Risk and Safety in Engineering

Prof. Dr. Michael Havbro Faber
Swiss Federal Institute of Technology
ETH Zurich, Switzerland
Contents of Today's Lecture

• The organisation of the lecture – practical stuff

• Why risk and safety in engineering?

• Decision problems in engineering

• Examples

• The lecture program
Organisation of the Lecture

• Course webpage address is: http://www.ibk.ethz.ch/fa/education/ws_safety/index

• Available on course webpage:
  ▪ Lecture notes for the entire course (non-printable version)
  ▪ Exercises
  ▪ Exercise Solutions

▪ Print edition of lecture notes for the entire course is available for a cost of CHF 45.

▪ PowerPoint presentations for each lecture will be uploaded on the webpage the latest one day before the respective lecture.

• Support will be available – you are welcome to contact Prof. Michael Faber in room HIL E 23.3 or contact Harikrishna Narasimhan in room HIL E 13.1 or by email (harikrishna@ibk.baug.ethz.ch)
Examination

• The exam for the course is an oral examination
  - the emphasis of the exam is to ensure that a fundamental understanding of the area of risk and safety in engineering is acquired by the students

• The confirmation (or “testat”) for admission to the examination is fulfilled by attending the lectures of the course.

• Doctoral students need to take the oral examination in order to get credit points for this course.
Why Risk and Safety in Engineering?

- What do engineers do?
- Plan, design, build, maintain and decommission
  - Infrastructure
    - Roads, water supply systems, tunnels, sewage systems, waste deposits, power supply systems, channels
  - Structures
    - Houses, hospitals, schools, industry buildings, dams, power plants, wind turbines, offshore platforms
- Safeguard
  - People
  - Environment
  - Assets
  - SUSTAINABLE DEVELOPMENT

from natural and man made hazards

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Engineering Decision Making for Society

- What do engineers do?

Is what we are doing of any relevance for society?
Engineering Decision Making for Society

- Examples of what we help to develop

Golden Gate Bridge - USA
Øresund bridge - Denmark
Engineering Decision Making for Society

• Examples of what we help to develop

Big Dig Boston/USA
Engineering Decision Making for Society

- Examples of what we help to develop

Hoover Dam - USA
Engineering Decision Making for Society

• Examples of what we help to develop

Hong Kong Island - China
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- Helping to control risks due to natural hazards

Tornados and strong winds
Engineering Decision Making for Society

- Helping to control risks due to natural hazards

Earthquakes
Engineering Decision Making for Society

• Helping to control risks due to degradation

Corrosion

Fatigue
Engineering Decision Making for Society

• **Helping to control risks due to accidents**

Fires

Explosions
Engineering Decision Making for Society

• Helping to control risks due to lack of knowledge

Over load

Design error
Engineering Decision Making for Society

- Helping to control risks due to malevolence

Bomb explosions

Airplane impacts
Why Risk and Safety in Engineering?

• What are engineers working with?

Real problems – the real world - nature

- Gravity
- Dynamics
- Concrete
- Waves
- Ice
- New materials
- Snow
- Temperature
- Water
- Soil
- Waste
- Rocks
- Chemicals
- Electricity
- Steel
- Wind
Why Risk and Safety in Engineering?

• How do engineers work with the real world?

We model the real world to the “best” of our knowledge.
Why Risk and Safety in Engineering?

• How do engineers use knowledge?

In a perfectly known world

- Models
- Costs/Benefits
- Decisions
Why Risk and Safety in Engineering?

- How do engineers establish knowledge?
Why Risk and Safety in Engineering?

- How do engineers use knowledge?
  - Data
  - Experience

Models

Uncertainty

- Models are not precise
- Data are not sufficient
- Natural variability
- Experience is subjective
Why Risk and Safety in Engineering?

- How do engineers make decisions

Data \rightarrow Models \rightarrow Costs/Benefits \rightarrow Decisions

Experience

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Why Risk and Safety in Engineering?

