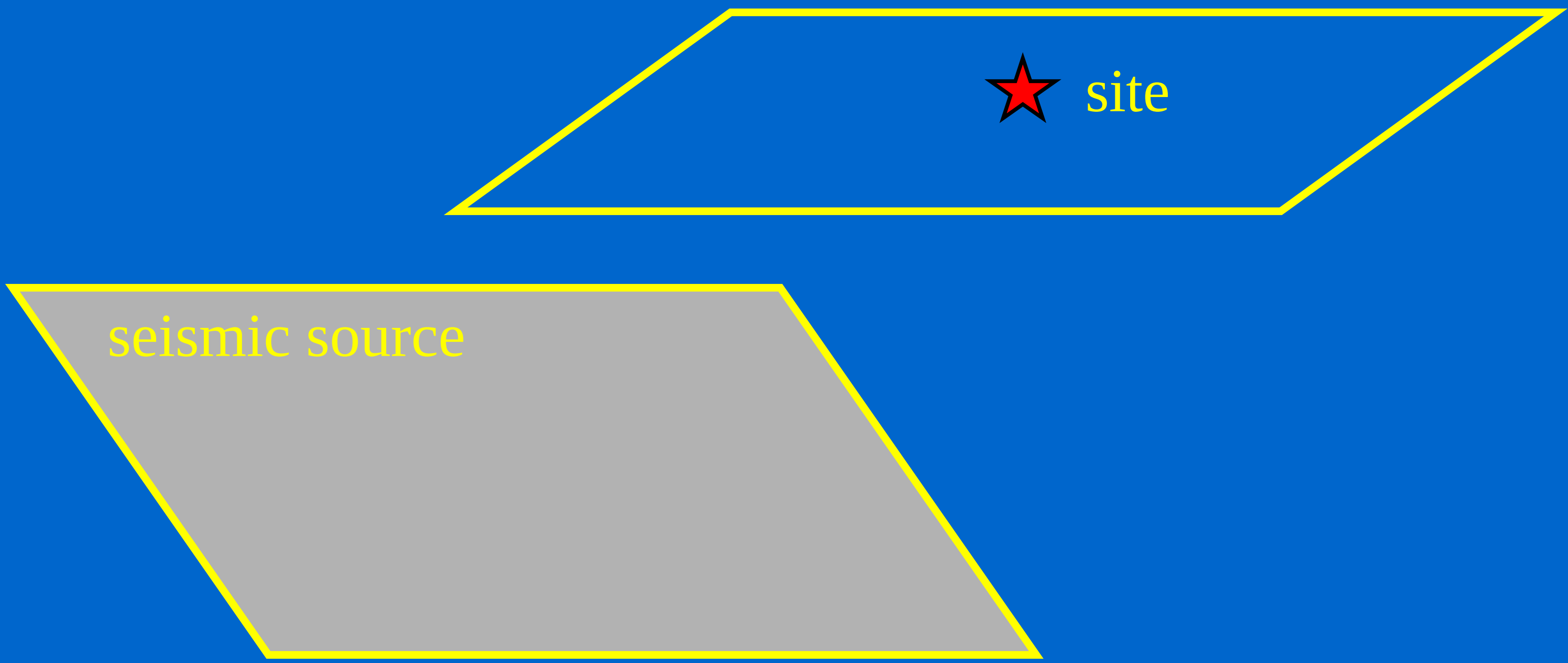
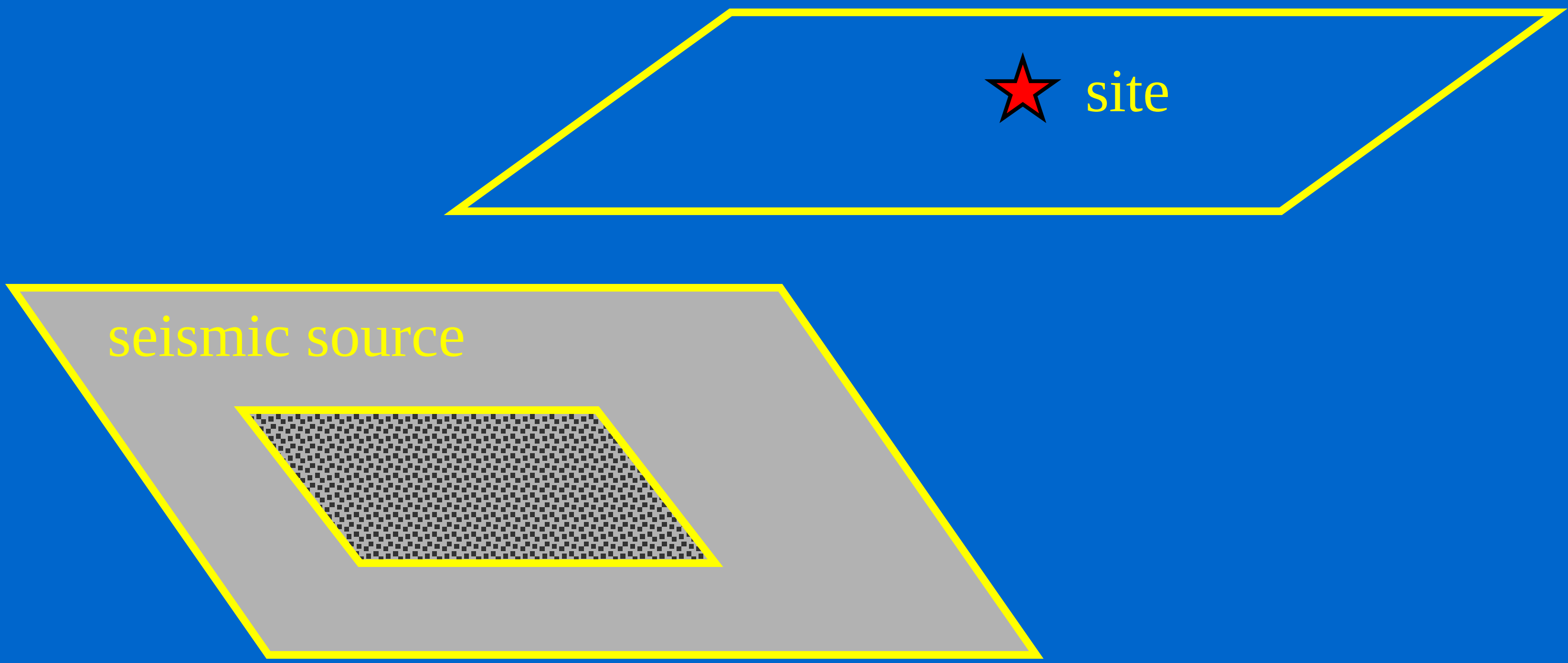


Seismological model

Finite-fault stochastic Green's function method



Seismological model

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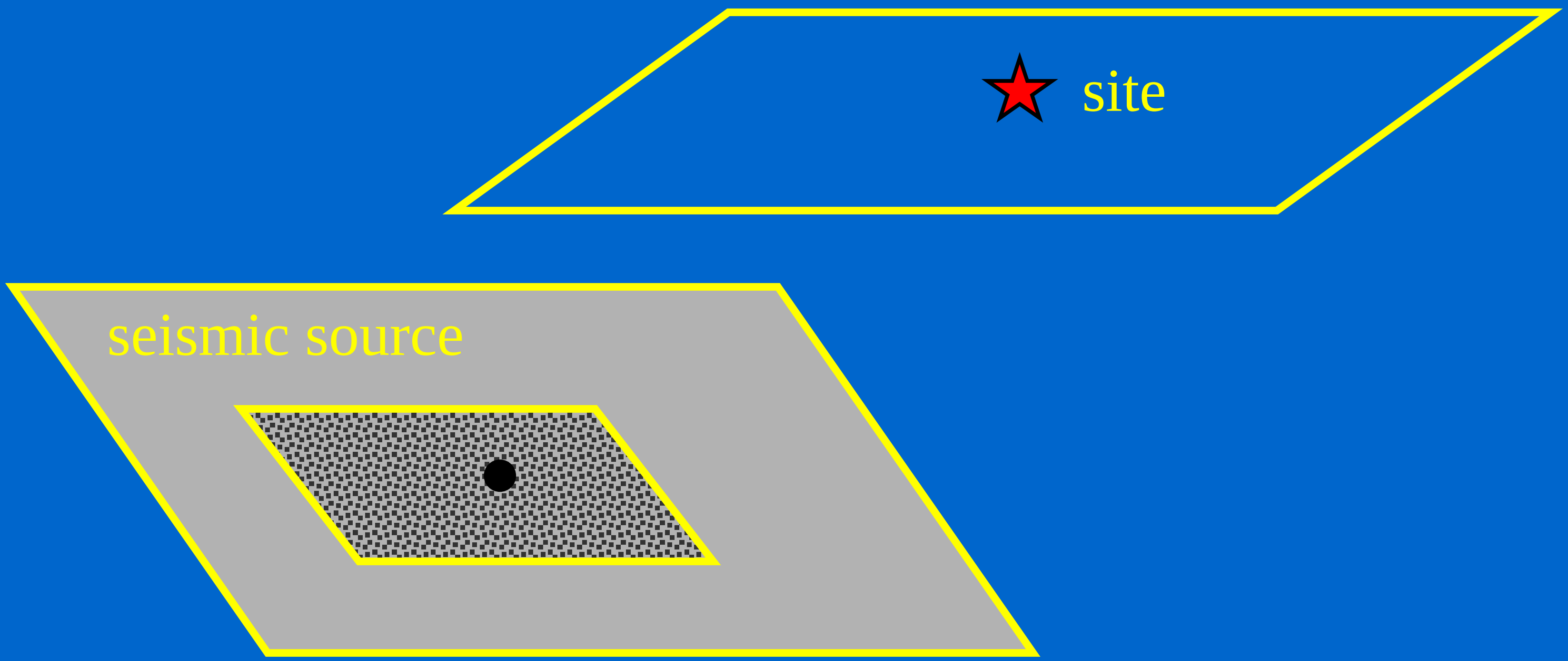

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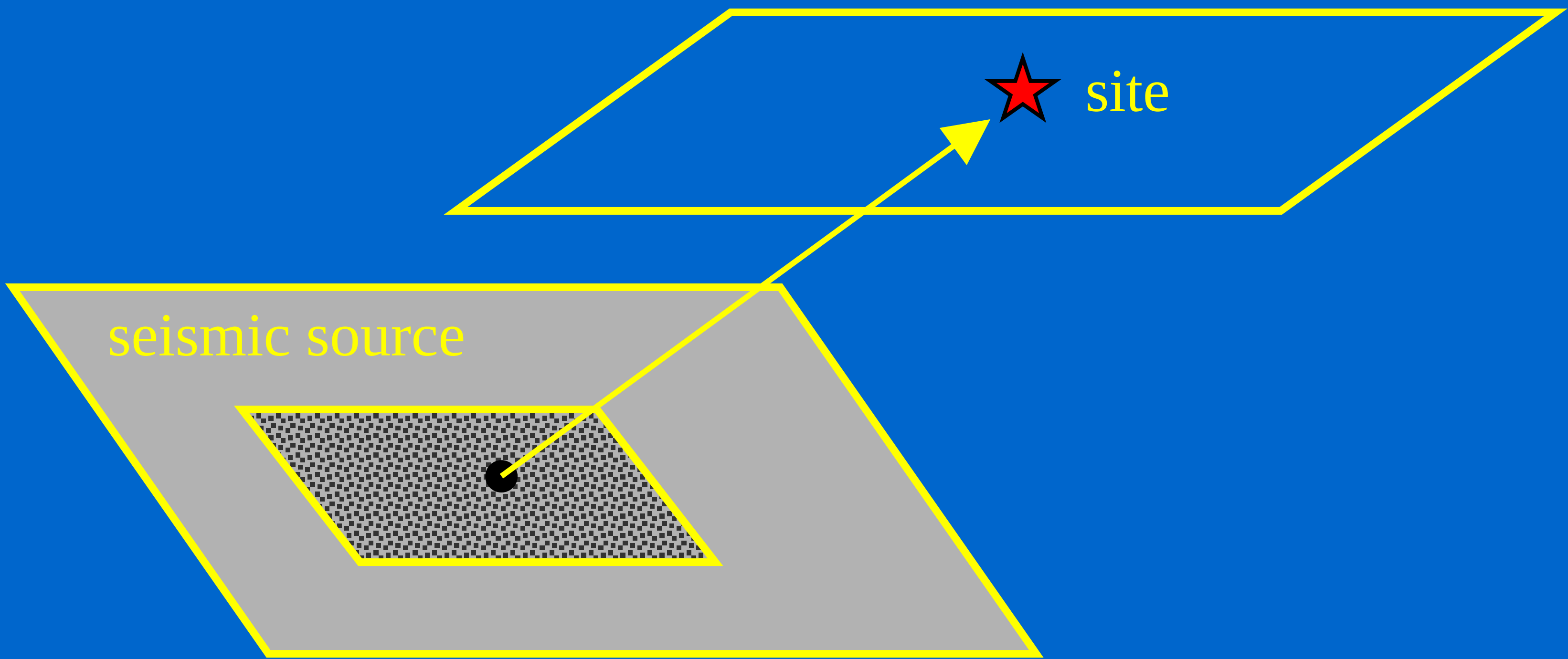

