INTERNATIONAL JOURNAL OF INTERDISCIPLINARITY IN THEORY AND PRACTICE
ITPB - NR.: 11, YEAR: 2016 – (ISSN 2344 - 2409)

RISK ANALYSIS AND SAFETY IN ROAD TUNNELS

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Abstract: *Risk analysis for the Slovak road tunnels is carried out according to technical conditions TP 02/2011 adopted on the basis of the requirements of the European Directive 2004/54 / EC on minimum safety requirements for tunnels in the trans-European road network with a length of more than 500 meters Government Regulation no. 344/2006. Model of risk analysis examines the personal risk of tunnel users and counted statistically expected value of the number of victims per year. For a more detailed examination of the risks of transporting dangerous goods through the tunnel, it is necessary to use a special risk model. A suitable example is specific risk model DG-Q_{RAM} (Dangerous Goods - Quantitative Risk Assessment Model), developed in partnership with OECD-PIARC. Tunnel Traffic & Operation Simulator of the University of Žilina in combination with unique softwares allows a research of the possible operating conditions during a normal service and model emergency situations.*

Keywords: Tunnel, traffic, risk analysis, safety, dangerous goods, road

1 RISK ANALYSIS MODEL

Risk analysis model (TP 02/2011), examines the personal risk of tunnel users, which means that all the parameters applied thereto solely for accidents to persons. Getting statistically expected value of the number of deaths per year. For the rating exist valuation limits, according to them, tunnels are classified in project preparation and some adjustments can be realized in existing tunnels if it´s allow by technical and operating conditions. Risks can be classified according due to mechanical damage, fire and transport of dangerous goods and the effects of dangerous goods are examined extremely simplified manner, and therefore the model is not suitable for deeper exploration of the risks of accidents (in the transport of dangerous goods). Given the results of the parametric study the influence of individual input parameters it can be concluded that the simplified model of the effects of dangerous goods should be on that model completely excluded or should be determined by objective parameters for the use of this parameter in the risk analysis (for example, because the minimum length of 500 m Rating tunnels). It should not be the case in view of the fact that the TP from authorized transport of dangerous goods recommended for deeper exploration risk to use a special risk model DG-QRAM (Dangerous Goods - Quantitative Risk Assessment Model), developed in partnership with the OECD-PIARC(Danišovič 2011). Nowadays, this document is used for a safety assessment of the tunnels operation.

1.1 The structure of the risk model

The structure of risk model requires a systematic approach and it consists of quantitative analysis of frequency and quantitative analysis of the consequences of accident (Fig. 1).

1.2 Risk assessment

Calculation was realized by researchers - engineer students (Ing. Martin Rázga) who worked on topics related to the scientific tasks solutions and PhD students (Ing. Peter Danišovič, PhD, Ing. Ján Filipovský, PhD). Remarks of the solvers of the research task oriented to the security of the operation in tunnels (Transport Research Centre) were used within a processing of doctoral thesis and results were processed in doctoral thesis.

Evaluation of the results of quantitative analysis is made from the relative risk evaluation comparison with a reference tunnel and absolute risk evaluation assigning to hazard classes.

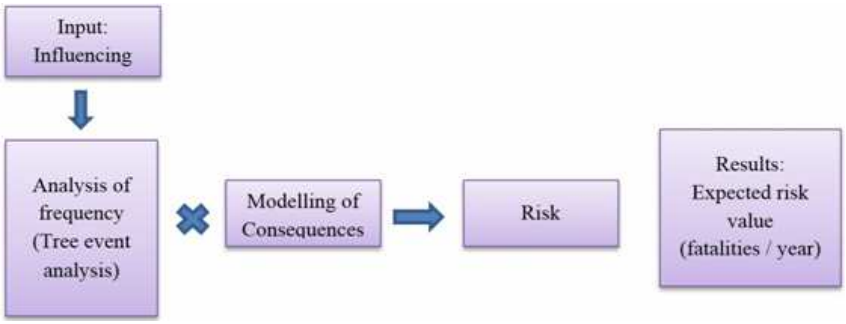

Fig. 1 Structure of the risk model, (TP 02/2011)