All activities are associated with uncertainties

Activities could be:

- Transport
- Work
- Sport

but also

- Production of energy
- Exploitation of resources
- Construction and operation of production and infrastructure projects
- Research and development

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Why Risk and Safety in Engineering?

Every day we must make decisions in regard to activities associated with uncertainties.

- Car driving
- Cooking
- Smoking
- Mountain climbing
- Surfing
- Stock trading
- Crossing the street

Every one of these activities is associated with uncertainties. We all have an opinion regarding the associated risks. We have gut feelings!
Why Risk and Safety in Engineering?

Disasters and accidents have always occurred

Some examples

Tacoma Narrows, Washington, 1940

Fort Mayer, Virginia, 1908

Open questions
- did we realise the risks?
- are the consequences acceptable?
Why Risk and Safety in Engineering?

Disasters and accidents have always occurred

Some examples

Kobe, 1995

Open questions
- did we realise the risks?
- are the consequences acceptable?
Why Risk and Safety in Engineering?

Disasters and accidents have always occurred

Some examples

Minneapolis, Minnesota, 2007

Open questions
- did we realise the risks ?
- are the consequences acceptable ?

New York, 2001

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Why Risk and Safety in Engineering?

Disasters and accidents have always occurred

Some examples

Open questions
- did we realise the risks?
- are the consequences acceptable?

Hurricane Katrina, New Orleans, 2005
Why Risk and Safety in Engineering?

Risk assessment, within the framework of decision analysis, provides a basis for rational decision making subject to uncertain and / or incomplete information.

Thereby we can take into account, in a consistent manner, the prevailing uncertainties and quantify their effect on risks.

Thus we may find answers to the following questions:

- How large is the risk associated with a given activity?
- How may we reduce and / or mitigate risks?
- How much does it cost to reduce and / or mitigate risks?
- What risks can we accept – what can we afford?
Definition of Risk

**Risk** is a characteristic of an activity relating to all possible events $n_E$ which may follow as a result of the activity.

The risk contribution $R_{E_i}$ from the event $E_i$ is defined through the product between

the event probability $P_{E_i}$

and

the consequences of the event $C_{E_i}$

The risk associated with a given activity $R_A$ may then be written as

$$R_A = \sum_{i=1}^{n_E} R_{E_i} = \sum_{i=1}^{n_E} P_{E_i} \cdot C_{E_i}$$
Decision Problems in Engineering

Uncertainties must be considered in the decision making throughout all phases of the life of an engineering facility.

- Safety of personnel
- Safety of environment
- Economic feasibility

Uncertainties:
- Traffic volume
- Loads
- Resistances (material, soil,..)
- Degradation processes
- Service life
- Manufacturing costs
- Execution costs
- Decommissioning costs

Planning and feasibility study
Investigations and tests
Design
Manufacturing
Execution
Decommissioning
Operation & maintenance

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Example – Decommissioning of the Frigg Field

- The Frigg Field – built 1972-1978

  - TCP2
  - TP1
  - CDP1

According to international conventions the structures must be decommissioned

Each structure:

Weight: 250000 t
Costs: 200 – 600 million CHF

- None of the platforms were designed for decommissioning!
Decision Problems in Engineering

- Structural Design

Exceptional structures are often associated with structures of
“Extreme Dimensions”

Great Belt Bridge under Construction

Concept drawing of the Troll platform
Decision Problems in Engineering

- Structural Design

or associated with structures fulfilling

“New and Innovative Purposes”

Concept drawing of Floating Production, Storage and Offloading unit

Illustrations of the ARIANE 5 rocket

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Decision Problems in Engineering

Before

- Optimal allocation of available resources for risk reduction
- Strengthening
- Rebuilding
- In regard to possible earthquakes

During

- Damage reduction/Control
- Emergency help and rescue
- After quake hazards

After

- Rehabilitation of infrastructure functionality
- Condition assessment and updating of reliability and risks
- Optimal allocation of resources for rebuilding and strengthening

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Decision Problems in Engineering

- Inspection and Maintenance Planning

Due to
- operational loading
- environmental exposure

structures will always to some degree be exposed to degradation processes such as
- fatigue
- corrosion
- scour
- wear
Decision Problems in Engineering