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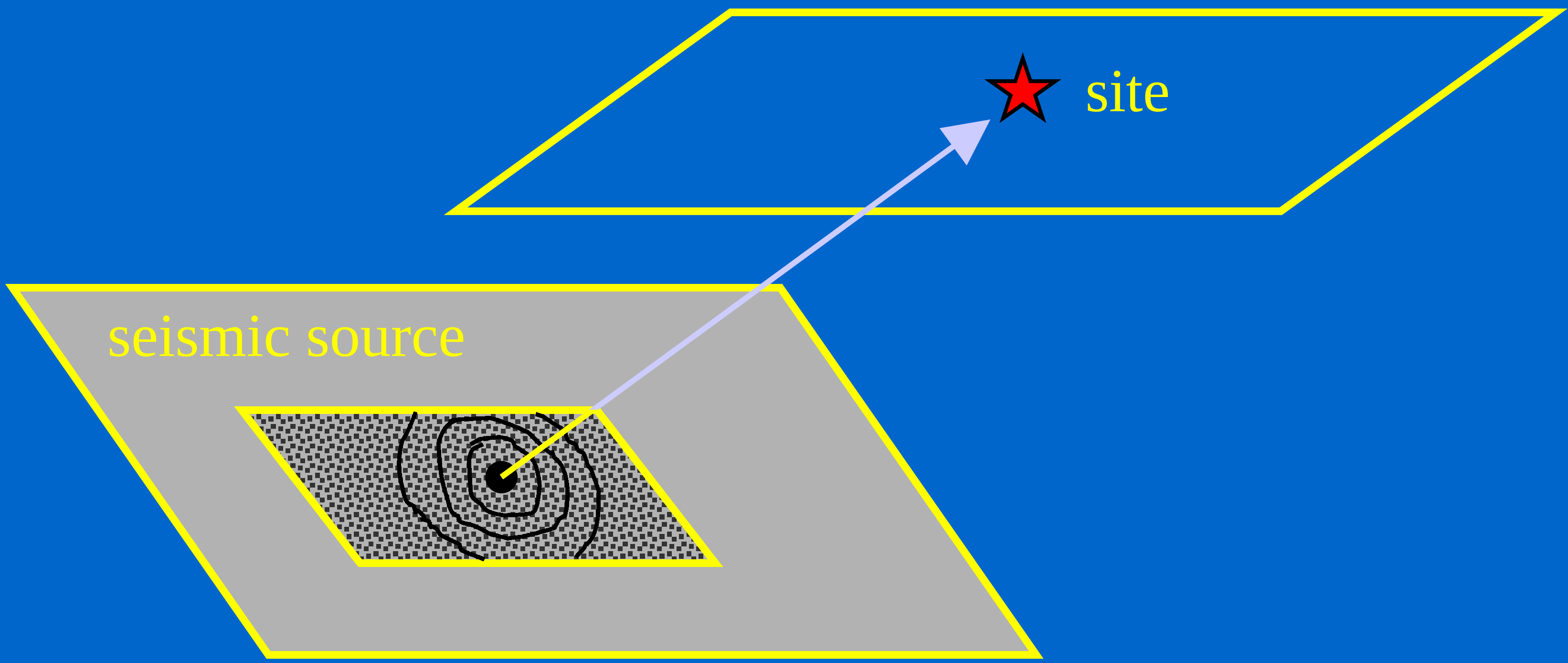

Seismological model

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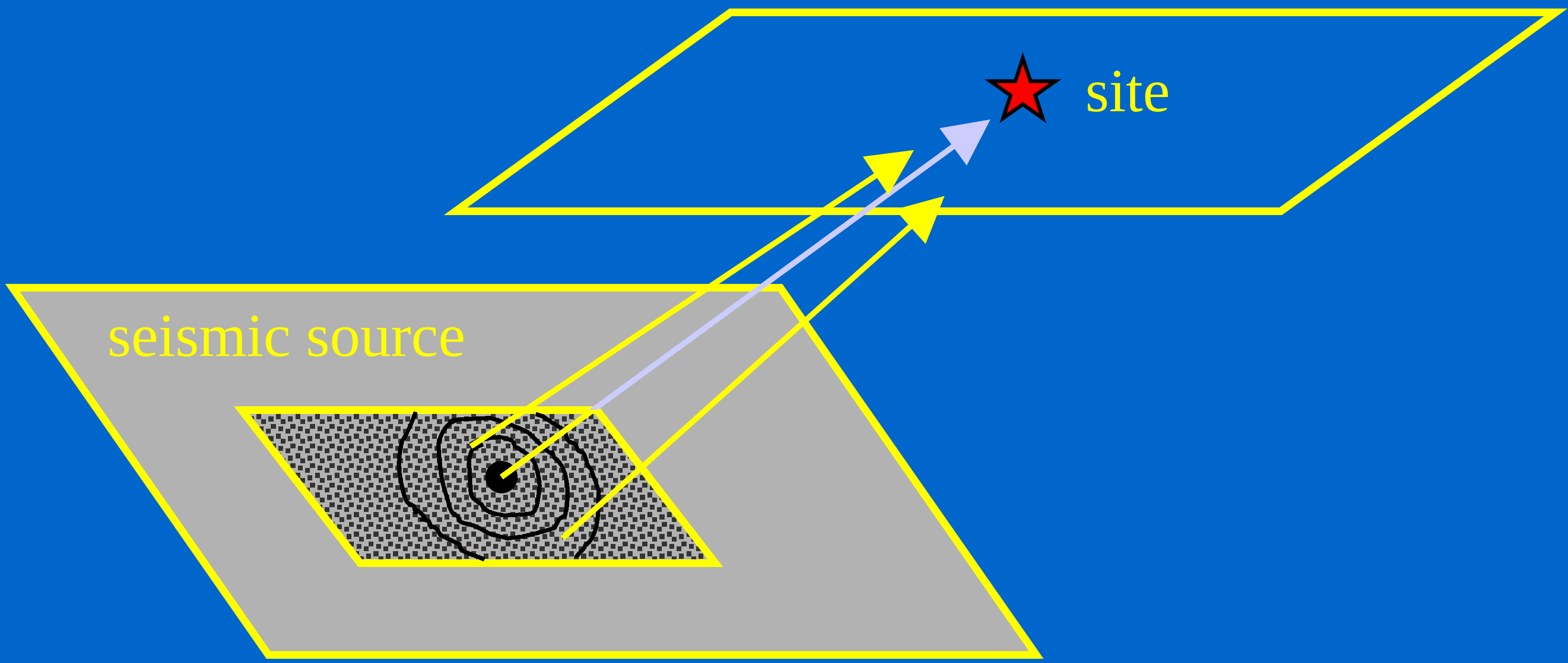

Seismological model

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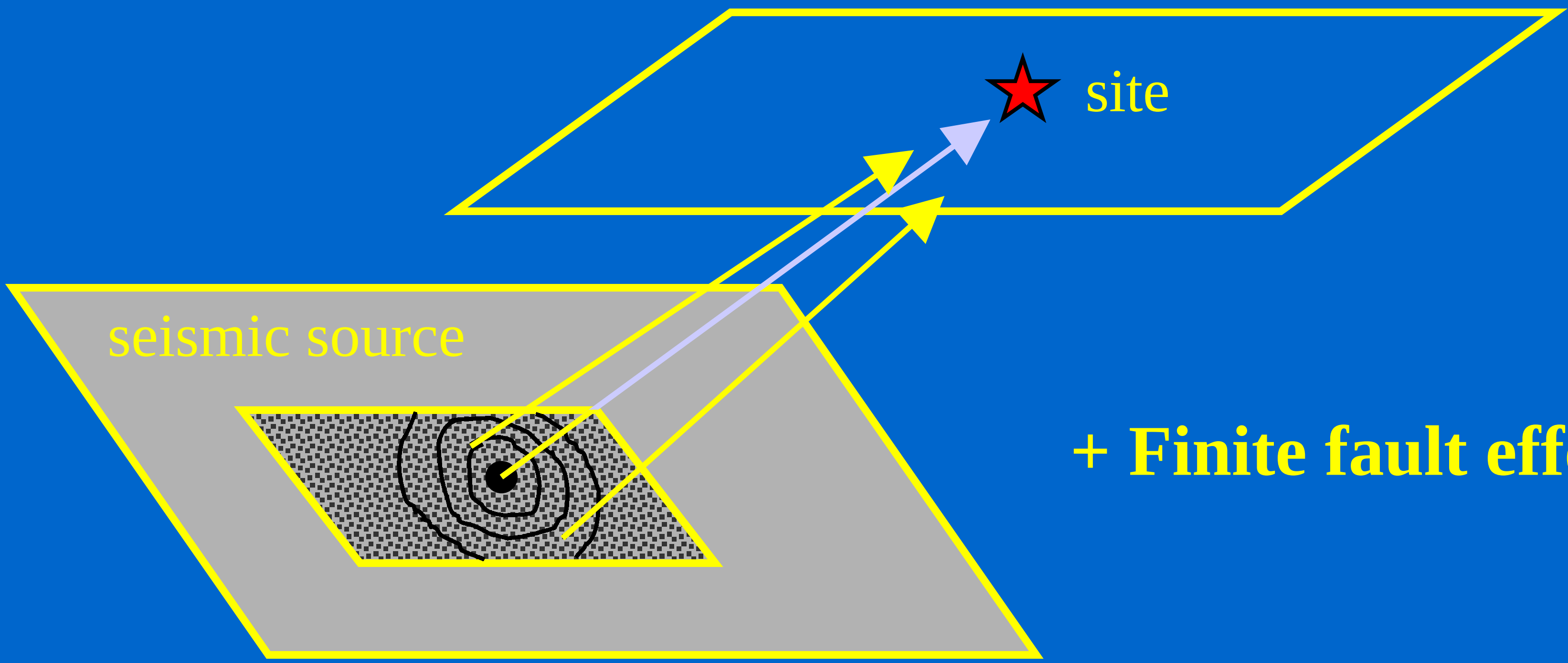

+ Finite fault effects

Application to a building in Tokyo

Kozo Keikaku Engineering

Application to a building in Tokyo

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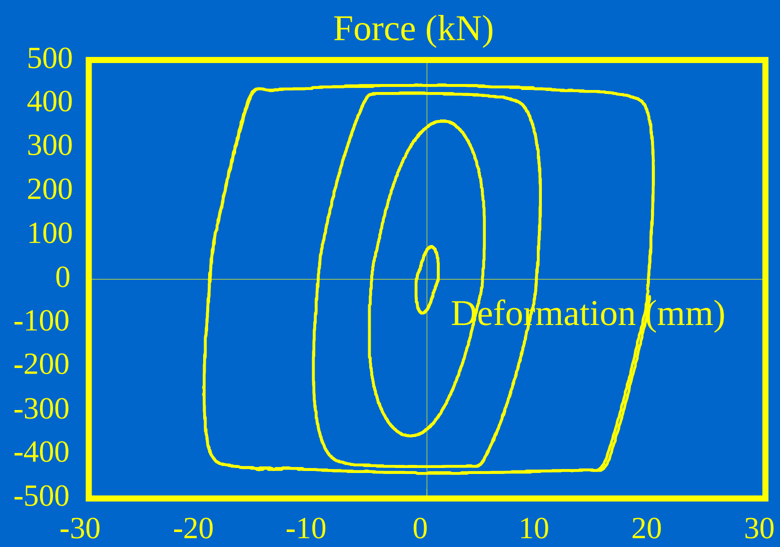
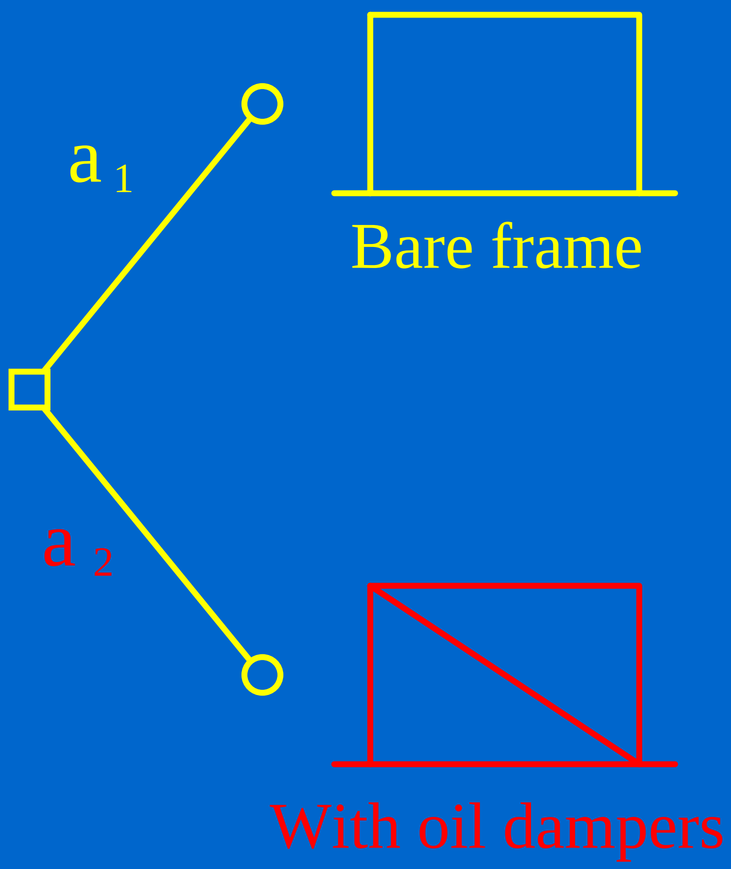