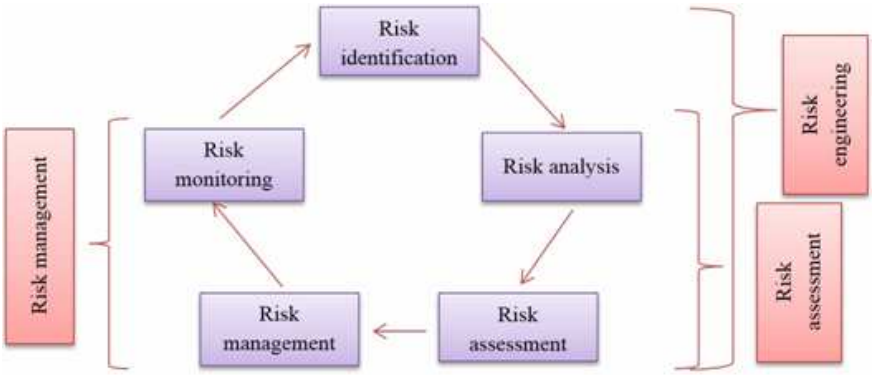

Fig 2. Risk management cycle, (Špička)

Relative risk assessment is that the tunnel complying with all relevant technical safety characteristics cannot show a higher risk than similar reference tunnel which satisfies relevant minimum requirements. In this way, it should be possible to prove that using prescriptive measures can keep a minimum level of security. However, experience shows various weaknesses in the model for calculating risk reference tunnel (Schlosser at al. 2013).

It is used a manual TP 02/2011 and TP 04/2014 for solving scientific tasks and realized evaluation serves as a basis for a preparation of tunnels operation prediction models processing. For each solution it is created an event tree according to incident´s nature (an accident or a fire in the tunnel) for specific tunnel conditions (Fig. 2) (Danišovič & Schlosser 2014).

Absolutely risk evaluation complements the relative evaluation and its goal is to provide information about absolute risk margin. Based on the expected value of risk (specified risk analysis) the studied tunnel is assigned to risk (hazard) class according to (TP 02/2011) (Table 1)

Tab. 1 Distribution of hazard classes, (TP 02/2011)

Expected Risk Value		Hazard classifications
Lower thresholds	Upper threshold	
-	0.02	I
> 0.02	0.10	II
> 0.10	0.50	III
> 0.50	-	IV

2 DANGEROUS GOODS AND THEIR TRANSPORT THROUGH THE TUNNEL

It is used a prescription TP 02/2011 in combination with QRAM software for the parameter´s evaluation. A parameter of quantity of vehicles with dangerous goods of the tunnel length 700 m of user (as an example) according to the methodology of the Centre transport research.

According to the prescription TP 02/2011 it is necessary to use a QRAM methodics because of small part of the influence of vehicles with dangerous goods. In some tunnels - according to the degree of danger - the passage of vehicles with dangerous goods is prohibited. Nowadays, it is reviewing the transit possibility of these vehicles, so we are accomplishing some calculations.

For a more detailed examination of the risks of transporting dangerous goods through the tunnel, it is necessary to use a special risk model. Suitable is for example QRA software, which was developed at the OECD-PIARC. This program is part of the equipment of the department of technology and management structures and in my doctoral thesis will be devoted to the analysis of the risks carriage of dangerous goods by applying the QRA model.

2.1 Exploration of ADR

Transport Research Centre of University of Žilina made the exploration of proportion of dangerous goods in transport through the tunnel. This research was aimed mainly to be objectively determination how much of transport dangerous goods is in the section of the road network. Although it was found out how many of these vehicles use a detour of tunnel, because in Slovak republic there is transport of dangerous goods through tunnel forbidden, and how many these vehicles drive through the tunnel despite the entry ban.