• Inspection and Maintenance Planning

For industrial facilities inspection and maintenance is also an important issue with regard to:

- reduction of production downtime
- safety of workers
- safeguarding the environment
Decision Problems in Engineering

- Inspection and Maintenance Planning

For industrial facilities inspection and maintenance is also an important issue with regard to:

- reduction of production downtime
- safety of workers
- safeguarding the environment
Decision Problems in Engineering
Decision Problems in Engineering

New emerging challenges have necessitated exceptional requirements with regard to construction management and safety.
The Risk Based Decision Process

Decisions → Criteria

Collection of Information → Decisions
Actions → Criteria

System

World

System boundary

Present

Future

Transfer of benefit, cost and reduced resources
The Risk Based Decision Process

Risk assessment supports decision making subject to uncertainties

The theoretical basis for risk based decision making is the theory of decision analysis

The main task is to optimally manage risks in terms of life safety, economic losses as well as potential damages to the environment
The Risk Based Decision Process

The risk assessment can be categorized according to the degree of detail.

**Level 1:**
Analysis of the probabilities of occurrence of critical events.

**Level 2:**
Analysis of the probabilities of occurrence of critical events and the corresponding consequences.

**Level 3:**
As for level 2, but with consideration of human errors as well as potential loss of lives – if relevant.

Categorization of risk assessments is useful!

Documents to what detail the risk assessment was performed!
Life Quality

- Demographical indicators

- Gross domestic product (GDP) per capita

![Graph showing GDP per capita from 1950 to 2010. The graph illustrates a steady increase in GDP per capita over the years, with a significant rise during the late 1990s and early 2000s.](image-url)
Life Quality

- Demographical indicators
  - Life expectancy at birth

![Graph showing life expectancy at birth from 1880 to 2000](image)
Life Quality

- Life quality can be assessed through the
  
  “Human Development Index” (UNO) or
  “Life Quality Index” (JCSS)

as a function of GDP, life expectancy, free time,…

GDP and life expectancy are important components

10-20% of the GDP is reinvested into life saving activities

Maintenance of infrastructure costs around 10-15 per cent of the available GDP

Cost efficiency is of tremendous importance!
Individual Risks

Based on statistical information the contribution to life risks of different activities may be assessed

<table>
<thead>
<tr>
<th>Activity/course</th>
<th>Number of fatalities per hour per 10^8 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountaineering (international)</td>
<td>2700</td>
</tr>
<tr>
<td>Aviation transport (international)</td>
<td>120</td>
</tr>
<tr>
<td>Deep sea travelling</td>
<td>59</td>
</tr>
<tr>
<td>Auto traffic</td>
<td>56</td>
</tr>
<tr>
<td>Mining (coal)</td>
<td>21</td>
</tr>
<tr>
<td>Construction work</td>
<td>7.7</td>
</tr>
<tr>
<td>Manufacturing/production</td>
<td>2.0</td>
</tr>
<tr>
<td>Accidents at home</td>
<td>2.1</td>
</tr>
<tr>
<td>Accidents at home (healthy persons)</td>
<td>0.7</td>
</tr>
<tr>
<td>Fires at home</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Structural failures</strong></td>
<td><strong>0.002</strong></td>
</tr>
</tbody>
</table>
Individual Risks