Hysteresis loops

Decision making between two alternatives



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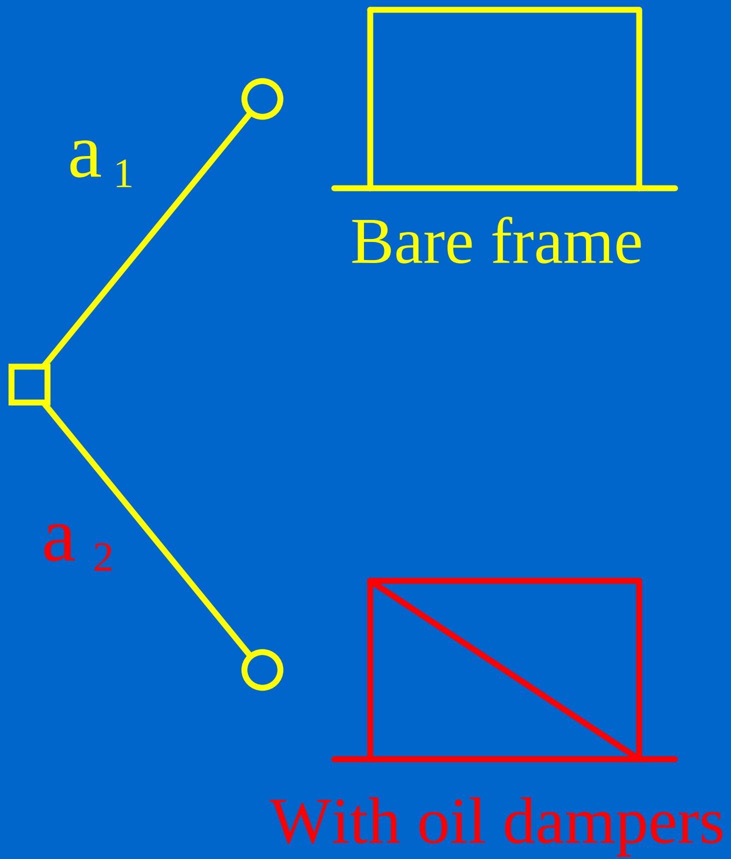
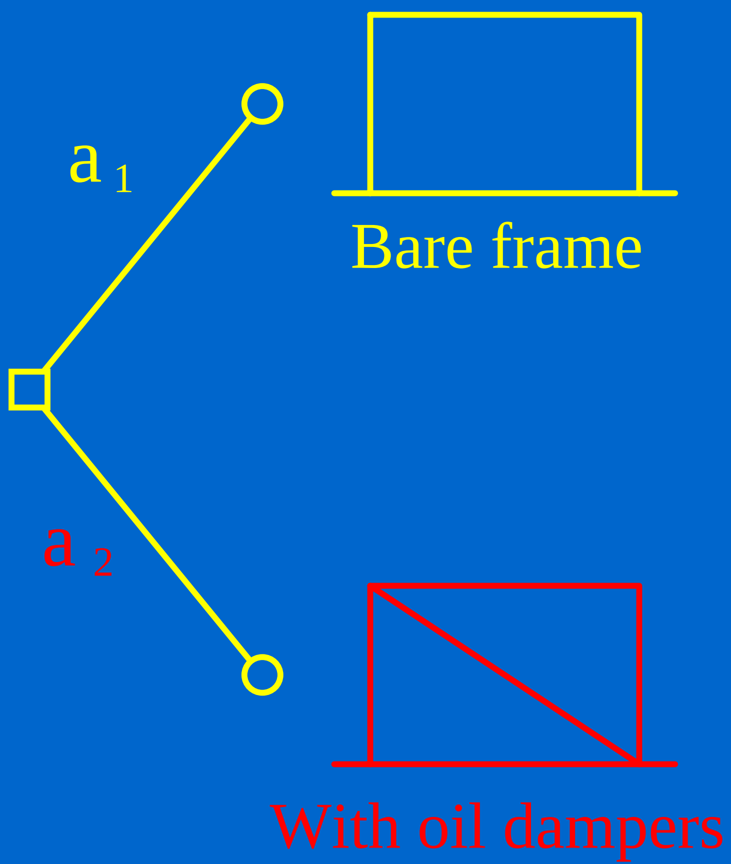


C_I = \$15.12 M

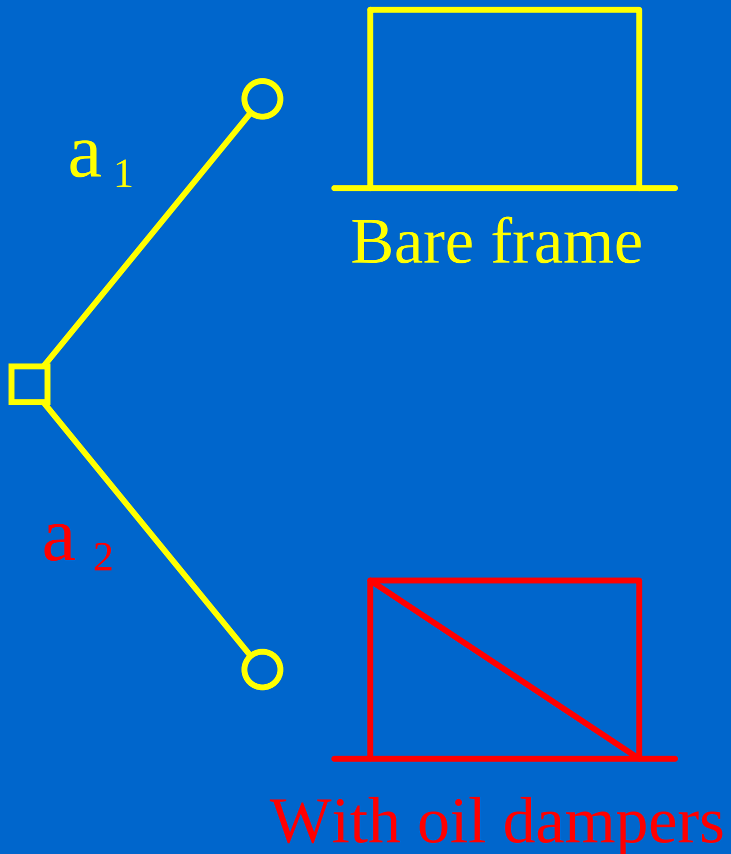
Decision making between two alternatives



C_I = \$15.12 M

C_I = \$15.12 M + \$0.36 M

Decision making between two alternatives



C_I = \$15.12 M

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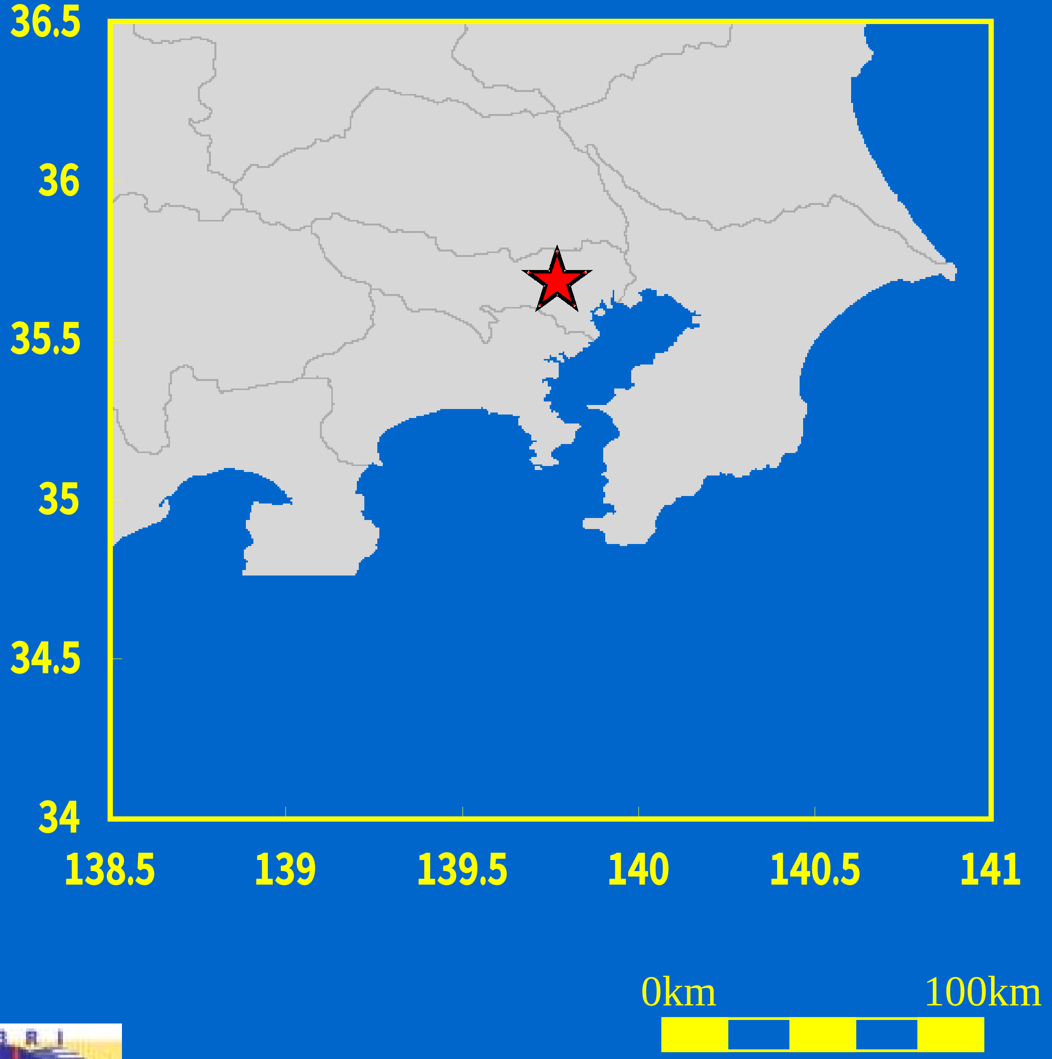
= \$15.48 M

Building site & seismic source



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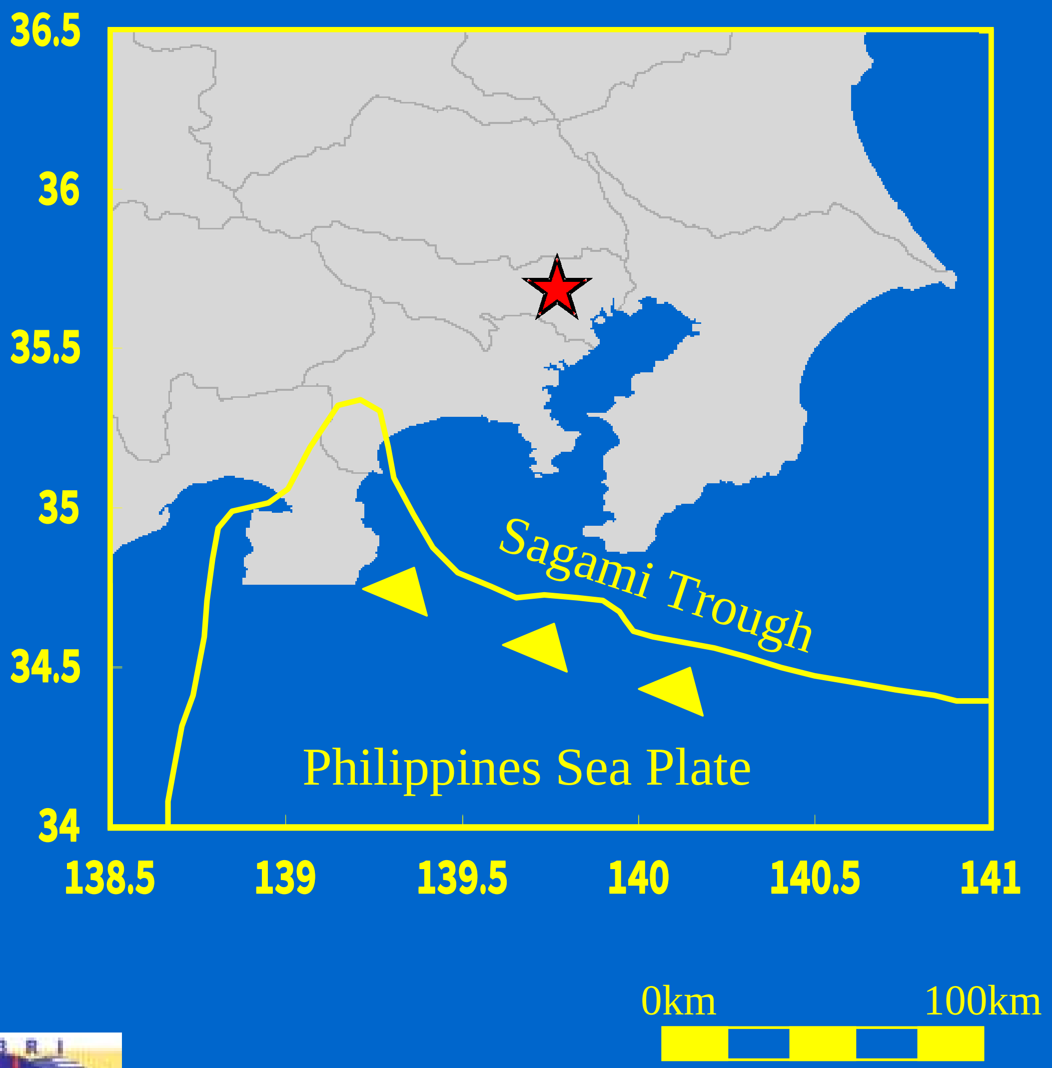

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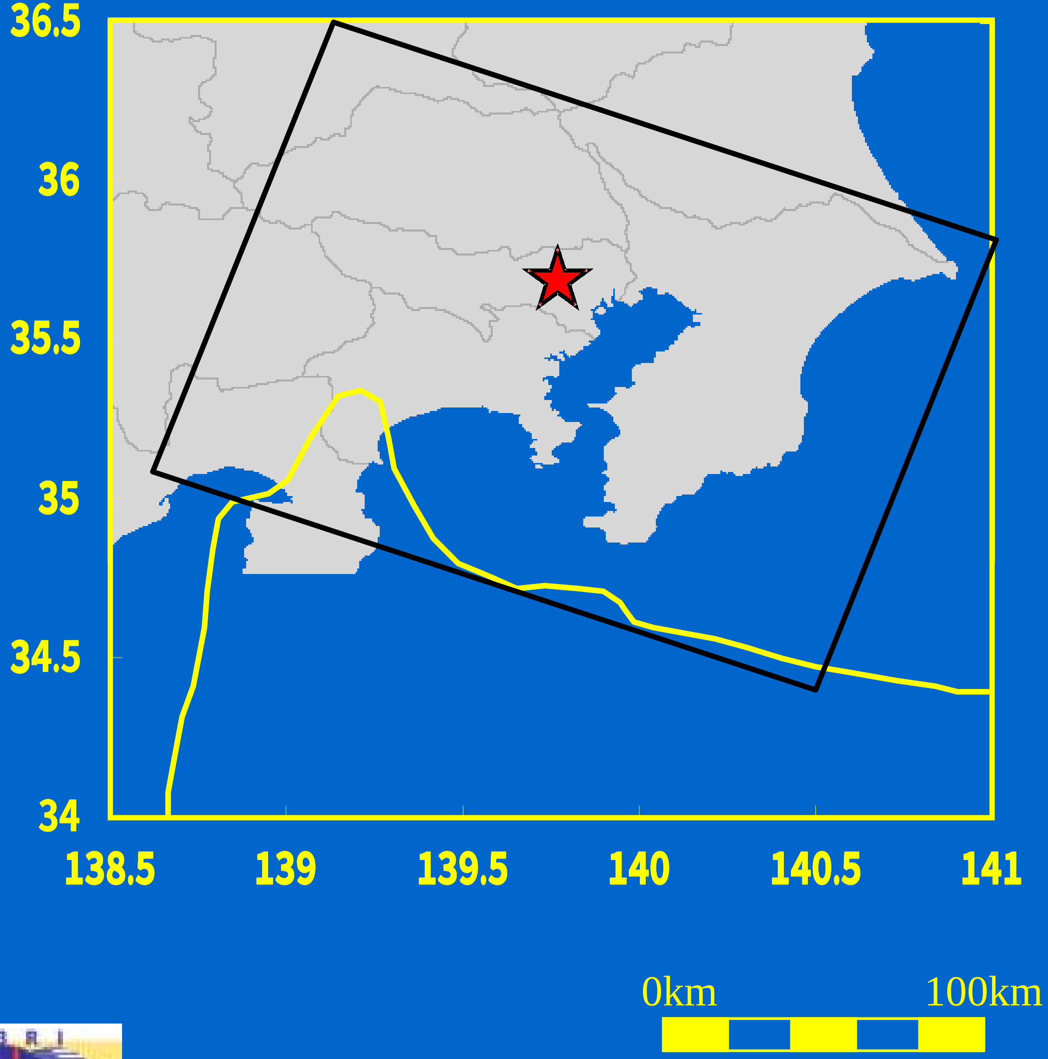