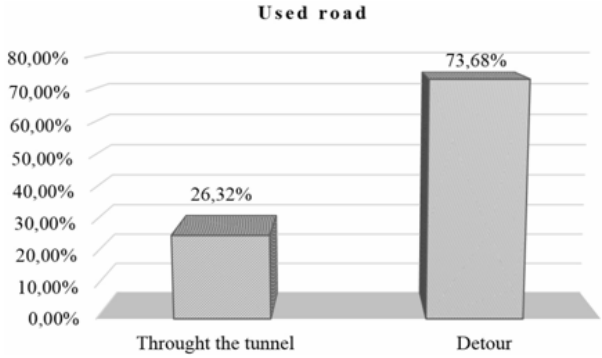

Fig. 3 The use of the tunnel with the transport of dangerous goods (source: own)

The research was carried out three days in the period from 5.3.2013 to 7.3.2013 from the place before the tunnel, where were two observers 24 hours a day. Result of the research showed that proportion of dangerous goods in this section is 2.19 % from the transport of HGVs. It was also found that

approximately 26.32 % of these HGVs with dangerous goods (marked as ADR) go through the tunnel despite the entry ban the transport of dangerous goods in road tunnels in Slovakia and 76.68% (Fig. 3) use the detour (Schlosser & Rázga & Danišovič 2014).

2.2 Risk analysis of one tube tunnel with transport of dangerous goods

Based on the experimentally determined ratio of the transport of dangerous goods was done re-calculation of risk analysis One tube tunnel according to TP 02/2011, but with modified input data, with the exact proportion of the transport of dangerous goods (2.19%). The result shows figure 4.

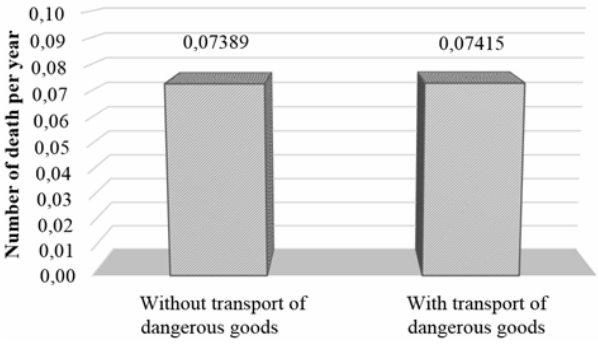

Fig. 4.The use of the tunnel with and without the transport of dangerous goods (source: own)

This figure shows that as soon as the transport of dangerous goods passed through the tunnel, the number of fatalities per year will increase from 0.07389 to 0.07415 which is an increase by about 2.8%. It seems that this difference is negligible, because proportion of transport of dangerous goods is not very large, but the danger is mainly that when vehicle with dangerous goods in an accident risk of fatalities is very big. With the increase in the number of highway tunnels in Slovakia in the near future, this fact can be important in the safety of road users.

3 TUNNEL TRAFFIC & OPERATION SIMULATOR

Basic composition of the Simulator consists from central control system (CCS - part of automatic tunnel equipment control), manual control module (MCM - part of manual control as separated module, it serves to a manual tunnel operation in the case of the central control system´s accident), software for prediction of phenomena (EMUT) - evidence of tunnel incidents. A workplace of one of two operators is in the figure 5.

It is possible to verify operating conditions at the Tunnel Traffic & Operation Simulator by real operation at the visualization on each operating condition. An operating condition with a formation of fire and the possible extension to other vehicles in the tunnel is in preparation too. Verification of operators response in operating conditions in the tunnel tube, also throughout a formation of fire, is possible only on the Tunnel Traffic & Operation Simulator in the Transport Research Centre. In the case of operating condition with dangerous goods transportations vehicles it is very necessary and required by the TP 04/2014 a preventive verifying of operators professional competence.

