Risk & Safety in Engineering

Dr. Jochen Köhler

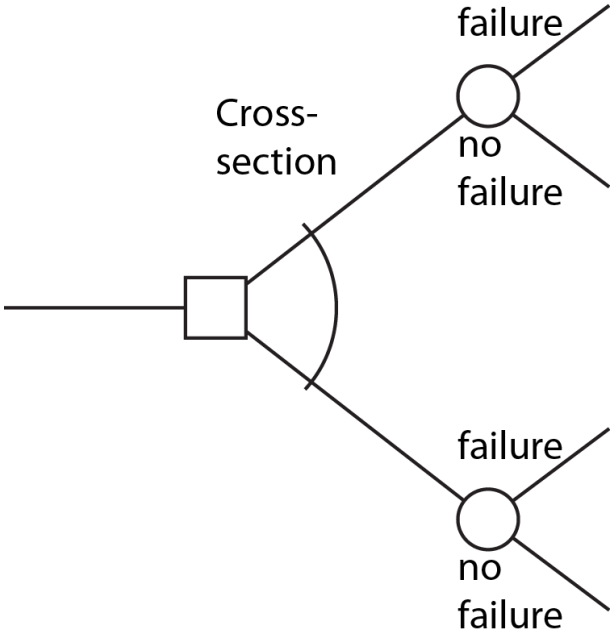
Content of today

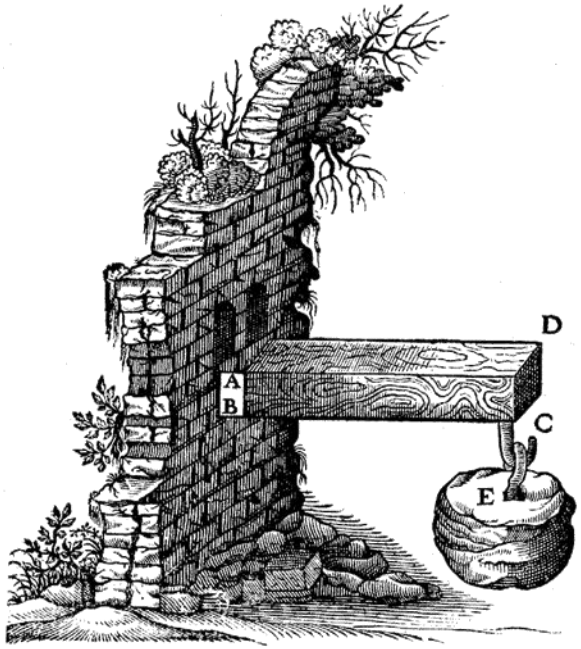
Repitition: Decision trees and examples

The Concept of Utility

Structural Engineering Decision Problem:

What is the proper cross section ?





Drawing: Leonardo da Vinci

Structural Engineering Decision Problem:

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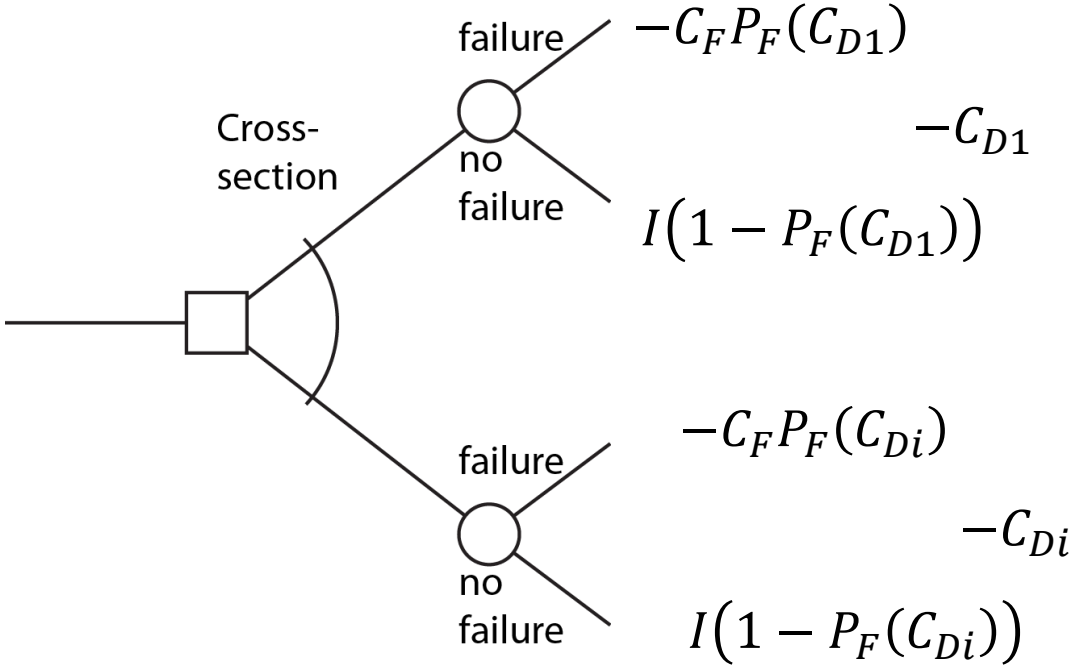

