

IABSE WORKSHOP ON RISK ACCEPTANCE RISK-BASED DECISION-MAKING IN TUNNEL





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ROAD TUNNEL SAFETY – GLOBAL VIEW



ROAD TUNNEL SAFETY – REGIONAL PERSPECTIVE

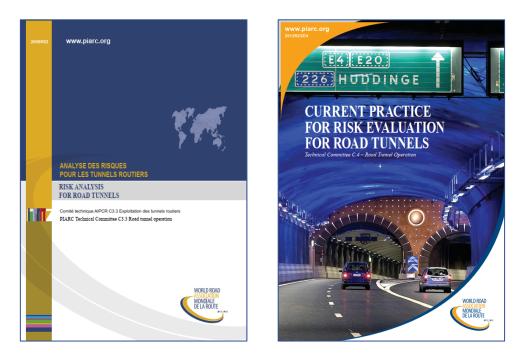
» Countries with a long history in tunnels

→ Developed their own national guidelines (several European countries, North America, Japan, …)

| funnelausrüstung | | |
|--|--|--|
| Belüftung | | Blatt 0.0 |
| GRUNDLAG | EN | RVS 09.02.31 |
| Tunnel Tunnel Equipment Ventilation Systems Basics | | |
| 3undesministeriu Österreichische I | m für Verkehr, Innovation und orschungsgesellschaft Straße | Technologie, GZ. BMVIT-300.041/0029-IV/ST-ALG/2014 – Schiene – Verkehr |
| v | RVS (| 9.02.31 |
| An die Autobahnen- und 1 ASFINAG Bau Ma ASFINAG Maut Sr ASFINAG Alponst ASFINAG Service ASFINAG Internat | rvice GmbH aßen GmbH GmbH | liengesellschaft |
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| RVS 1. Jun | 201.02.31: Tunnel 2014 Tunnelausrüstung Belüftung Grundlagen | |
| für die Anwendun | im Bereich des Straßen- und Ve | erkehrswesen ausgearbeitet. |
| Richtlinien sind H definierten Anwer | andlungsvorschriften mit bindend dungsbereich dar. Sie beruhen a | dem Charakter und stellen den Stand der Technik für einen auf gesetzlichen, normativen und weiteren aktuellen techni- |
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| AG Turnahau | herheitseinrichtungen | FORSCHUNGSGESELLSCHAFT |
| AG: Turnelbeu AA: Betriebs- und Si | | STRASSE . SCHIENE . VERKEHR Mr Lolos over Were |

» Countries with little /no experience in tunnels

- \mapsto No own guidelines
- → Typically refer to guidelines from other countries or to PIARC documentation
- └→ often confusing or even contradictory requirements



ROAD TUNNEL SAFETY – GLOBAL VIEW

ROAD TUNNEL SAFETY – HISTORICAL PERSPECTIVE

In the past:

» Tunnel safety implicitly included in prescriptive national guidelines – by defining a certain technical standard for tunnel structure & equipment

In 2004:

- » EC-Directive 2004/54/EC (in Europe)
 - → Definition of mandatory minimum safety requirements initiating a harmonisation of national guidelines; national guidelines typically are stricter than minimum safety requirements
 - → Implementation of risk assessment as new tool for road tunnel safety management at national basis

Now:

» Several different "national" risk assessment methodologies are used in different national regulatory environment, some of them also internationally

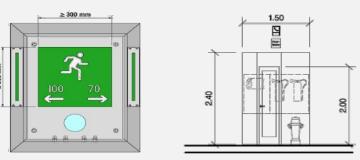


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ROAD TUNNEL SAFETY – BASICS

PRESCRIPTIVE VERSUS RISK-BASED APPROACH

Prescriptive approach





Risk based approach

A tunnel is safe if it is designed in line with valid regulations

- » Technical specification of safety features of a tunnel
- » Standardisation of design, easy to implement, but quite rigid
- » Traffic characteristics, operational issues, user behaviour, residual risk ... many aspects not addressed

A tunnel is safe if it meets predefined risk criteria

- » Structured, harmonised and holistic safety analysis as basis for decision making
- » Consideration of specific characteristics of a tunnel, much more flexible
- » Quantitative evaluation of residual risk / of effects of safety measures

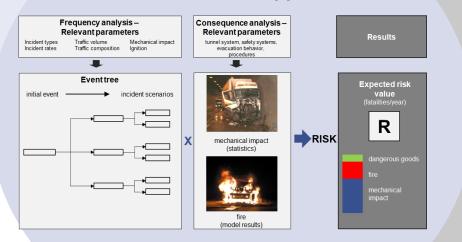
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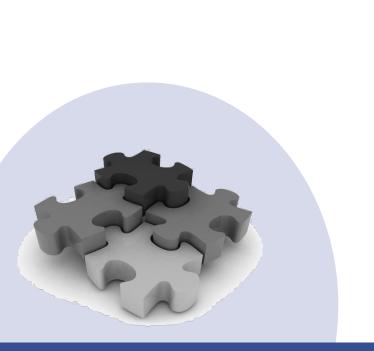
ROAD TUNNEL SAFETY – BASICS

PRESCRIPTIVE VERSUS RISK-BASED APPROACH

§ Legal / regulatory environment

Risk Assessment Approach





"Prescriptive approach and risk based approach have to be used as complementary elements of the safety assessment process."

