TuRisMo – Risk Model for Austrian Road Tunnels

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TuRisMo – Risk Model for Austrian Road Tunnels

Introduction

Definitions

What is risk analysis?

- a big family of different approaches, methods and complex models combining various methodological components for specific tasks
- systematic analysis of sequences and interaction effects in potential incidents
- thereby, identifying weak points in the system and recognising possible improvement measures
- risk analysis makes the quantification of risks feasible
Definitions

What`s the purpose of risk analysis?

• to check the general consistency of safety planning
• to choose between alternatives
• to demonstrate safety in case of deviations from prescriptions
• to optimize safety planning in terms of cost-effectiveness
• a performance based approach for the assessment of safety standards
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Introduction

**Background**

- Traditional way of assessment of road tunnel safety in Austria:

  **Prescriptive guidelines – prescriptive approach**

  … a tunnel is safe if it is designed in line with valid guidelines

- However, the Austrian design code for road tunnel ventilation (RVS 9.261 or RVS 09.02.31) also contains a simple tool for a risk related safety assessment

- The EU-directive 2004/54/EC establishes the performance based approach (risk based approach) as supplementation to the traditional prescriptive approach
Main objectives

The main objectives are

- to develop a risk analysis methodology for Austria, which fulfils the requirements of article 13 of the EU-directive

- to provide a tool to assess safety of a tunnel with special characteristics according to EU-directive, annex I

- to provide a quantitative and understandable basis for a new „simplified method“ of risk assessment of road tunnels, which is to be integrated in the new RVS 09.02.31 guideline
**General principles of methodical approach**

- Method focuses on „standard risks“ – transport of hazardous goods has to be assessed separately
- Method follows an integrated approach
- Method includes the main risk influencing factors and their interrelations in a quantitative way
- Method mainly uses specific data from Austrian road tunnels
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Methodical Approach

Data base of risk analysis

- Evaluation of 447 tunnel accidents with personal injuries ¹)

- Covering 60 uni-directional and 21 bi-directional Austrian motorway tunnels (period 1999 – 2003)

¹) provided by KfV – Kuratorium für Verkehrssicherheit
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Methodical Approach

**Elements of methodical approach**

The methodical approach combines two basic methodical components

- a quantitative *frequency analysis*
- a quantitative *consequence analysis*

The method investigates the risk to tunnel users

- reference value: expected value of the societal risk (fatalities per year)
- the shares in risk of mechanical effects, fire and hazardous goods effects are shown separately
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Methodical Approach

- **Sequence of risk analysis**

  **Input: Influencing factors**
  - Tunnel length
  - Traffic volume
  - Portion of heavy vehicles

  **Modelling of Consequences**

  **Logical tree**
  - Initial event
  - Accident scenarios

  **Results**
  - Expected risk value (fatalities/year)

  **RISK**
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Methodical Approach

**Frequency analysis – event tree approach**

Basic value of accident rates (accidents with personal injuries):

<table>
<thead>
<tr>
<th>accident types</th>
<th>uni-directional tunnel</th>
<th>bi-directional tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>single car accident</td>
<td>40%</td>
<td>17%</td>
</tr>
<tr>
<td>front-end collision</td>
<td>59%</td>
<td>50%</td>
</tr>
<tr>
<td>head-on collision</td>
<td>1%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Accident rates are modified in dependence of tunnel length and traffic volume!
Consequence analysis

- Estimation of extent of damage of mechanical accidents:
  Evaluation of tunnel accident data base

- Estimation of extent of damage of accidents involving fire:
  Combination of ventilation model with evacuation simulation model
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Methodical Approach

**Consequence analysis – ventilation model**

- Two different fire scenarios (5 MW, 30 MW)
- Two different ventilation regimes (longitudinal ventilation, transversal ventilation) ²)

²) provided by TU Graz, FVT
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Methodical Approach

**Consequence analysis – evacuation simulation model**

- **Software**: Building Exodus 4.0
- **Example**: fire in a bi-directional tunnel with longitudinal ventilation;
  distance between emergency exits: 1,000m (above)
  distance between emergency exits: 250m (below)
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Methodical Approach