- Accidents account only for 4% of all deaths

Illness such as heart failure, cancer and strokes account for 58%

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>probability/year</th>
<th>probability/lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport Accidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pedestrian</td>
<td>2.13E-05</td>
<td>1.64E-03</td>
</tr>
<tr>
<td>- Pedal cyclist</td>
<td>2.78E-06</td>
<td>2.14E-04</td>
</tr>
<tr>
<td>- Motorcycle rider</td>
<td>1.07E-05</td>
<td>8.24E-04</td>
</tr>
<tr>
<td>- Car occupant</td>
<td>5.24E-05</td>
<td>4.05E-03</td>
</tr>
<tr>
<td>- Occupant of heavy transport vehicle</td>
<td>1.31E-06</td>
<td>1.01E-04</td>
</tr>
<tr>
<td>- Bus occupant</td>
<td>1.30E-07</td>
<td>1.00E-05</td>
</tr>
<tr>
<td>- Animal rider or occupant of animal-drawn vehicle</td>
<td>4.07E-07</td>
<td>3.14E-05</td>
</tr>
<tr>
<td>- Occupant of railway train or railway vehicle</td>
<td>9.12E-08</td>
<td>7.04E-06</td>
</tr>
<tr>
<td>- Air and space transport accidents</td>
<td>3.22E-06</td>
<td>2.49E-04</td>
</tr>
<tr>
<td>Non-transport Accidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Falls</td>
<td>5.27E-05</td>
<td>4.07E-03</td>
</tr>
<tr>
<td>- Struck by or against another person</td>
<td>1.58E-07</td>
<td>1.22E-05</td>
</tr>
<tr>
<td>- Accidental drowning and submersion</td>
<td>1.15E-05</td>
<td>8.88E-04</td>
</tr>
<tr>
<td>- Exposure to electric current, radiation, temperature, and pressure</td>
<td>1.51E-06</td>
<td>1.17E-04</td>
</tr>
<tr>
<td>- Exposure to smoke, fire and flames</td>
<td>1.16E-05</td>
<td>8.96E-04</td>
</tr>
<tr>
<td>- Uncontrolled fire in building or structure</td>
<td>9.38E-06</td>
<td>7.24E-04</td>
</tr>
<tr>
<td>- Contact with venomous animals and plants</td>
<td>2.14E-07</td>
<td>1.65E-05</td>
</tr>
<tr>
<td>- Earthquake and other earth movements</td>
<td>9.82E-08</td>
<td>7.58E-06</td>
</tr>
<tr>
<td>- Storm</td>
<td>1.89E-07</td>
<td>1.46E-05</td>
</tr>
<tr>
<td>- Flood</td>
<td>1.23E-07</td>
<td>9.48E-06</td>
</tr>
<tr>
<td>- Lightning</td>
<td>1.54E-07</td>
<td>1.19E-05</td>
</tr>
<tr>
<td>- Alcohol</td>
<td>1.06E-06</td>
<td>8.20E-05</td>
</tr>
<tr>
<td>- Narcotics and hallucinogens</td>
<td>2.28E-05</td>
<td>1.76E-03</td>
</tr>
<tr>
<td>Intentional self-harm</td>
<td>1.07E-04</td>
<td>8.26E-03</td>
</tr>
<tr>
<td>Assault</td>
<td>7.12E-05</td>
<td>5.49E-03</td>
</tr>
<tr>
<td>Legal intervention</td>
<td>1.39E-06</td>
<td>1.07E-04</td>
</tr>
<tr>
<td>Operations of war</td>
<td>5.96E-08</td>
<td>4.60E-06</td>
</tr>
<tr>
<td>Complications of medical and surgical care</td>
<td>1.06E-05</td>
<td>8.18E-04</td>
</tr>
</tbody>
</table>
Individual Risks

• Occupational risks

<table>
<thead>
<tr>
<th>Occupation sector</th>
<th>% of employees</th>
<th>Fatalities per 100,000 employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private industry</td>
<td>90</td>
<td>4.2</td>
</tr>
<tr>
<td>- Agriculture, forestry and fishing</td>
<td>14</td>
<td>22.7</td>
</tr>
<tr>
<td>- Mining</td>
<td>2</td>
<td>23.5</td>
</tr>
<tr>
<td>- oil and gas exploitation</td>
<td>1</td>
<td>23.1</td>
</tr>
<tr>
<td>- Construction</td>
<td>20</td>
<td>12.2</td>
</tr>
<tr>
<td>- Manufacturing</td>
<td>10</td>
<td>3.1</td>
</tr>
<tr>
<td>- Transportation and public utilities</td>
<td>16</td>
<td>11.3</td>
</tr>
<tr>
<td>- Wholesale trade</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>- Retail trade</td>
<td>9</td>
<td>2.1</td>
</tr>
<tr>
<td>- Finance, insurance, and real estate</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>- Services</td>
<td>12</td>
<td>1.7</td>
</tr>
<tr>
<td>Government</td>
<td>10</td>
<td>2.7</td>
</tr>
<tr>
<td>- Federal (including resident armed forces)</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>4.0</td>
</tr>
</tbody>
</table>
## Individual Risks