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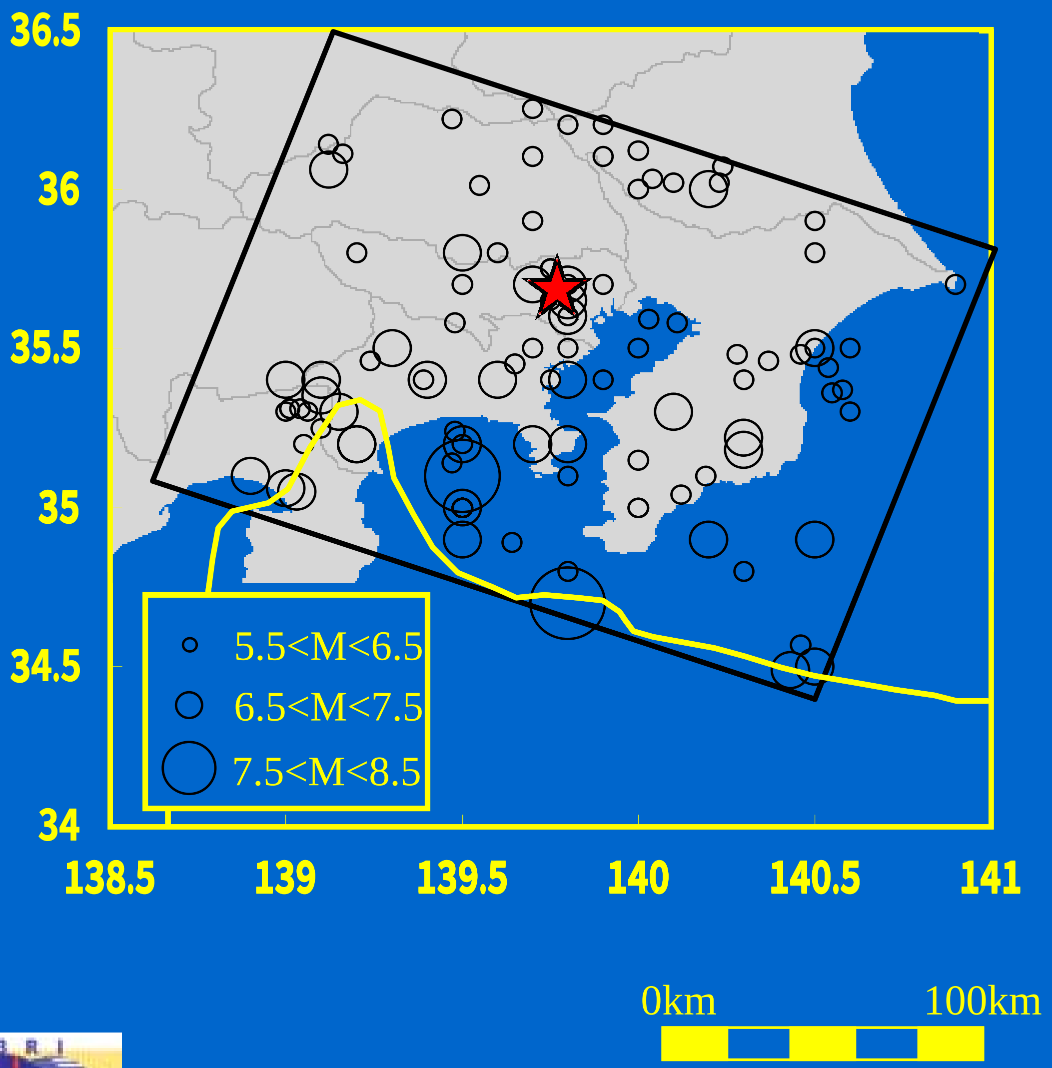

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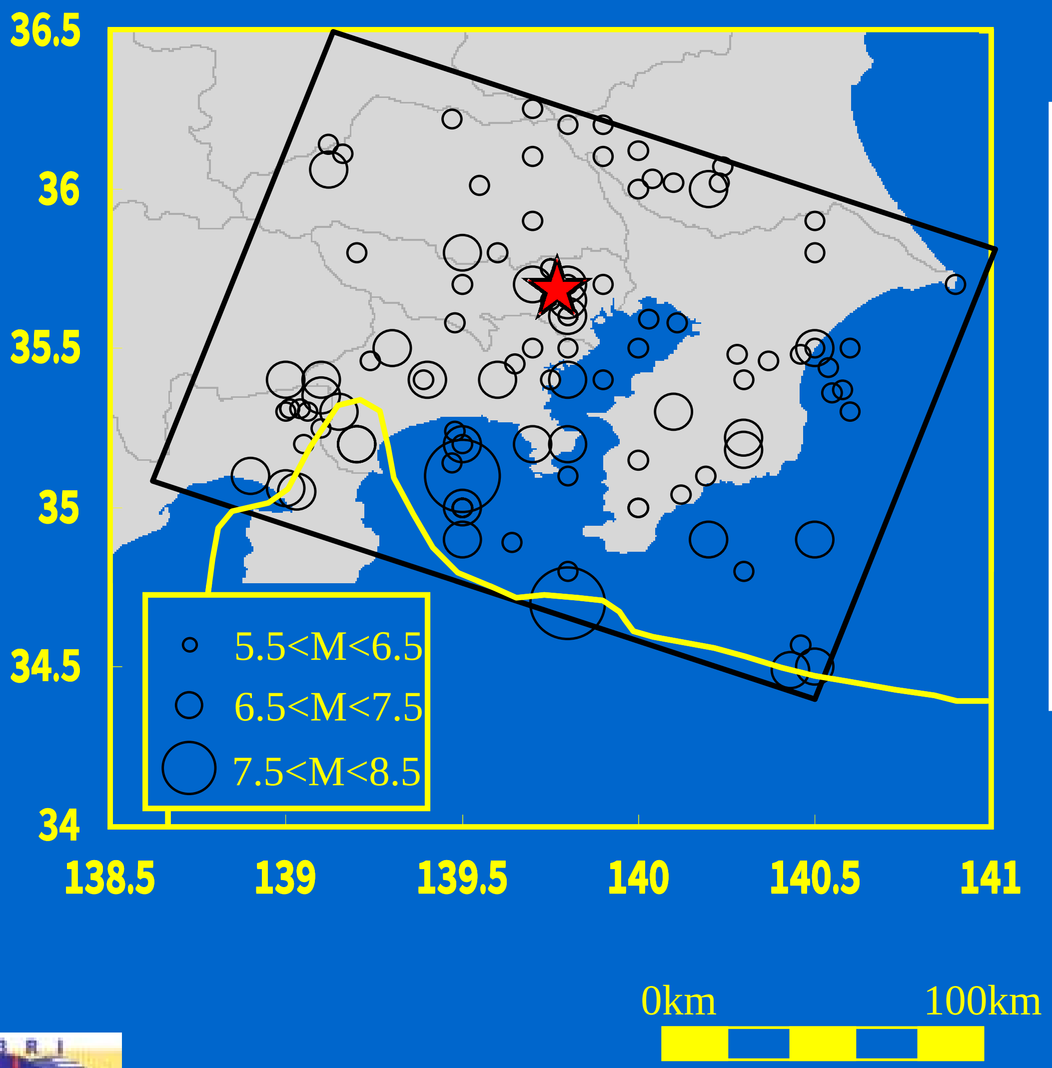
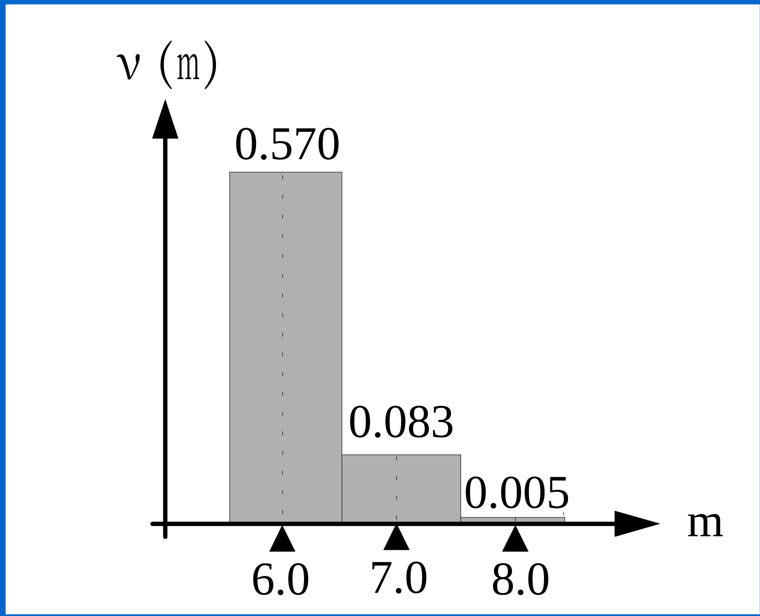
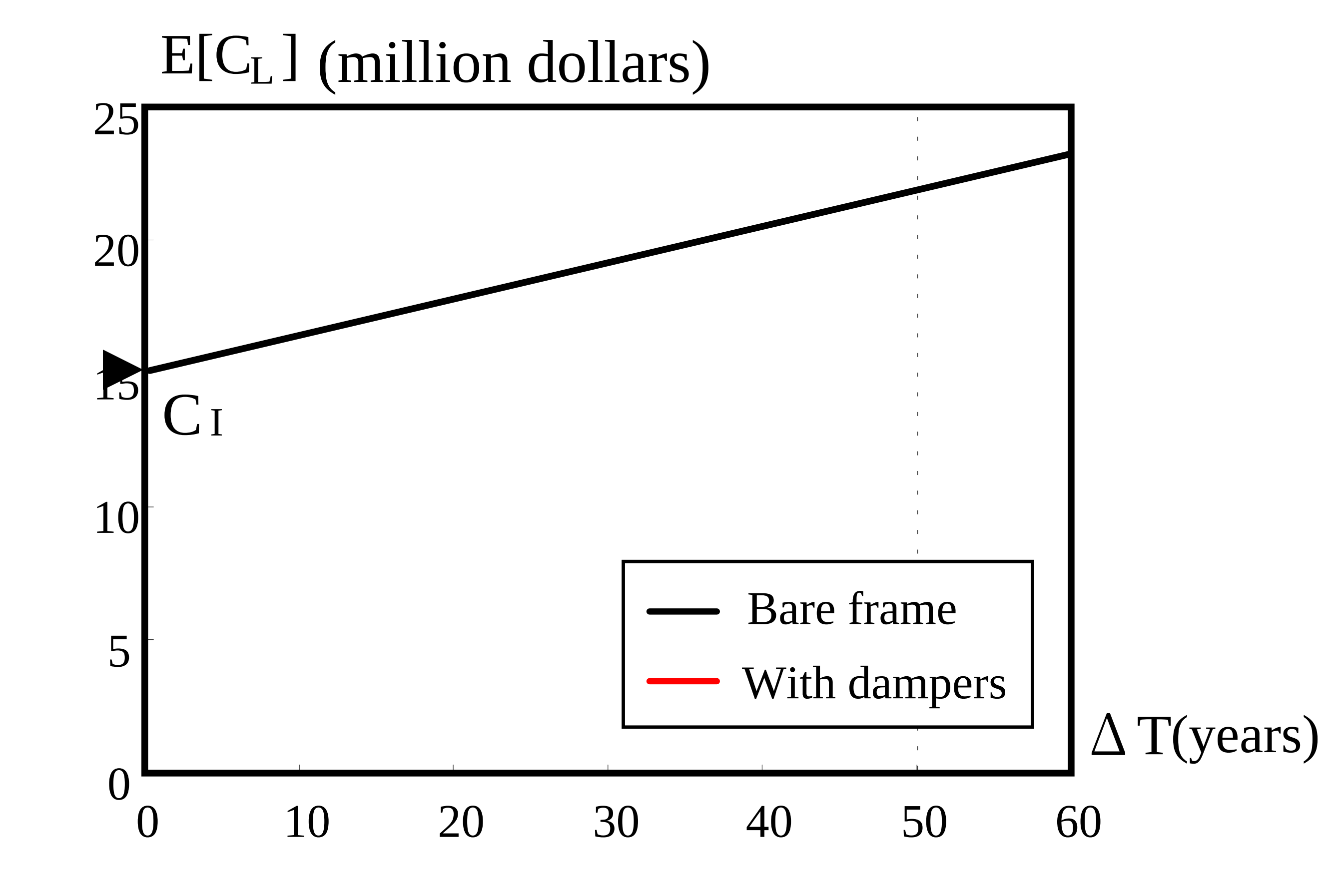




magnitude – annual rate

Lifetime vs. expected life-cycle cost

$$E[C_L] = C_I + \Delta T \times \sum_{all\ sources} \sum_{j=1}^{K} \nu(m_j) \cdot E[C_D(m_j)]$$