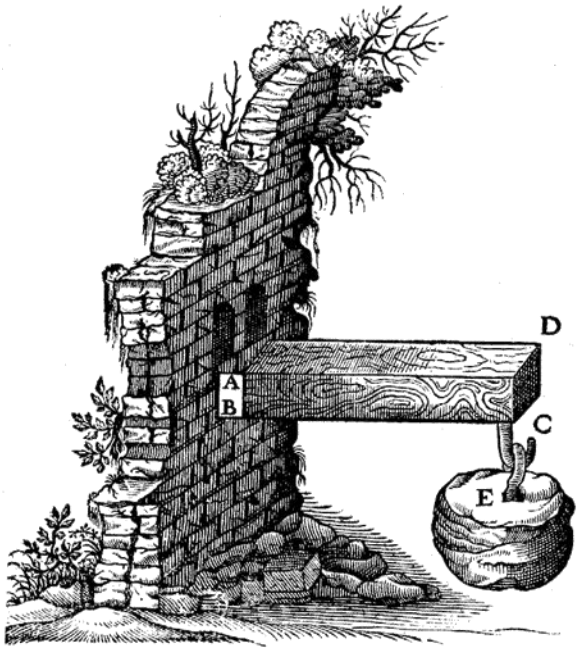

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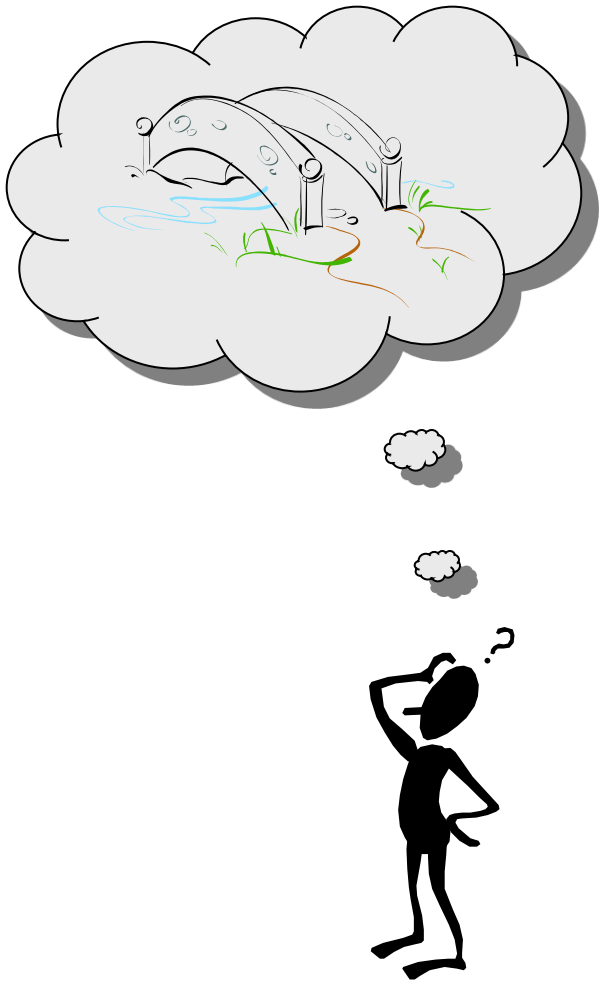
Structural Engineering Decision Problem:

Optimal Design:



Expected Benefit of the Structure

Benefit of the Structure in Service

Reliability

Risk

$$E[B] = I\left(1 - P_F\left(C_D\right)\right) - C_D - C_F P_F\left(C_D\right)$$

C_D : *Design Cost*;