### Natural disasters

<table>
<thead>
<tr>
<th>Victims</th>
<th>Insured losses</th>
<th>Event</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 000</td>
<td>–</td>
<td>Storm and flood catastrophe</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>250 000</td>
<td>–</td>
<td>Earthquake in Tangshan (8.2 Richter scale)</td>
<td>China</td>
</tr>
<tr>
<td>138 000</td>
<td>3</td>
<td>Tropical cyclone Gorky</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>60 000</td>
<td>–</td>
<td>Earthquake (7.7 Richter scale)</td>
<td>Peru</td>
</tr>
<tr>
<td>50 000</td>
<td>156</td>
<td>Earthquake in Gilan</td>
<td>Iran</td>
</tr>
<tr>
<td>25 000</td>
<td>–</td>
<td>Earthquake in Armenia</td>
<td>Armenia, ex-USSR</td>
</tr>
<tr>
<td>25 000</td>
<td>–</td>
<td>Earthquake in Tabas</td>
<td>Iran</td>
</tr>
<tr>
<td>23 000</td>
<td>–</td>
<td>Volcanic eruption on Nevado del Ruiz</td>
<td>Colombia</td>
</tr>
<tr>
<td>22 000</td>
<td>233</td>
<td>Earthquake (7.4 Richter scale)</td>
<td>Guatemala</td>
</tr>
<tr>
<td>19 118</td>
<td>1063</td>
<td>Earthquake in Izmit</td>
<td>Turkey</td>
</tr>
<tr>
<td>15 000</td>
<td>100</td>
<td>Earthquake (moment magnitude 7.7) in Gujarat</td>
<td>India, Pakistan</td>
</tr>
<tr>
<td>15 000</td>
<td>106</td>
<td>Cyclone 05B devastates Orissa state</td>
<td>India, Bangladesh</td>
</tr>
<tr>
<td>15 000</td>
<td>–</td>
<td>Flooding following monsoon rains in northern parts</td>
<td>India</td>
</tr>
<tr>
<td>15 000</td>
<td>530</td>
<td>Earthquake (8.1 Richter scale)</td>
<td>Mexico</td>
</tr>
<tr>
<td>15 000</td>
<td>–</td>
<td>Dyke burst in Morvi</td>
<td>India</td>
</tr>
<tr>
<td>10 800</td>
<td>–</td>
<td>Flooding in Bay of Bengal and Orissa state</td>
<td>India</td>
</tr>
<tr>
<td>10 000</td>
<td>234</td>
<td>Flooding, mudslides, landslides</td>
<td>Venezuela, Colombia</td>
</tr>
</tbody>
</table>
## Individual Risks