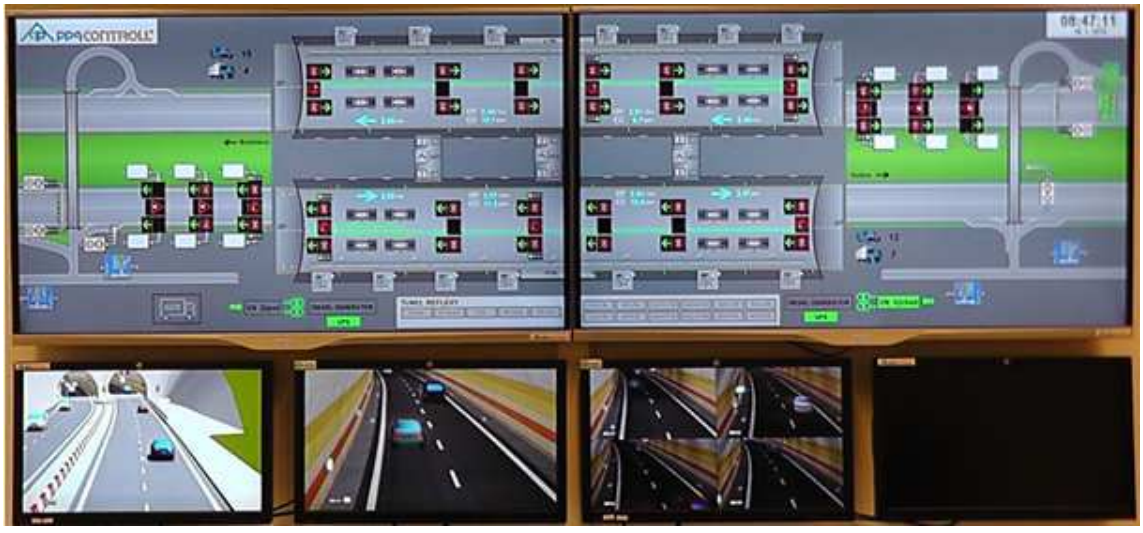

Fig. 5 Tunnel Traffic and Operation Simulator (source: own)

3.1 EMUT - Software for prediction of phenomena

EMUT is a special program for evidence and evaluation of incidents in the tunnel. It is registered every change compared to the tunnel´s operating conditions under normal operating conditions, when an intervention of technology´s operator and traffic´s operator is not required. An example of evaluation from monitored tunnels is in figure 6 and 7.

Similarly, it is possible to create a graphic representation of incidents in tunnels at a different frequency assessment of an monitored parameter.

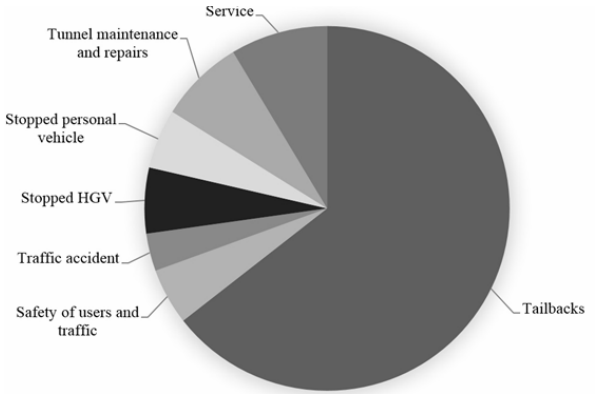

Fig. 6 Sectoral graph of events in a one tube tunnel (per year, source: own)

Fig. 7 The number of incidents in both tunnel tubes for a period of 1 month (source: own)

4 CONCLUSIONS

It is possible to assess qualitatively each highway tunnel´s parameter in the project preparation and in the operation using a risk analysis and special software for the evaluation of tunnel´s emergencies. The outputs from research of scientists PhD students and practice specialists allows a direct application of outputs in practice.

Risk analysis, special operators operations and operating conditions simulation on the Tunnel Traffic & Operation Simulator allows to increase a professional competence of operators, who manages the highway tunnels operation. Lessons learned from solutions are useful in practice and they contribute significantly to improve the environment by optimalization of the highway tunnel tubes design.

Acknowledgement: *The research is financed by: his contribution is the result of the project implementation: "Centre of Transport Research" (ITMS 26220220135) supported by the Research & development Operational Programme funded by the ERDF. "We support research activities in Slovakia/project co-founded from the resources of the EU"*

The research is supported by the European Regional Development Fund and the Slovak state budget by the projects "Research Centre of the University of Žilina" - ITMS 26220220183.

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