Methodology – risk calculation

<table>
<thead>
<tr>
<th>Input: Influencing factors</th>
<th>Modelling of Consequences</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunnel length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portion of heavy vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical tree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>initial event</td>
<td>accident scenarios</td>
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<td></td>
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<td></td>
<td>0.013924</td>
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<tr>
<td></td>
<td>0.0000590</td>
<td></td>
</tr>
</tbody>
</table>

Expected risk value

RISK

0.005503

0.0005658
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Risk evaluation

### Strategy of risk evaluation

- Risk evaluation is done by relative comparison, by comparing the tunnel as it is to a reference tunnel, designed and equipped in accordance with the requirements of the EU-directive.

- Safety measures which are required according to Austrian regulations but exceed the minimum safety requirements as per EU-directive are considered as alternative measures.

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(Minimum safety standard)

- Tunnel with deviating characteristics
- Minimum requirements as per EU Directive for specific tunnel
- Tunnel with alternative measures
Definition of the tunnel (example for demonstration)

- Existing single tube tunnel, length 5.0 km
- Bi-directional traffic, 10,000 vehicles per day, 25% heavy goods vehicles
- Emergency exits: every 500m
- Ventilation: transversal ventilation, extraction openings with dampers every 100m

Design and equipment of the tunnel are in line with the requirements of the EU-directive, only share of heavy goods vehicles exceeds reference value of 15% → risk has to be assessed
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Case study

Results of investigation

The following cases are investigated

- A – risk of reference tunnel (definition of risk criteria)

![Diagram showing A with 0.128 fatalities/year]
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Case study

**Results of investigation**

The following cases are investigated

- A – risk of reference tunnel (definition of risk criteria)
- B – risk of existing tunnel

![Diagram showing comparison of risks A and B with values 0.128 fatalities/year for A and 0.139 fatalities/year for B]
Results of investigation

The following cases are investigated:

- A – risk of reference tunnel (definition of risk criteria)
- B – risk of existing tunnel
- C – alternative measure: reduction of cross passage distance from 500m to 250m

![Diagram showing fatalities per year for cases A, B, and C with values 0.128, 0.139, and 0.130 respectively]
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Case study

Results of investigation

The following cases are investigated

- A – risk of reference tunnel (definition of risk criteria)
- B – risk of existing tunnel
- C – alternative measure: reduction of cross passage distance from 500m to 250m
- D – alternative measure: speed limit 60km/h instead of 80 km/h for heavy goods vehicles

![Diagram showing risk calculations for A, B, C, D cases with numbers of fatalities/year: A: 0.128, B: 0.139, C: 0.130, D: 0.101]
Results of investigation

The following cases are investigated:

- A – risk of reference tunnel (definition of risk criteria)
- B – risk of existing tunnel
- C – alternative measure: reduction of cross passage distance from 500m to 250m
- D – alternative measure: speed limit 60km/h instead of 80 km/h for heavy goods vehicles
- E – alternative measure: second tunnel tube (uni-directional traffic)
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Conclusions

• TuRisMo - the new risk model for risk assessment of Austrian road tunnels is now completed and has been successfully applied to several tunnels.

• The method is a consistent and understandable basis for a performance based safety assessment of road tunnels.

• The method can be used for different applications such as
  - check of general consistency of safety planning
  - evaluation of effectiveness of alternative safety measures
  - optimisation of safety planning in terms of cost-effectiveness
  - demonstration that tunnel safety standards are full filled e.g. in case of deviations from prescriptions
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Conclusions

• On the basis of TuRisMo a new simplified method for the safety classification of Austrian road tunnels has been developed (published in the new RVS 09.02.31)

• Risk analysis inevitably deliver fuzzy results, which have to be interpreted accordingly

• Be aware that a risk analysis is always a simplification of real conditions and can never predict the course of real events; however, it enables to make decisions on a sound basis

Thank you for your attention!