### Malevolence - terrorism

<table>
<thead>
<tr>
<th>Victims¹</th>
<th>Insured losses²</th>
<th>Date</th>
<th>Event</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>at least 3000</td>
<td>19 000</td>
<td>11.09.2001</td>
<td>Terror attack against WTC, Pentagon and other buildings</td>
<td>USA</td>
</tr>
<tr>
<td>300</td>
<td>—</td>
<td>23.10.1983</td>
<td>Bombing of US Marine barracks and French paratrooper base in Beirut</td>
<td>Lebanon</td>
</tr>
<tr>
<td>300</td>
<td>6</td>
<td>12.03.1993</td>
<td>Series of 13 bomb attacks in Mumbai</td>
<td>India</td>
</tr>
<tr>
<td>270</td>
<td>138</td>
<td>21.12.1988</td>
<td>PanAm Boeing 747 crashes at Lockerbie due to bomb explosion</td>
<td>UK</td>
</tr>
<tr>
<td>253</td>
<td>—</td>
<td>07.08.1998</td>
<td>Two simultaneous bomb attacks on US embassy complex in Nairobi</td>
<td>Kenya</td>
</tr>
<tr>
<td>166</td>
<td>145</td>
<td>19.04.1995</td>
<td>Bomb attack on government building in Oklahoma City</td>
<td>USA</td>
</tr>
<tr>
<td>127</td>
<td>45</td>
<td>23.11.1996</td>
<td>Hijacked Ethiopian Airlines Boeing 767-260 ditched at sea</td>
<td>Indian Ocean</td>
</tr>
<tr>
<td>118</td>
<td>—</td>
<td>13.09.1999</td>
<td>Bomb explosion destroys apartment block in Moscow</td>
<td>Russia</td>
</tr>
<tr>
<td>100</td>
<td>—</td>
<td>04.06.1991</td>
<td>Arson in arms warehouse in Addis Ababa</td>
<td>Ethiopia</td>
</tr>
<tr>
<td>100</td>
<td>6</td>
<td>31.01.1999</td>
<td>Bomb attack on Ceylinco House in Colombo</td>
<td>Sri Lanka</td>
</tr>
</tbody>
</table>

¹ Dead or missing ² Excluding liability losses; in USD m, at 2001 price level
Sources of Risks in Engineering

Any activity carries a risk potential

It is important that this potential is fully understood

Only when the risk potential is fully understood can rational decisions be identified and implemented
Sources of Risks in Engineering

Case where the risk potential was not fully appreciated

The Tjörn bridge in Sweden

Just after construction
Sources of Risks in Engineering

Case where the risk potential was not fully appreciated

The Tjörn bridge in Sweden

A few weeks later
Sources of Risks in Engineering

Failures in structural engineering

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Number of samples</th>
<th>Retrofit / Disposal</th>
<th>Usage</th>
<th>Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>high rising building</td>
<td>362</td>
<td>39</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td>152</td>
<td>62</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Traffic structures</td>
<td>75</td>
<td>29</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Dams</td>
<td>51</td>
<td>10</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>Rest</td>
<td>52</td>
<td>21</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>All cases</td>
<td>692</td>
<td>40</td>
<td>58</td>
<td>58</td>
</tr>
</tbody>
</table>

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Sources of Risks in Engineering

Failures in structural engineering

<table>
<thead>
<tr>
<th>Category</th>
<th>Rest</th>
<th>Interrim structures</th>
<th>Technical</th>
<th>Site and installation</th>
<th>Fitting</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural damage</td>
<td>692</td>
<td>9</td>
<td>4</td>
<td>11</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>Cost of damages</td>
<td>692</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>72</td>
</tr>
<tr>
<td>Damage of persons</td>
<td>60</td>
<td>19</td>
<td>12</td>
<td>4</td>
<td>6</td>
<td>20</td>
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</tbody>
</table>
Sources of Risks in Engineering

Failures in structural engineering

Primary causes of structural failure

- Poor construction procedures: 54.3%
- Inadequate connection elements: 47%
- Inadequate load behavior: 42.2%
- Unclear contract information: 23.5%
- Contravention of instructions: 21.8%
- Unforeseeable events: 7.1%
- Errors in design calculations: 2.5%
- Reliance on construction accuracy: 1.8%
- Complexity of project system: 1.2%

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Aim of the lecture

• General introduction to risk and safety in engineering
• Basics and principles of risk based decision analysis
• Theory and technical aspects of risk assessment
• Methods of reliability analysis and introduction to the JCSS probabilistic model code
• Introduction to time variant and systems reliability analysis and assessment of structural robustness
• Illustration of computer tools for risk and reliability analysis
• Applications for design, assessment and maintenance planning
• Understanding of engineering optimization and risk acceptance