C_F : *Failure Cost*;

P_F : *Failure Probability*

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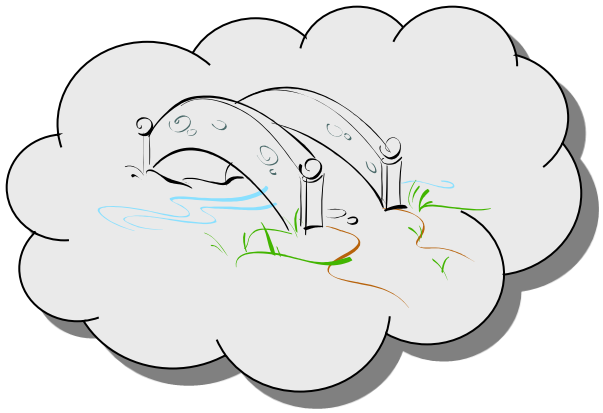

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$$E[B] = I\left(1 - P_F\left(C_D\right)\right) - C_D - C_F P_F\left(C_D\right) \Rightarrow \frac{\partial E[B]}{\partial C_D} = 0$$

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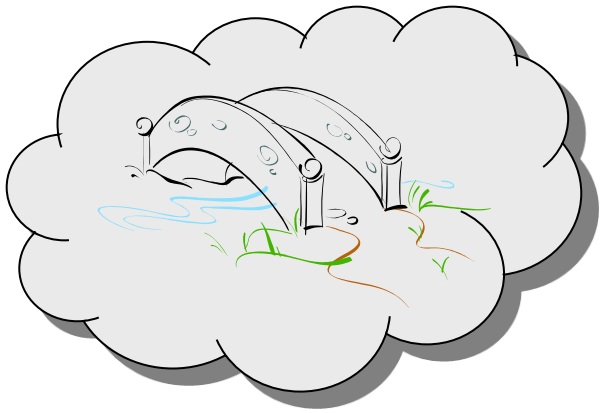

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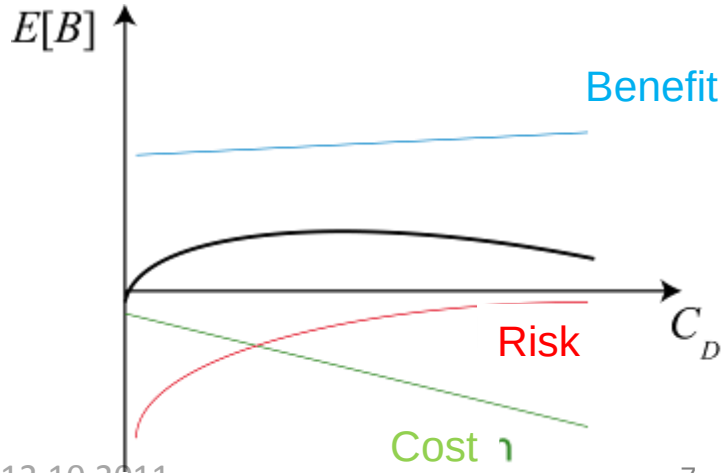

The probability of failure plays an important role !!!

The Concept of Utility

- Utility is one of the two ingredients of risk based decision making.

- Utility is in general expressed in terms of attributes, e.g.:
  - Cost
  - Life safety
  - Noise
  - Environmental impact
  - Travel time
  - Traffic capacity
  - Etc.

- The essence of utility is to transform attributes into a single scale.

The Concept of Utility

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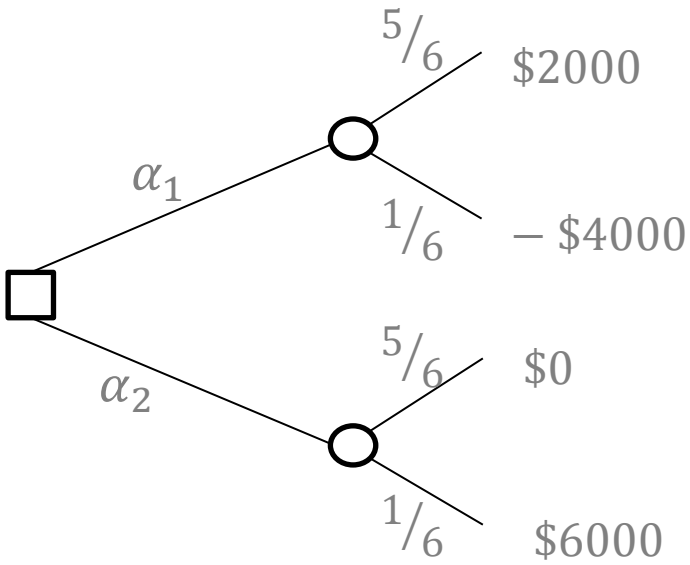