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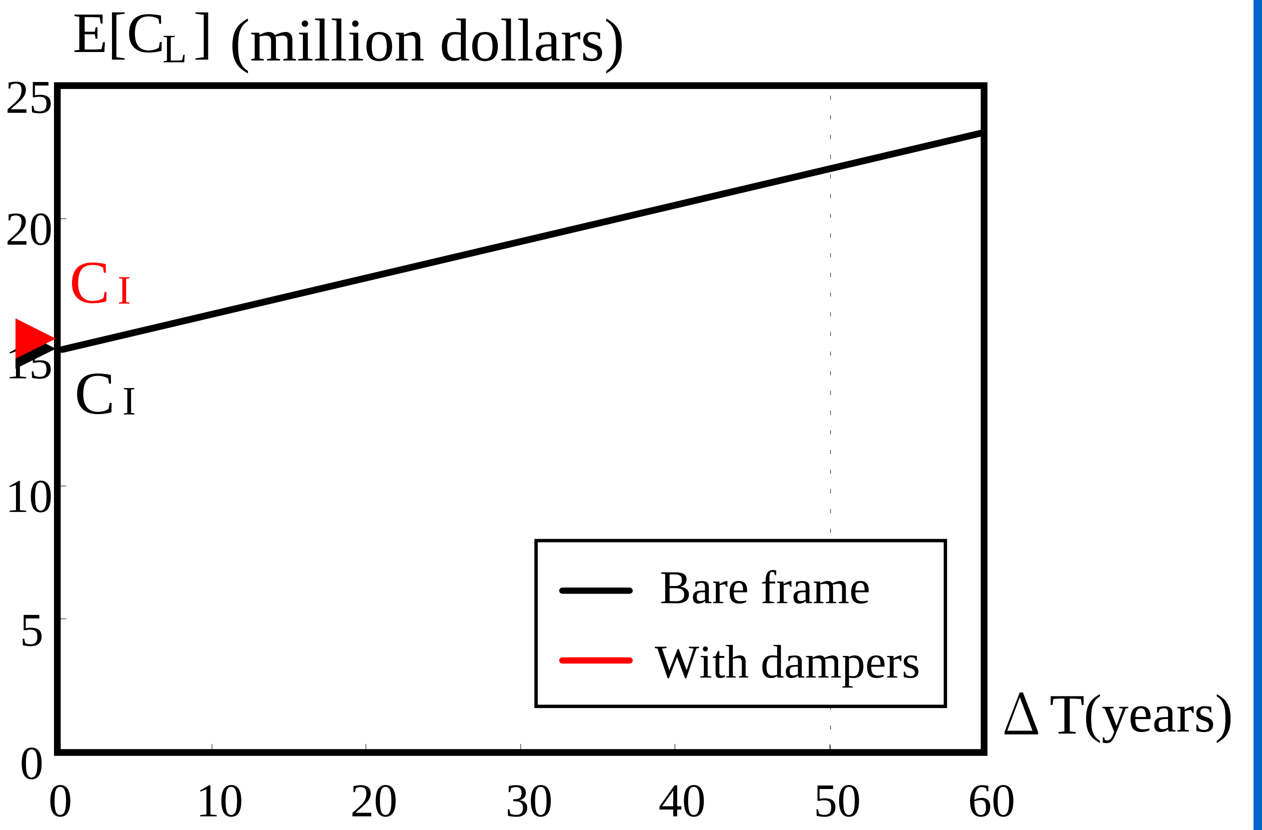

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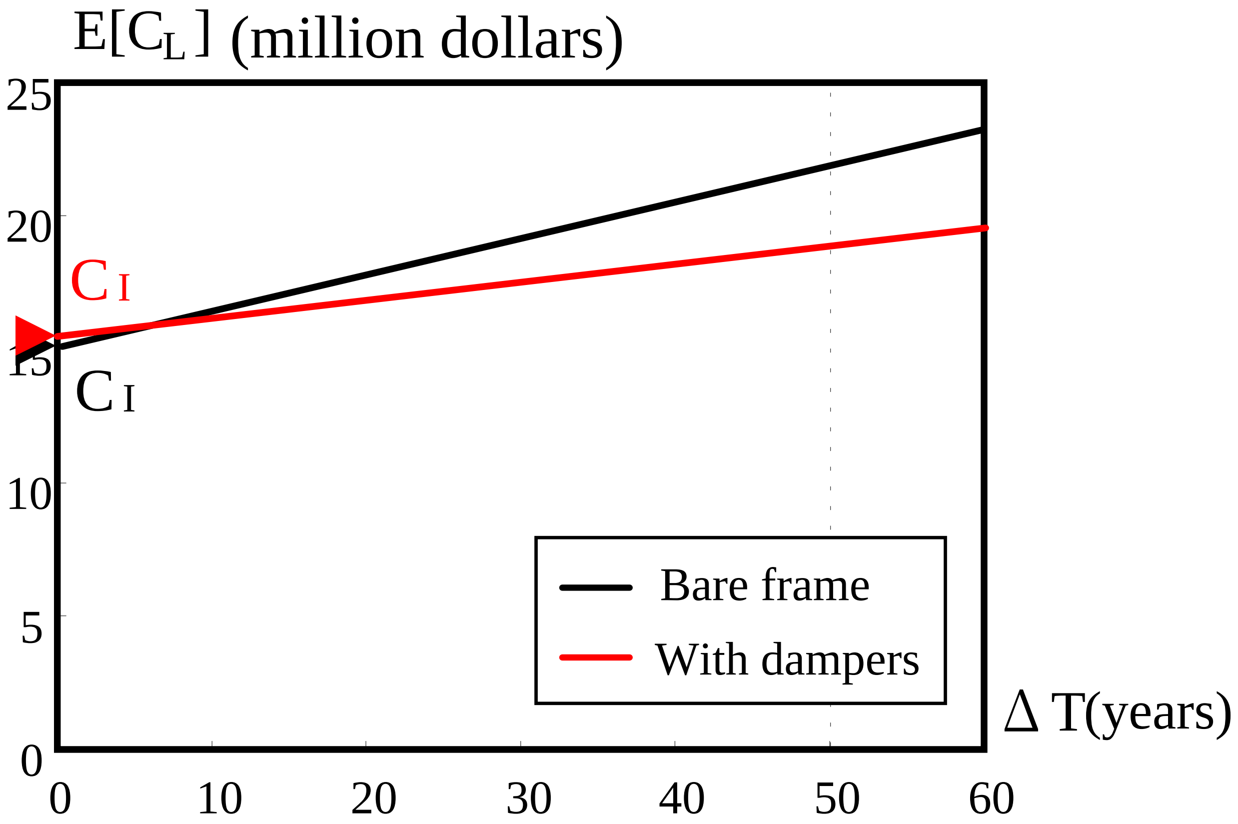

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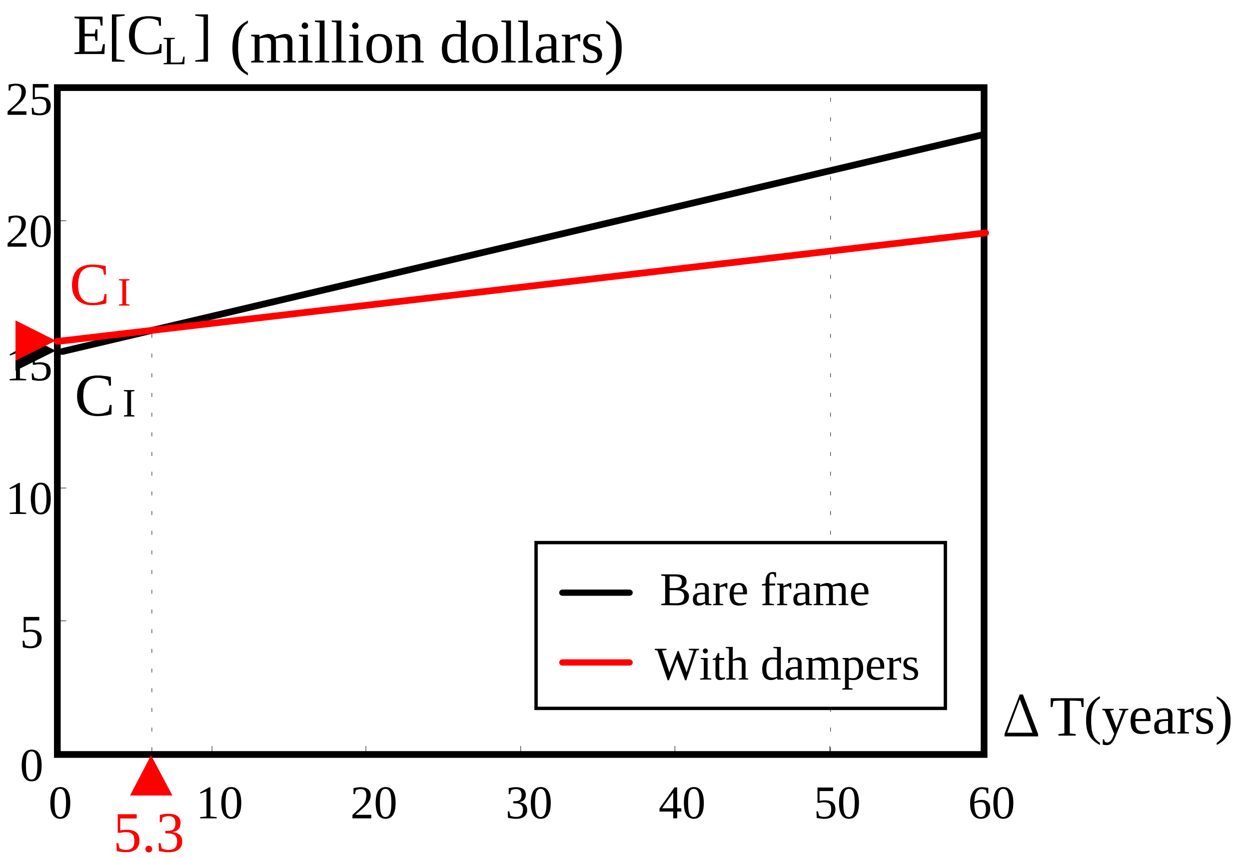

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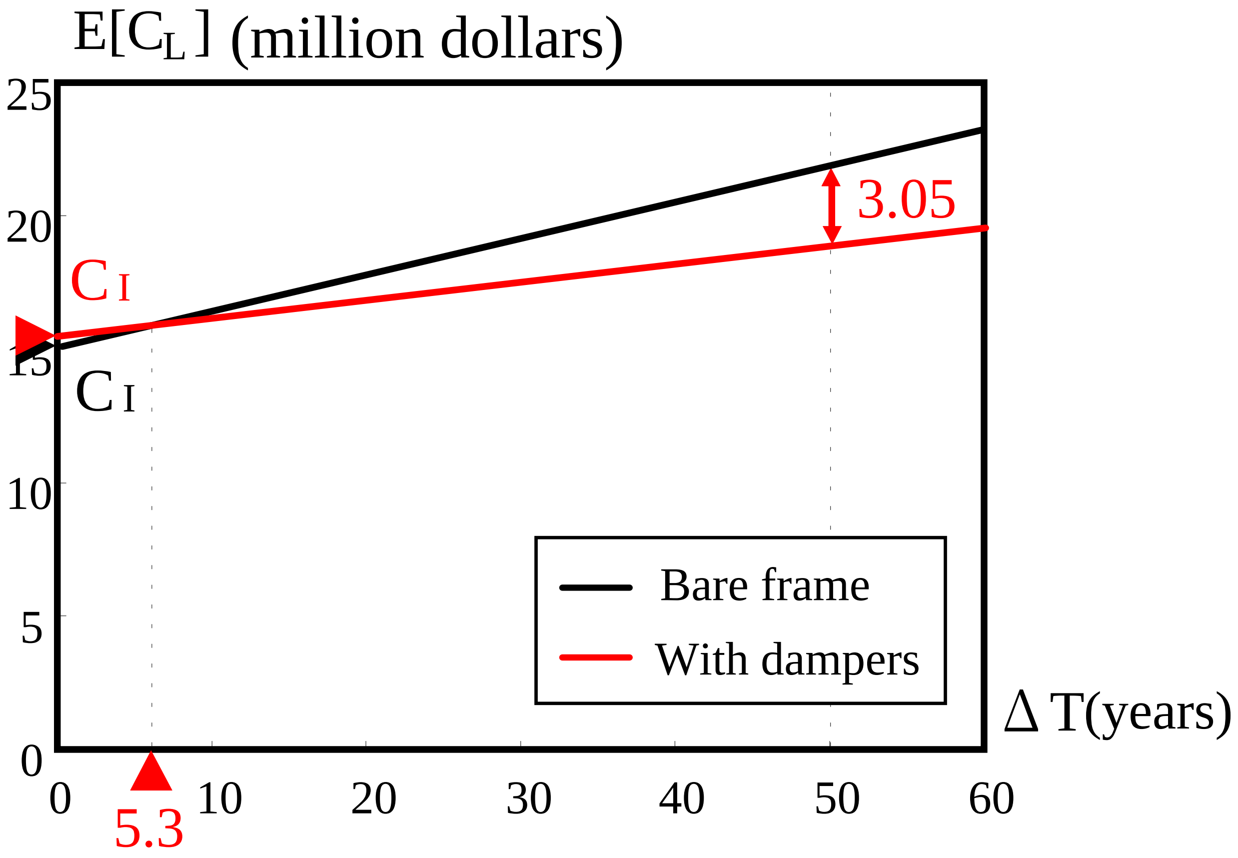

Generalization for non-Poisson renewal model

$$E\left[C_L\right] = C_I + \Delta T \times \sum_{all\ sources} \sum_{j=1}^{K} \nu(m_j) \cdot E\left[C_D(m_j)\right]$$

Generalization for non-Poisson renewal model

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+ Non-Poisson renewal model, e.g., BPT model