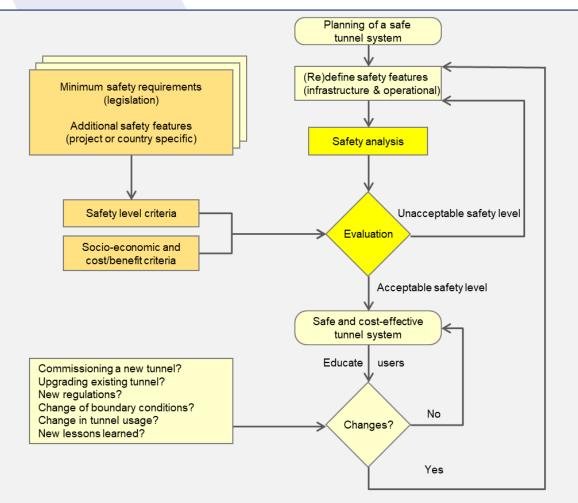
> (PIARC Report 2012R23, Current Practice for Risk Evaluation for Road Tunnels)



ROAD TUNNEL SAFETY – BASICS



INTEGRATION OF RISK-BASED APPROACH INTO TUNNEL LIFE CYCLE



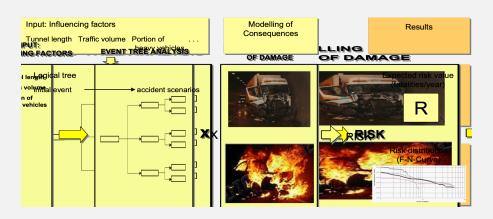
Implementation of safety criteria & socio economic criteria into safety evaluation throughout the life cycle of a tunnel

(PIARC report 2007R07, Integrated Approach to Road Tunnel Safety)

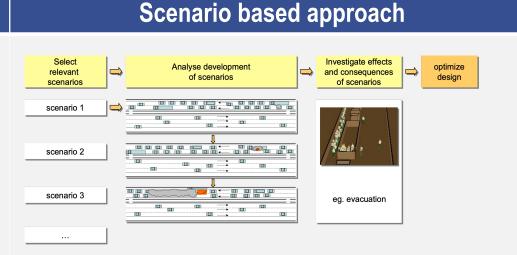
RISK ASSESSMENT – METHODS

SYSTEM BASED / SCENARIO BASED APPROACH

System based approach



- » Investigation of the overall system in an integrated process
- » Assessment of risk values for the whole system
- » Results: fully quantitative expected risk value (Ev) or F/N » Results: semi-quantitative quantification of curve
- » Evaluation by quantitative reference criteria & expert pinion



» Analysis of relevant scenarios

- » Obtaining information on frequency / consequences for individual scenarios
- consequences and/or identification of non-compliance
- » Evaluation by expert opinion

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RISK EVALUATION - PRINCIPLES

- » Relative risk evaluation approach
 - → Quantitative risk profile of existing state of a tunnel is compared to a reference state which is representing a sufficient level of safety
 - → Typical approach for system-based risk assessment methodologies (e.g. in Austria, Germany) and for alternative route comparisons in DG-transport
- » Absolute risk acceptance criteria
 - └→ Quantitative risk profile of a tunnel is compared to absolute threshold values
 - → Applied in countries with legally defined risk thresholds (e.g. in the Netherlands) and for DG-transport through tunnels (first stage in multistage assessment process)
- » Expert opinion
 - → Independent expert, nominated by the administrative authority, evaluates the semi-quantitative risk assessment results
 - → Typical approach for a scenario-based risk study (e.g. in France)
- » ALARP principle
 - → It needs to be demonstrated that all "reasonable" safety measures have been implemented;
 - → what is reasonable? Can be combined with willingness to pay approach

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RISK EVALUATION - PRINCIPLES

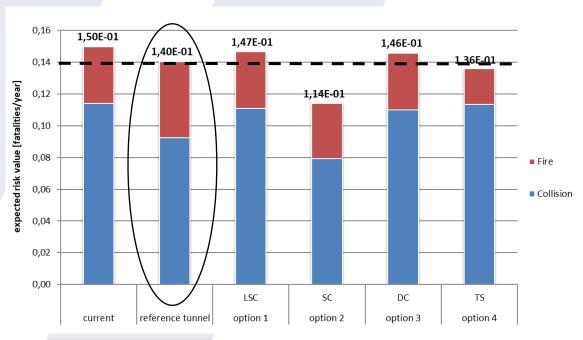


RELATIVE RISK EVALUATION APPROACH – EXAMPLE: AUSTRIA

» Regulated in Austrian Guideline for Tunnel Risk Analysis RVS 09.03.12

» Reference tunnel must fulfil minimum safety requirements according to Road Tunnel Safety Law (corresponds to EC-Directive) - requirements less strict than in the Austrian design guidelines -> certain flexibility

» For some critical parameters of this reference tunnel standardised specifications are provided, e.g.