Swiss Federal Institute of Technology
## Organisation of the Lecture

<table>
<thead>
<tr>
<th>DATE</th>
<th>SUBJECT</th>
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<tbody>
<tr>
<td>16.09.09</td>
<td><strong>Introduction and overview</strong></td>
</tr>
<tr>
<td></td>
<td>- Life quality, risks and decision making</td>
</tr>
<tr>
<td></td>
<td>- Hazards and causes of failures</td>
</tr>
<tr>
<td>23.09.09</td>
<td><strong>Review of probability theory and statistics</strong></td>
</tr>
<tr>
<td></td>
<td>- Uncertainties in engineering modeling</td>
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<td>- Basic data analysis</td>
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<td>- Random variables and processes</td>
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<td>- Engineering model building</td>
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<tr>
<td>30.09.09</td>
<td><strong>Engineering decision analysis</strong></td>
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<td>- Prior decision analysis</td>
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<td>- Posterior decision analysis</td>
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<td>- Pre-posterior decision analysis</td>
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<tr>
<td>07.10.09</td>
<td><strong>Risk assessment in civil engineering</strong></td>
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<td>- Procedures of risk assessment</td>
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<td>- Scenario identification and analysis</td>
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<td>- System representation</td>
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<td>- Probabilities and consequences</td>
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<td>- Multi scale indicator based risk assessment</td>
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<tr>
<td>14.10.09</td>
<td><strong>Classical reliability analysis</strong></td>
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<td>- Failure rate data</td>
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<td>- The reliability function</td>
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<td>- Updating of failure rates based on data</td>
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<td>- Failure rate functions and the bath-tub curve</td>
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<tr>
<td>21.09.09</td>
<td><strong>Structural reliability analysis</strong></td>
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<tr>
<td></td>
<td>- First and Second Order Reliability Methods</td>
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<td>- Monte Carlo and importance sampling</td>
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<tr>
<td>28.09.09</td>
<td><strong>Software tools for reliability analysis</strong></td>
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<tr>
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<td>- Presentation of the COMREL program</td>
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<td>- Exercises in the PC-lab</td>
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<tr>
<td>04.11.09</td>
<td><strong>The JCSS probabilistic model code</strong></td>
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<tr>
<td></td>
<td>- Probabilistic modeling of resistances</td>
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<td>- Probabilistic modeling of loads</td>
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<tr>
<td>11.11.09</td>
<td><strong>Systems reliability analysis and robustness</strong></td>
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<td>- Series and parallel system analysis</td>
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<td>- Structural systems analysis</td>
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<td>- Robustness assessment of structures</td>
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<td>18.11.09</td>
<td><strong>Time variant reliability analysis</strong></td>
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<tr>
<td></td>
<td>- The Poisson and the Normal processes</td>
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<td>- The first excursion problem and mean out crossing rates</td>
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<td>- Approximations in time variant reliability analysis</td>
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<td>- Treatment of non ergodic variables and random sequences</td>
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<tr>
<td>25.11.09</td>
<td><strong>Bayesian Probabilistic Nets (BPN) in risk assessment</strong></td>
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<td>- Basic theory of BPN</td>
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<td>- Application of BPN in risk assessment</td>
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<td>- Application of BPN in large scale risk management</td>
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<tr>
<td>02.12.09</td>
<td><strong>Reliability based structural design and assessment</strong></td>
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<tr>
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<td>- Safety formats of design codes</td>
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<td>- Calibration of design codes</td>
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<td>- Reliability updating</td>
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<td>- Assessment of existing structures (and SIA 269)</td>
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<td>09.12.09</td>
<td><strong>Risk based inspection and maintenance planning</strong></td>
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<td>- The basic problem</td>
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<td>- Modeling of degradation processes</td>
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<td>- Inspection quality and the PoD concept</td>
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<td>- Generic approaches to inspection planning</td>
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<td>16.12.09</td>
<td><strong>Optimal decision making and risk acceptance criteria</strong></td>
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<td></td>
<td>- Optimality in engineering decision making</td>
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<td>- The ALARP principle for acceptability</td>
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<td>- The Life Quality Index and acceptable life safety</td>
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<td>- Societal life saving costs and willingness to pay</td>
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