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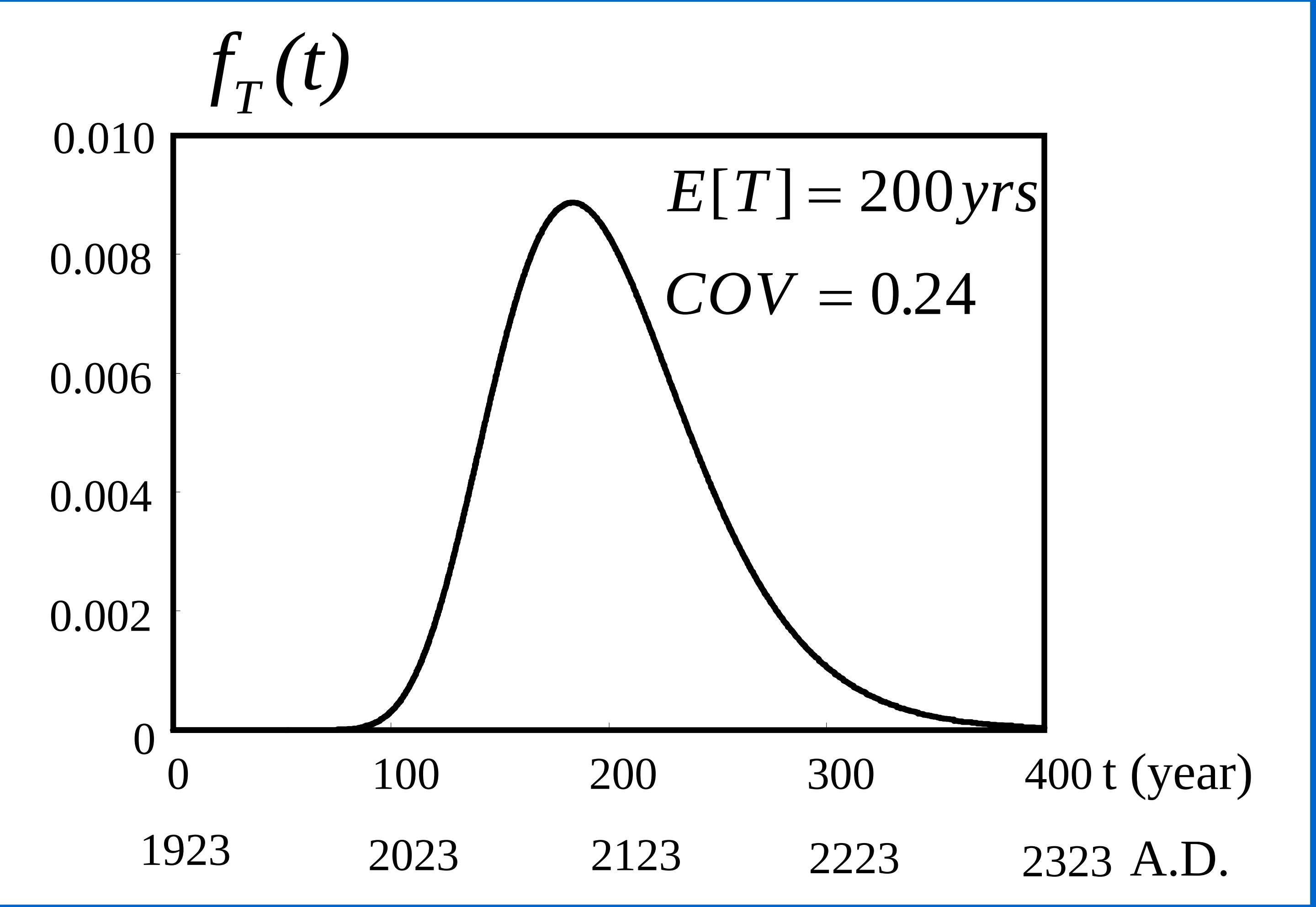
+ Non-Poisson renewal model, e.g., BPT model

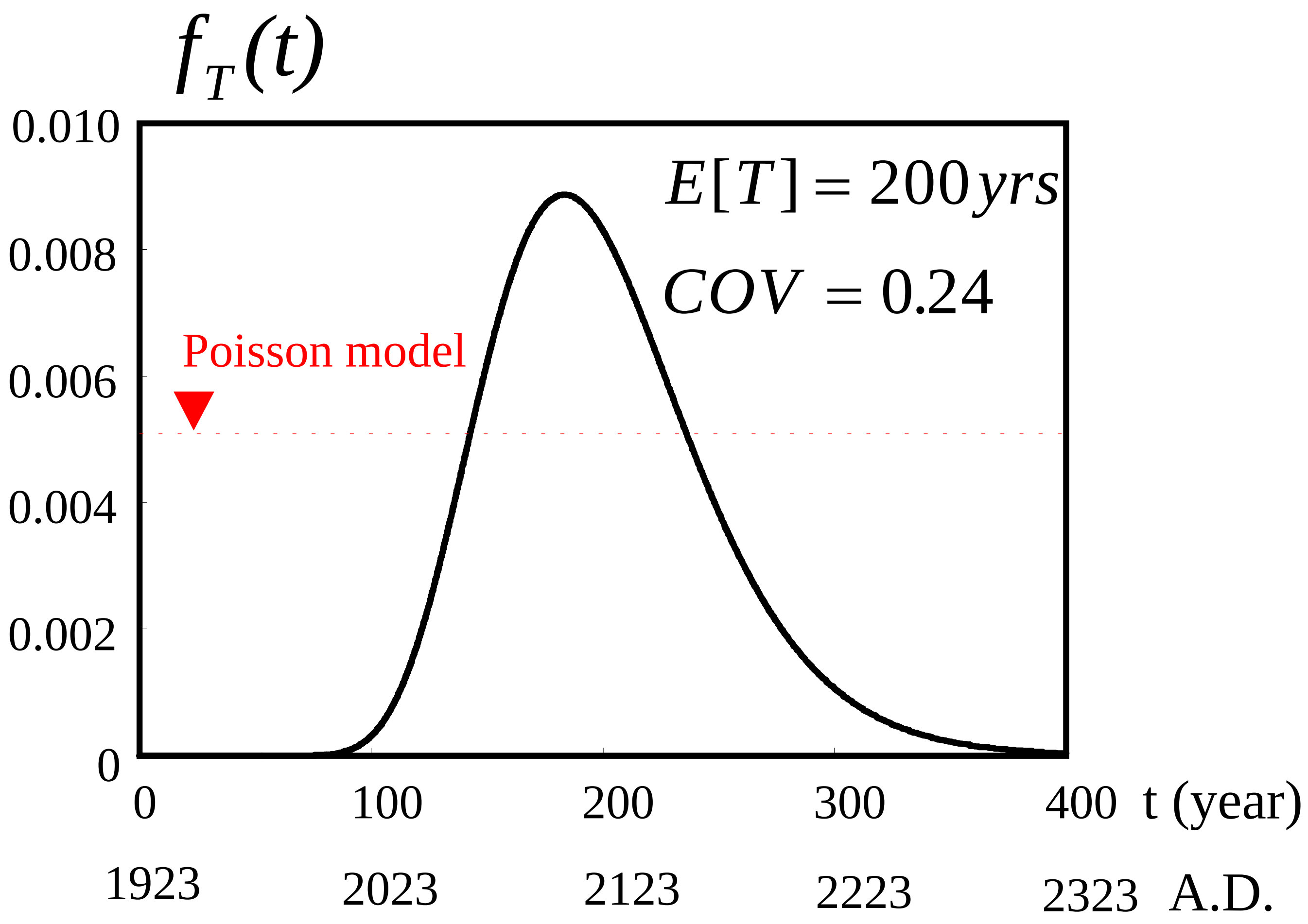
$$E\left[C_L\right] = C_I + \sum_{all\ sources} \sum_{j=1}^{K} E\left[C_D(m_j)\right] \int_{t_0}^{t_0+\Delta T} \sum_{n=1}^{\infty} f_{T_{nth}}(m_j, t | T > t_0) dt$$

Brownian Passage Time model (WGCEP, HERP)



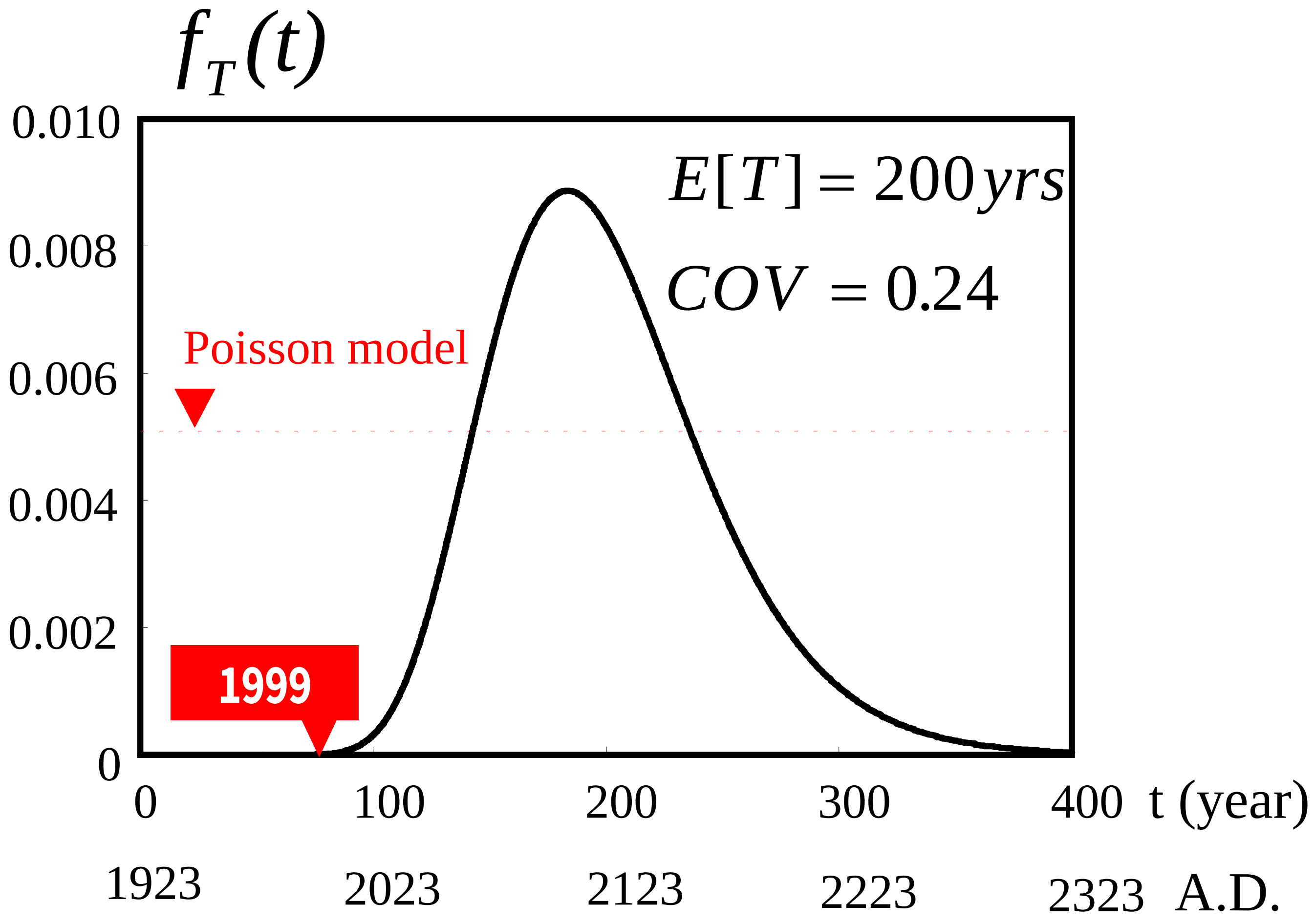
PDF of waiting time to the next earthquake

Brownian Passage Time model (WGCEP, HERP)



PDF of waiting time to the next earthquake

Brownian Passage Time model (WGCEP, HERP)



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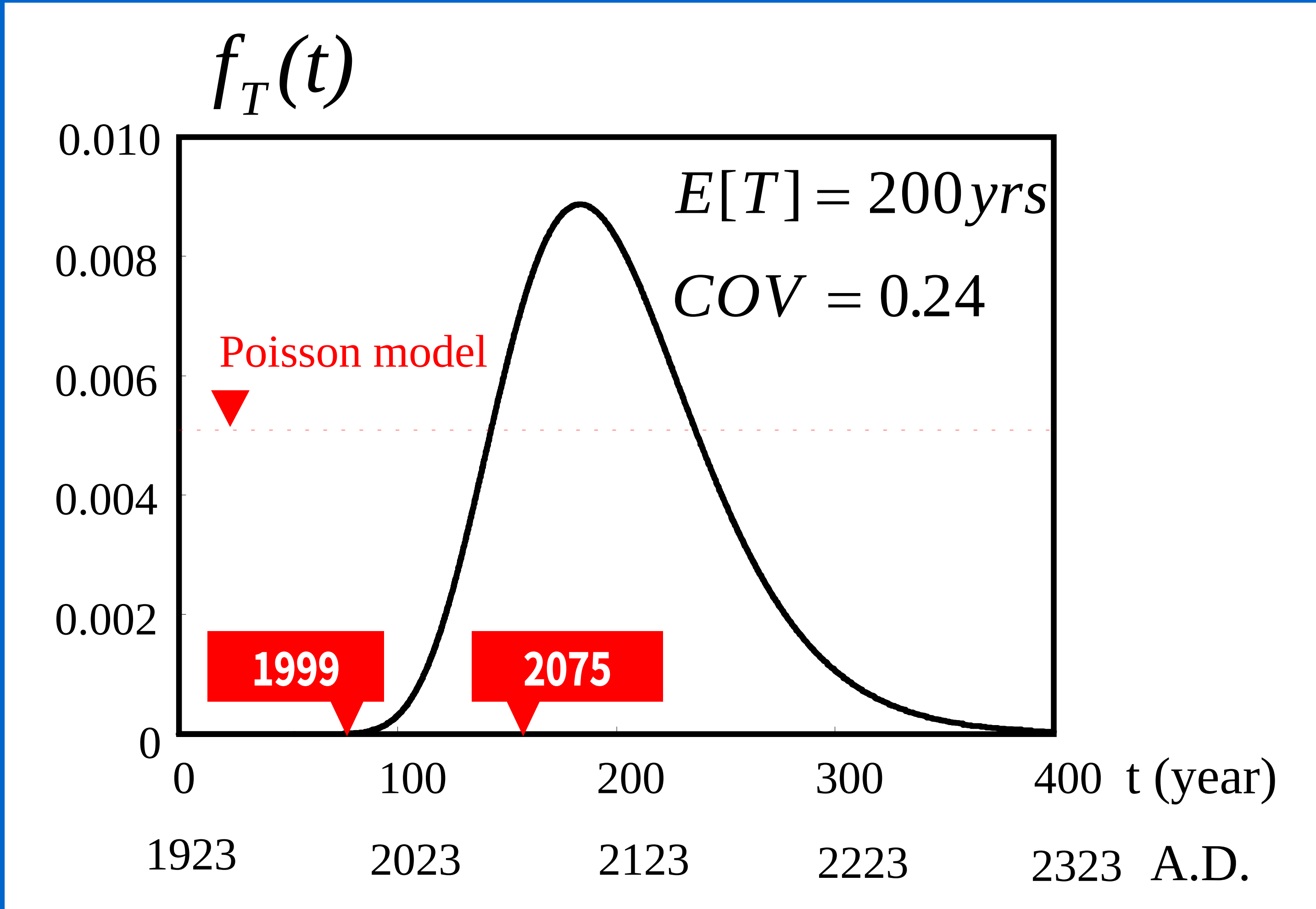