The Concept of Utility

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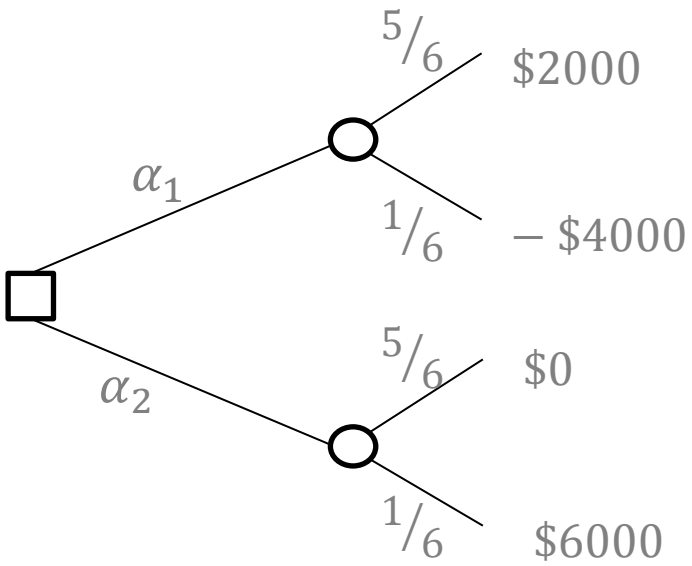
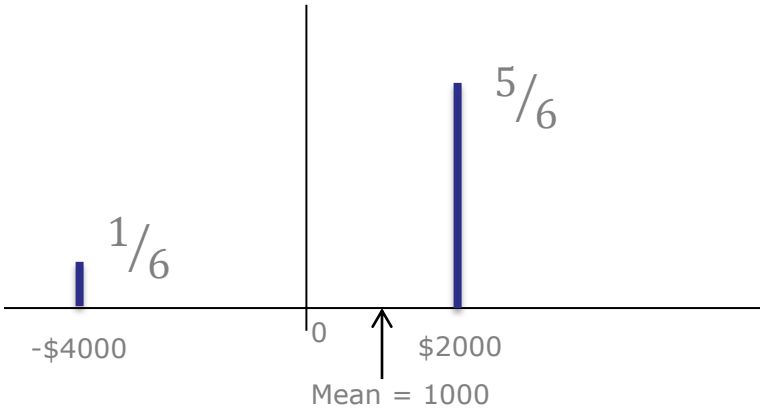
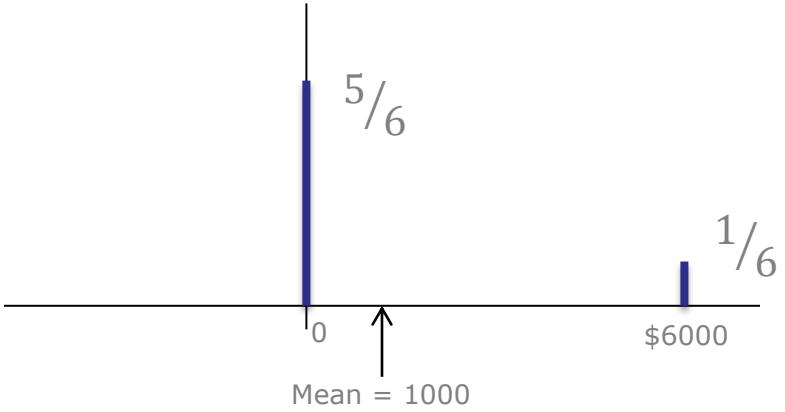