\hookrightarrow No congestion

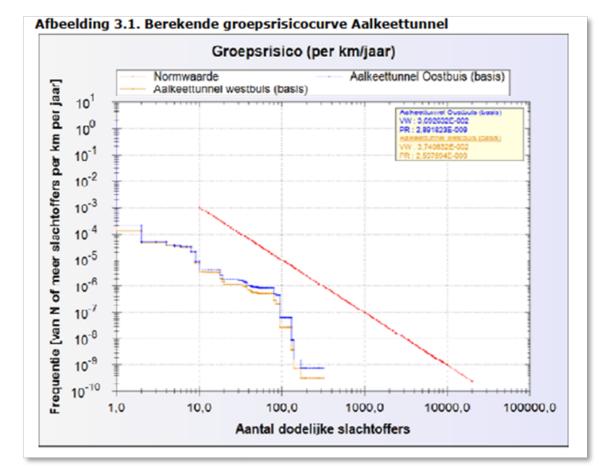
- → Reference values for traffic composition & some other parameters on the basis of definitions in the EC-Directive (e.g. 15% HGV)
- └→ Ventilation system: according to principles defined in the EC-Directive, but technical standard (layout, performance, operation etc.) according to Austrian design guidelines
- Speed: 100 km/h for unidirectional tunnels, 80 km/h for bidirectional tunnels

RISK EVALUATION - PRINCIPLES



ABSOLUTE RISK ACCEPTANCE CRITERIA – EXAMPLE: NETHERLANDS

- » Risk acceptance curve defined in Dutch Tunnel Safety Law
- » Applicable to DG risks and risks of major fires (≥ 10 casualties) hence limited to low probability / high consequence incidents
- » Risk acceptance criteria defined per km (tunnel length) and year; with a negative square coefficient for risk aversion
- » Rijkswaterstaat Tunnel Risk Model QRA 2.0 must be used (software is annex to corresponding tunnel regulations)
- » Many parameters in Dutch tunnels are standardised, hence most of the tunnels are very similar (unidirectional traffic, longitudinal ventilation, high traffic load, similar technical equipment)



DISCUSSION & PERSONAL VIEWS



- » I see two different ways of how to apply QRA for road tunnels
 - → For a clearly defined purpose, with a strictly national regulatory background: method, application rules & risk evaluation approach are regulated, many parameters are standardised
 - In a wider context for risk-based decision making in general (e.g. in countries without own guidelines, or for specific tasks, like decision on additional mitigation measures, combined with cost-benefit considerations): selection of method + risk evaluation approach according to subject
- » QRA method and risk evaluation approach are not independent e.g. an absolute evaluation approach is linked to a specific method (e.g. DG-QRAM) and requires the standardisation of relevant parameters (see e.g. the Dutch example)
- » A relative risk evaluation approach is much more flexible: for many use cases a plausible reference case can easily be found – everywhere, also in countries without own tunnel regulations
- » A relative approach establishes a link between prescriptive requirements and the risk-based approach, by "translating" the not tangible safety level of a "safe" tunnel (= in line with regulatory requirements) into a quantitative risk profile
- » A prerequisite for an absolute approach is the existence of broadly accepted quantitative acceptance criteria; if these are not existing yet (e.g. in the legal environment) it is a big challenge to establish them (e.g. when updating the German methodology this approach was eliminated, because it was never put into practice)

DISCUSSION & PERSONAL VIEWS



- » A relative approach is less sensitive to the fuzziness which is inherent in all risk assessment methodologies
- » Quantification of risk is always helpful, because it gives a feeling for the influence of certain parameters and the effects of certain measures; however, sometimes quantitative results are misinterpreted as precise figures, even by experts
- » Quantitative risk evaluation should be seen as a tool and an expert opinion is always needed additionally, to interpret results in a proper manner
- » However, a mere expert opinion approach opens room for biased and arbitrary decisions
- » A well-though combination of relative & absolute elements can be quite useful (see e.g. the Austrian one, where a relative approach is used for decision making, on the absolute risk of a tunnel is used to define the level of tunnel equipment in the technical design guidelines

Table 1: Risk classes

| Expected | Risk classes | |
|-------------|--------------|--------------|
| Under limit | Upper limit | RISK CIdSSES |
| | 0.02 | I |
| 0.02 | 0.1 | II |
| 0.1 | 0.5 | III |
| 0.5 | | IV |