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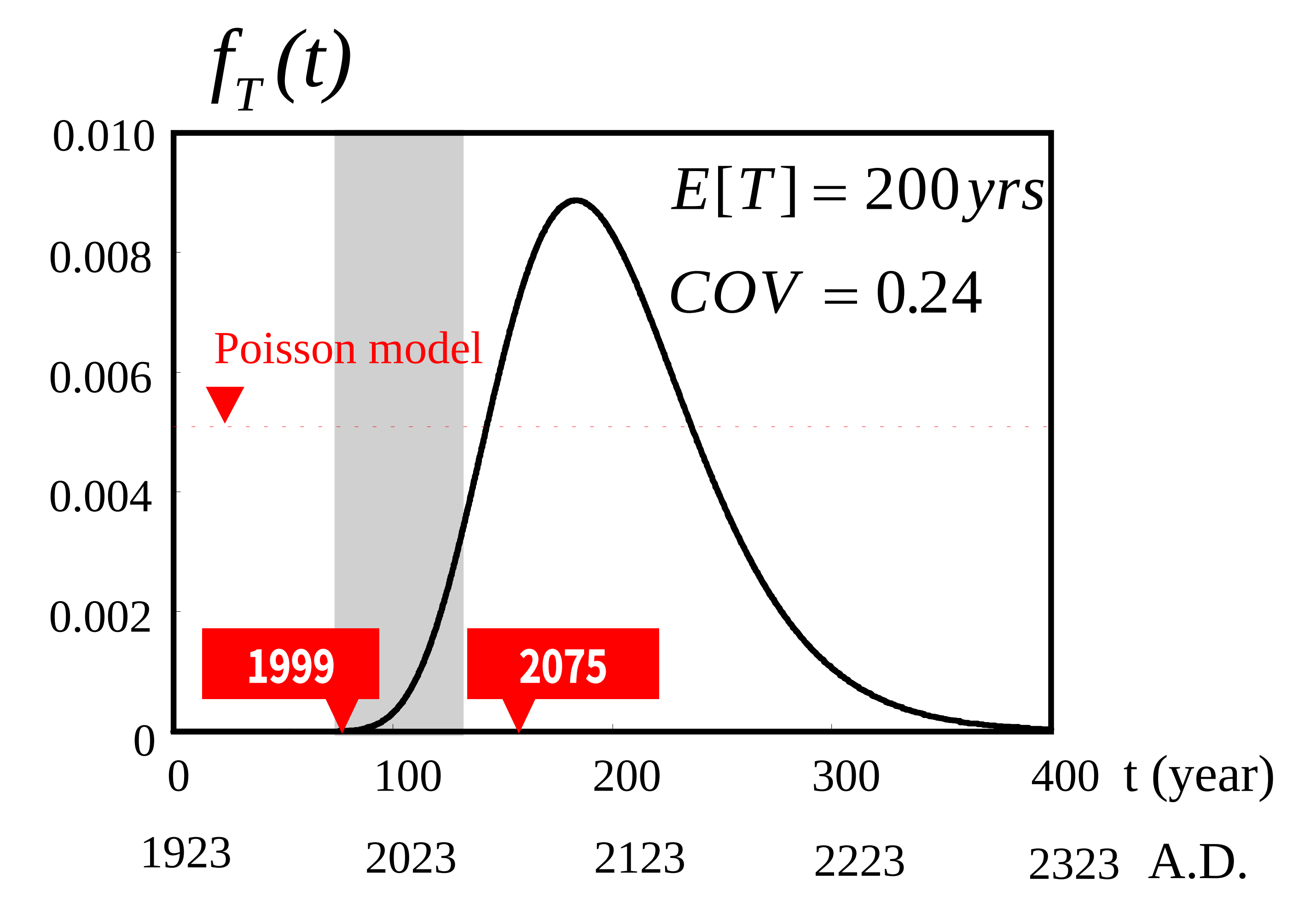

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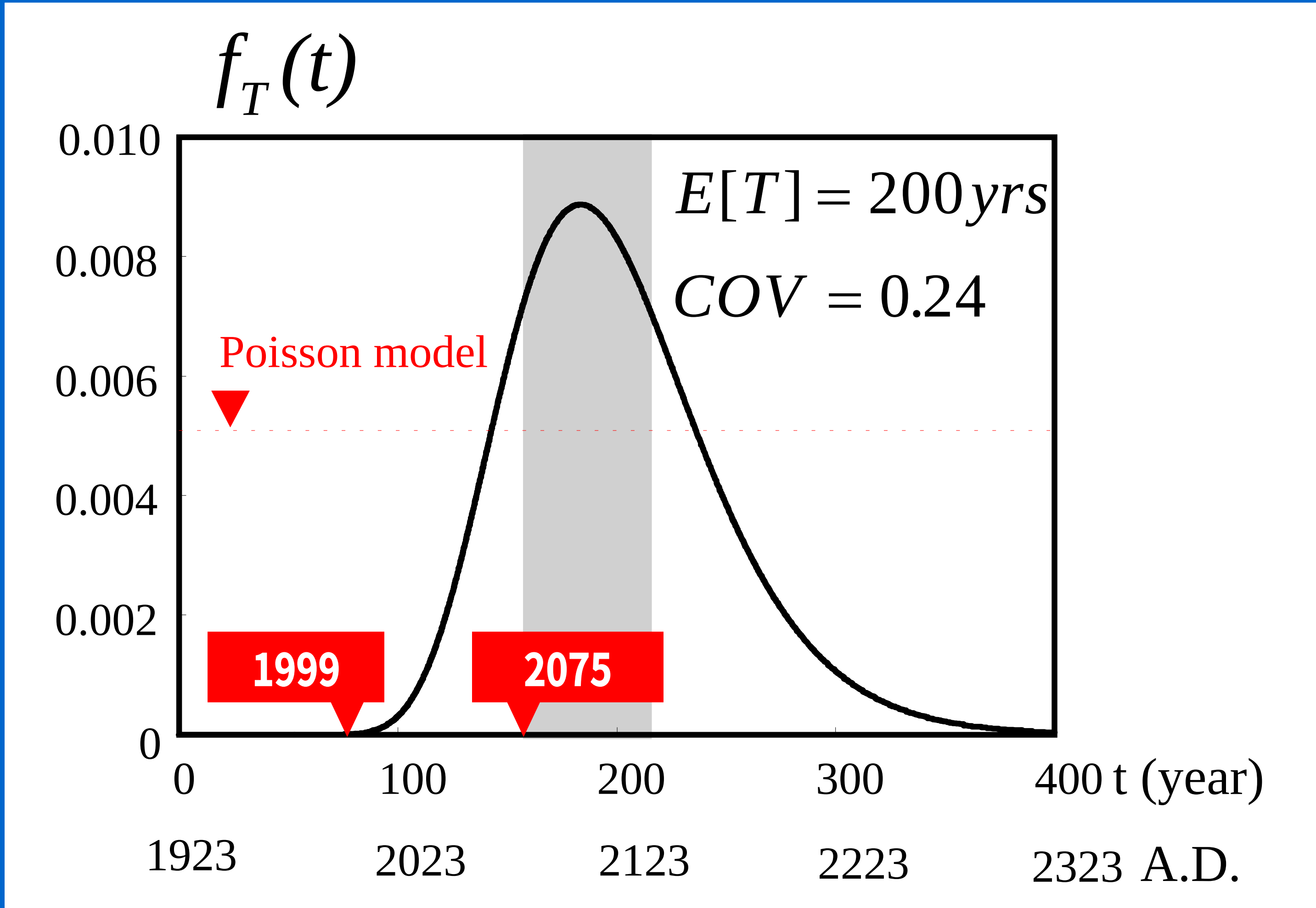
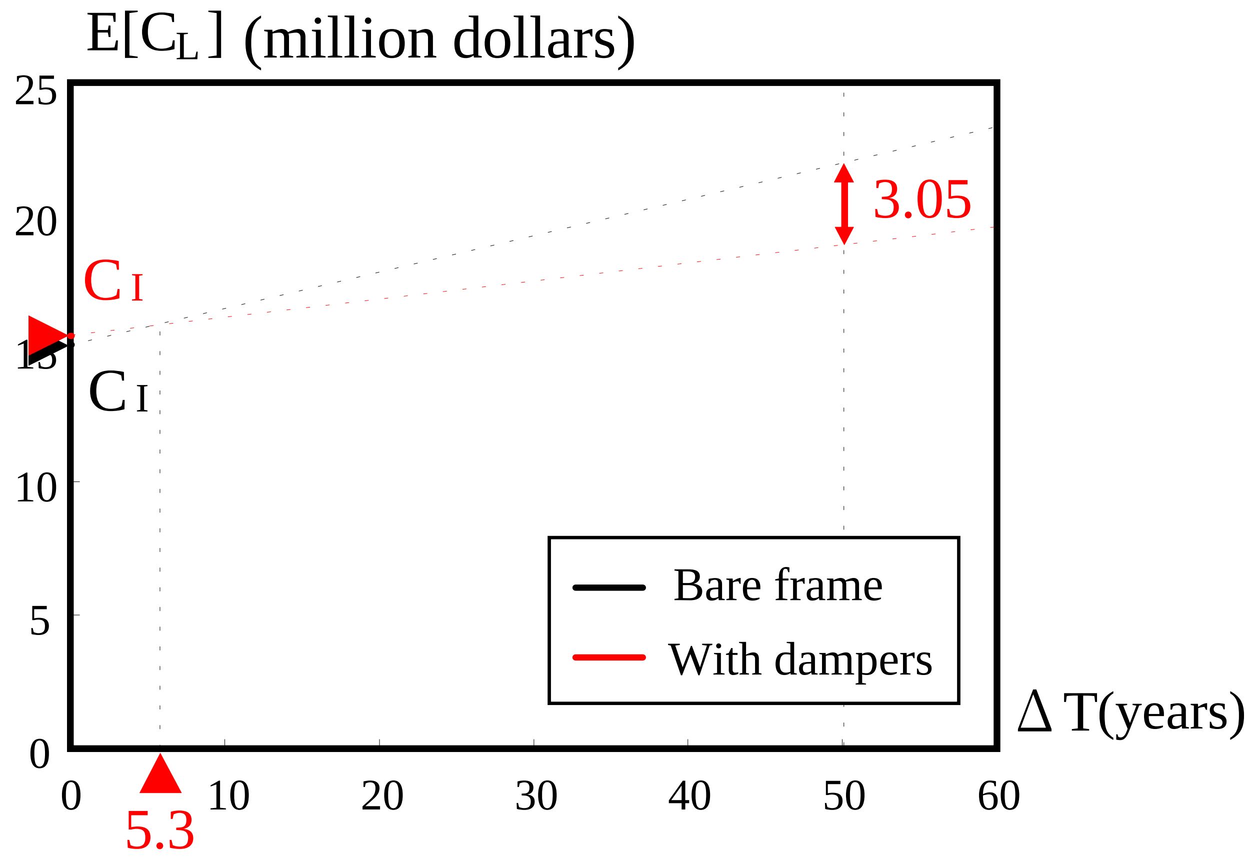


PDF of waiting time to the next earthquake

Lifetime vs. expected LCC (BPT model: t_0 = A.D.1999)