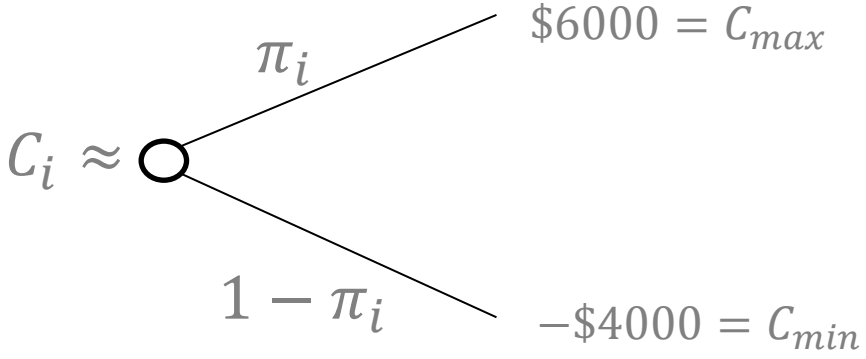




The Concept of Utility

- Basic reference lottery tickets (example cont.)
  - Idea: assign $\pi's$ that «certainty equivalents» are obtained based on a reference lottery.

$$\mathbf{C} = \begin{pmatrix} \$6000 \\ \$2000 \\ \$0 \\ -\$4000 \end{pmatrix}$$



The Concept of Utility

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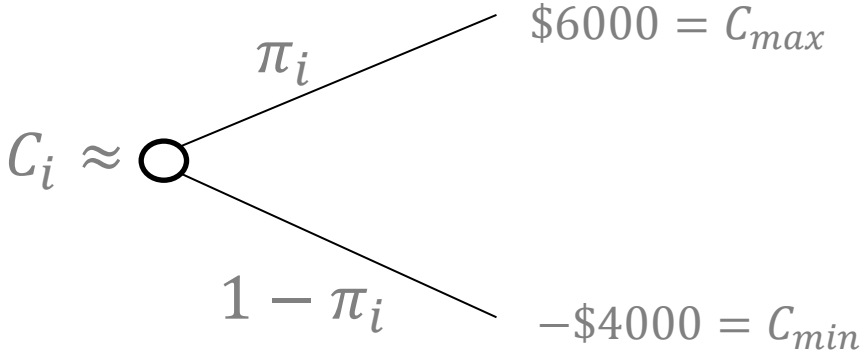
C_i	π_i
$6000	1
$2000	0.92
$0	0.8
-$4000	0



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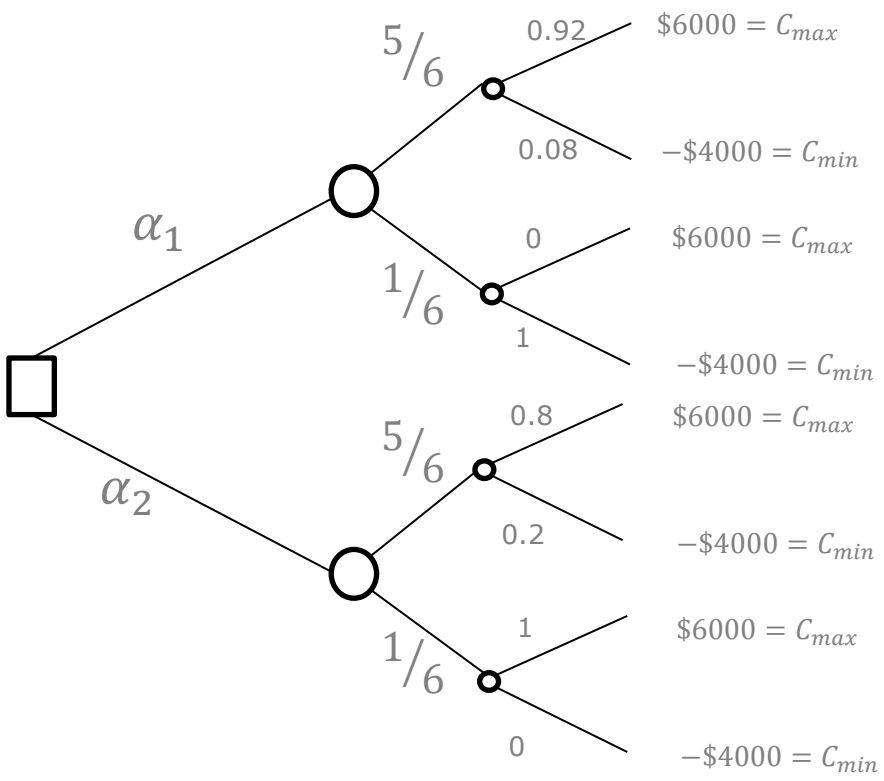

$2000

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$0

$6000