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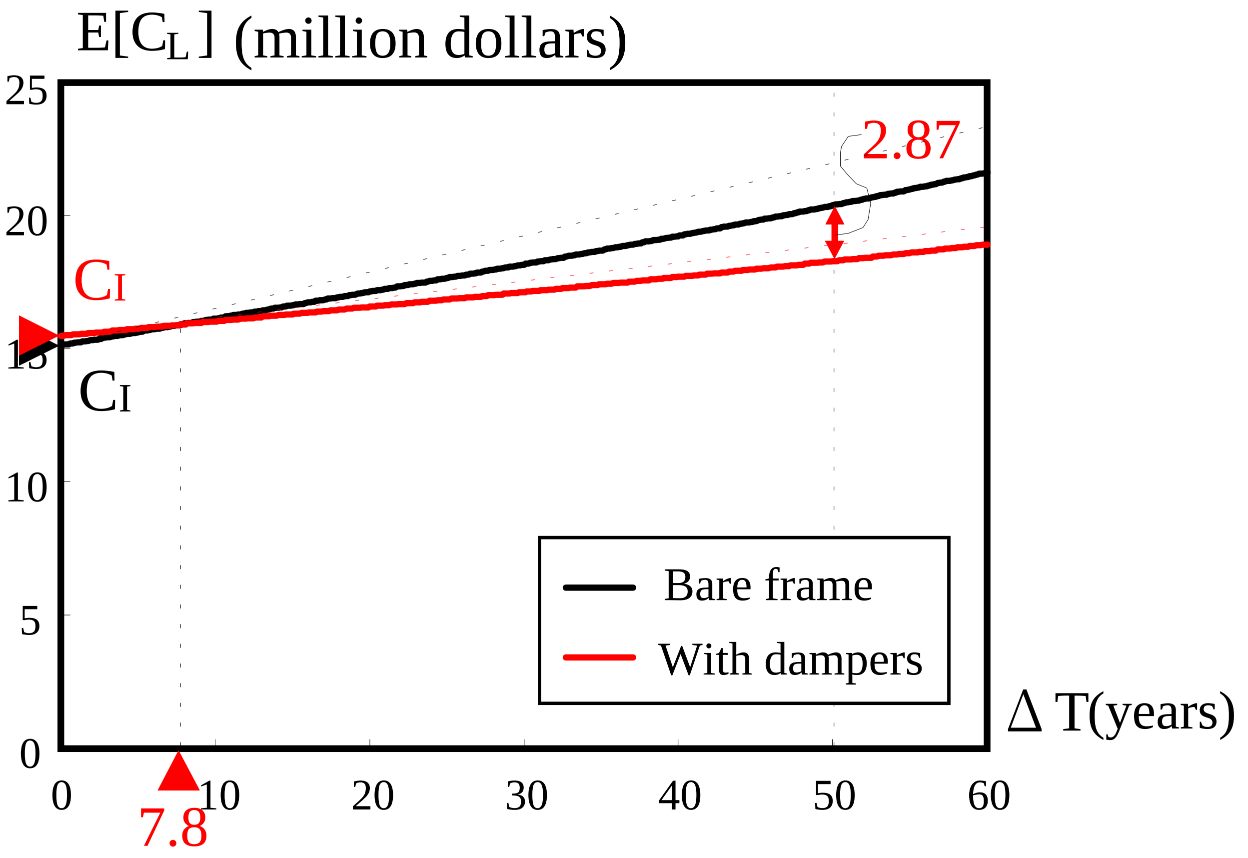
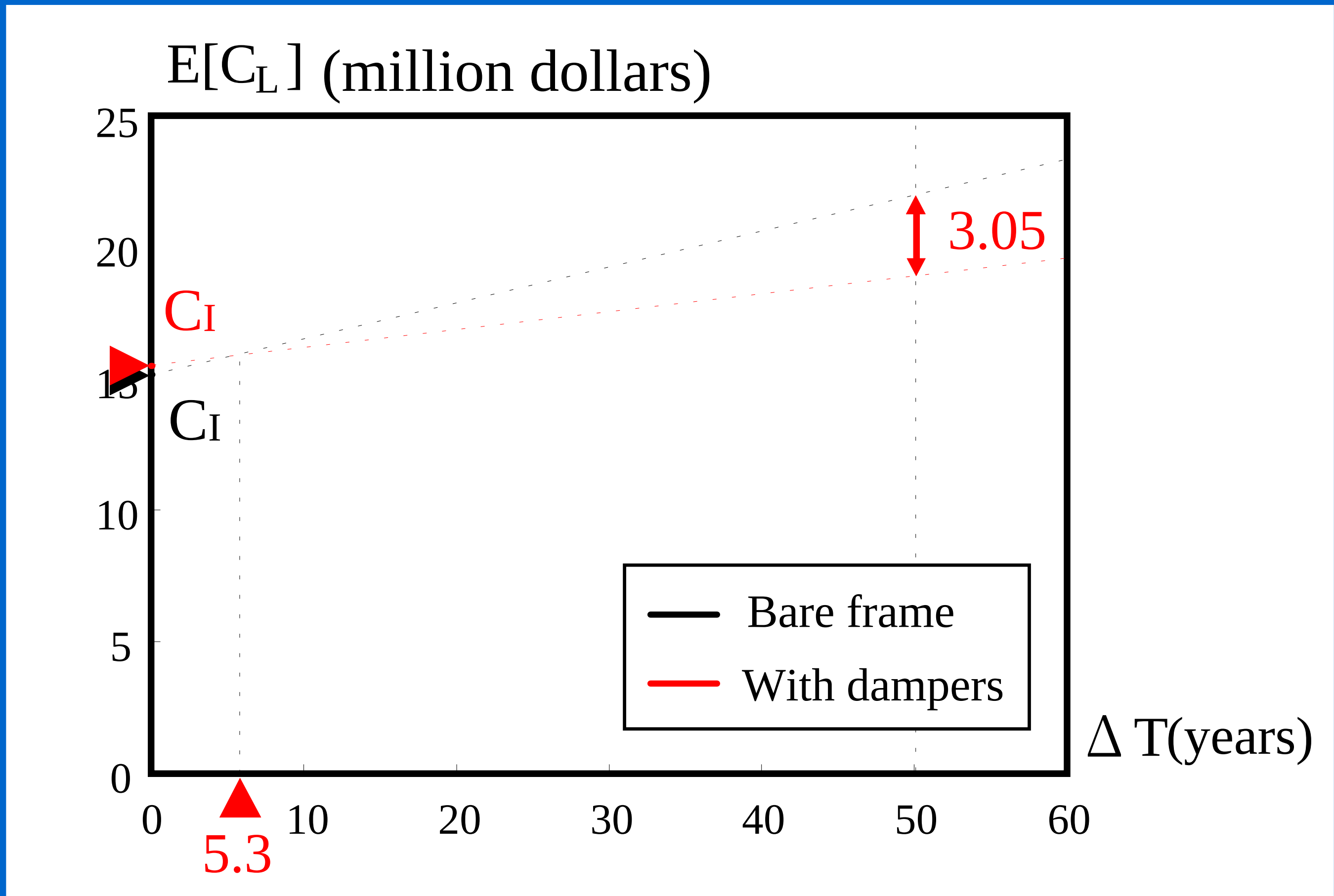
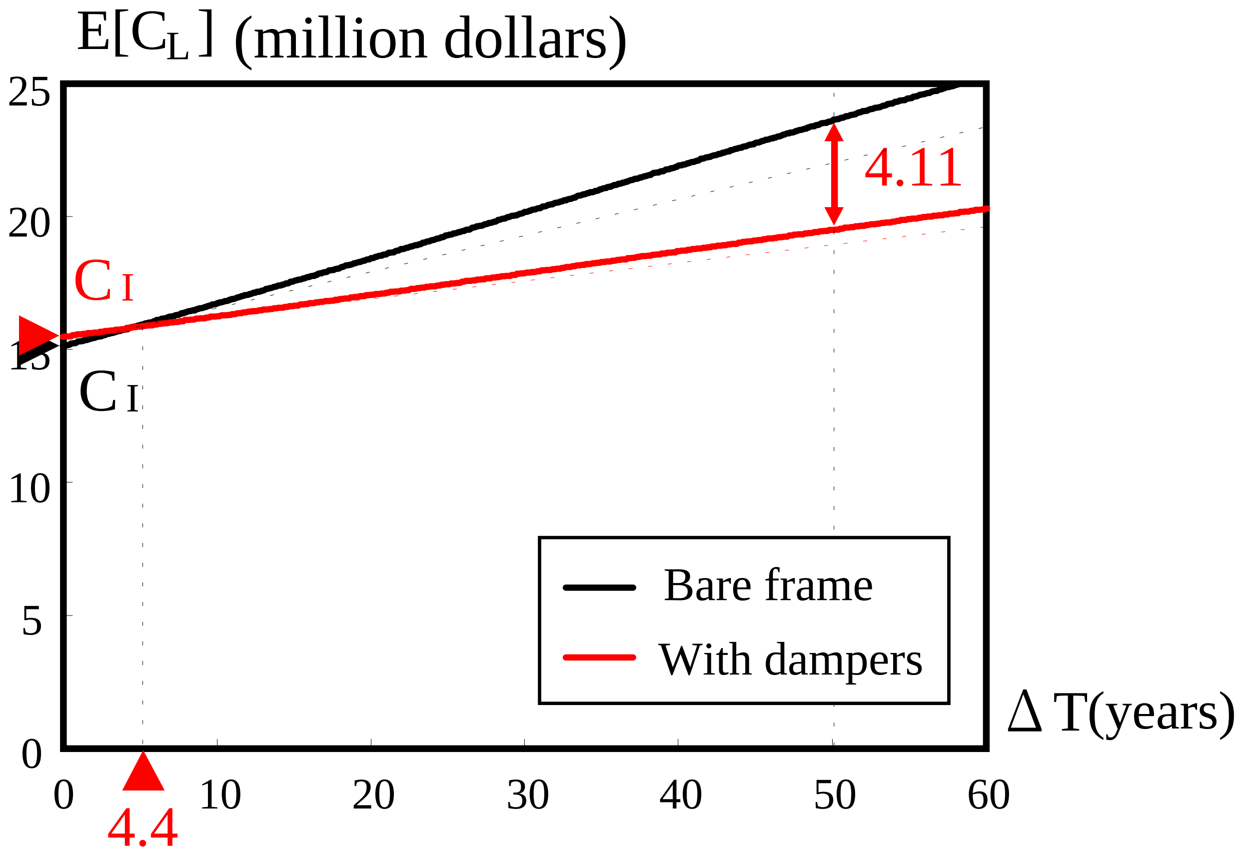


Lifetime vs. expected LCC (BPT model: t_0 = A.D.2075)



Lifetime vs. expected LCC (BPT model: t_0 = A.D.2075)



Conclusions (Basic formulation)

- Expected life-cycle cost is formulated as follows.

$$E\left[C_L\right] = C_I + \sum_{all\ sources} \sum_{j=1}^{K} E\left[C_D(m_j)\right] \int_{t_0}^{t_0+\Delta T} \sum_{n=1}^{\infty} f_{T_{nth}}(m_j, t | T > t_0) dt$$

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1. Strong motion seismology
2. Geotechnical engineering
3. Structural engineering
4. Social economics, etc.

Conclusions (Case study)

- Installation of oil dampers is effective in reducing expected life-cycle cost in the KKE building.

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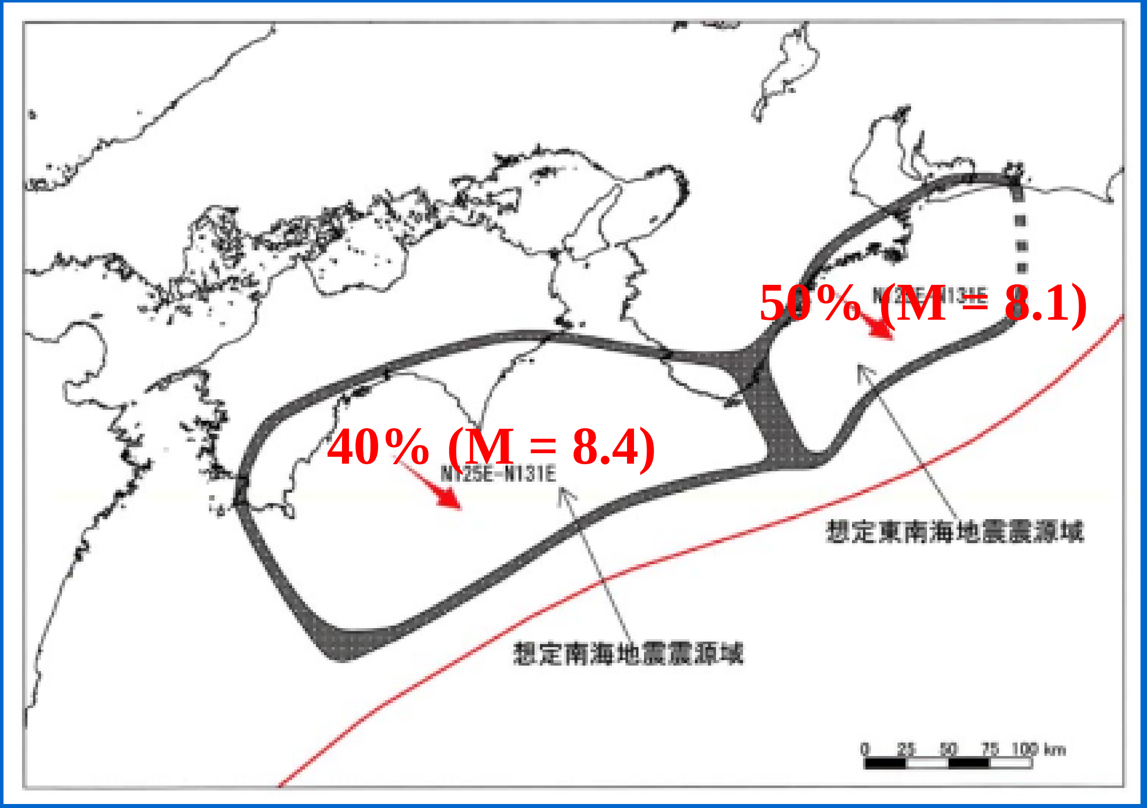
◆ Installation of oil dampers is effective in reducing expected life-cycle cost in the KKE building.

◇ The appropriate initial investment is cost-effective, in particular, in seismically active region.

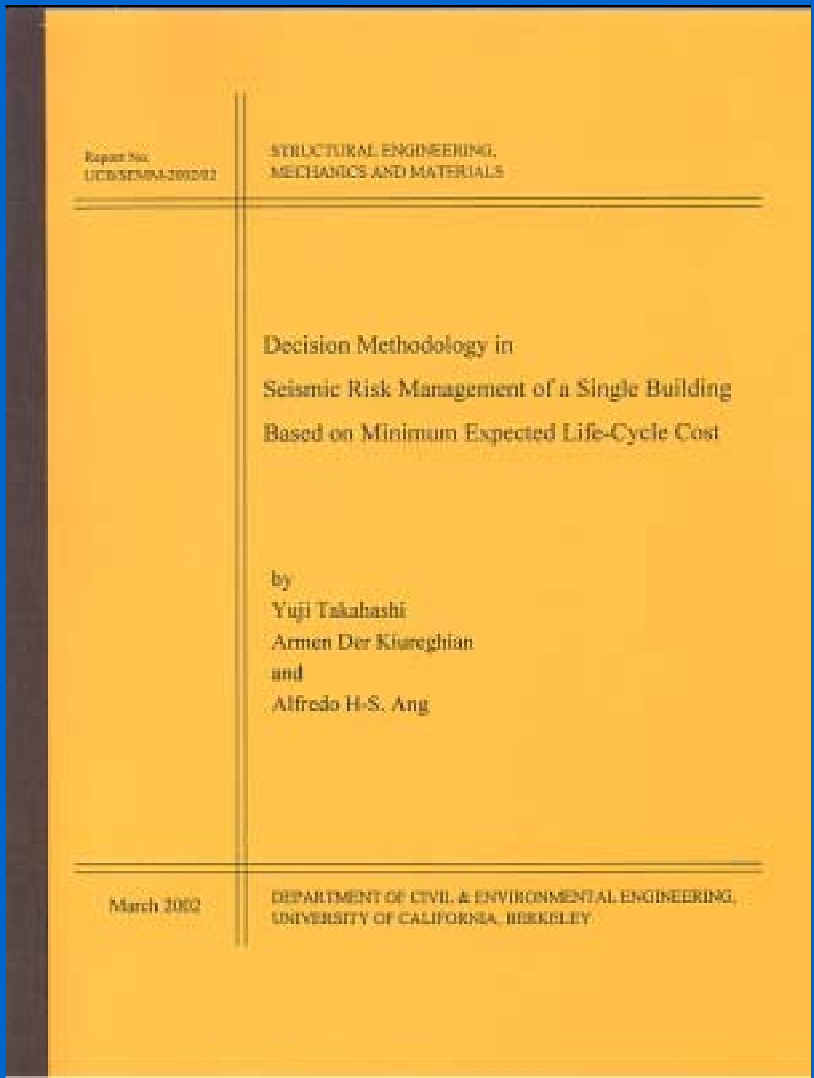
Current study

Application to seismically active regions



(HERP, 2001)

Details in UCB/SEMM Report


STRUCTURAL ENGINEERING,
MECHANICS AND MATERIALS

Decision Methodology in
Seismic Risk Management of a Single Building
Based on Minimum Expected Life-Cycle Cost

by
Yuji Takahashi
Armen Der Kiureghian
and
Alfredo H-S. Ang

March 2002

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