

5. EXAMPLES OF INTERESTING FINDINGS FROM REAL INCIDENT INFORMATION

Whereas *chapters 3 et 4* are addressing incident data evaluation at the level of a road network, *chapter 5* is focussing on real incidents at the level of an individual tunnel; it shall provide a realistic idea of incidents happening in road tunnels (see documentation of real incidents in appendix 5.1) as well as give examples which conclusions can be drawn at object level, based on the evaluation of such individual incidents. It can also be an interesting source for emergency services when they are looking for realistic scenarios for planning exercises.

The present chapter is organised as follows:

- At first, the purpose of this chapter is exposed, and the way how the required information was gathered is presented;
- Then, a survey of different kind of information of interest that can be derived from real incident information is given;
- Then, examples of how the different stakeholders involved in tunnel safety can take benefit of this information of interest are highlighted.

5.1. INFORMATION COLLECTED

Real incident information can be used either for general/statistical (see *chapters 3 et 4*) or illustrative purposes. Both approaches allow drawing interesting conclusions although those conclusions are of different types. As a function of the target goal (statistical or illustrative), the way to use the collected data (see *chapter 2*) is not the same.

Even if related to a specific context, it is often possible to draw conclusions of general interest based on qualitative, but detailed information of real incidents (videos, incident reports, etc.).

One purpose of this chapter is to give an idea of the type of findings and conclusions which can be drawn when using real incident information for illustrative (not statistical) purposes, based on the collection of various types of incidents as reported in *appendix 5.1*.

The information used in this chapter has been collected worldwide by TC 3.3 members through interviews, on the basis of a questionnaire specifically elaborated for the purpose of this report. The data collected have been dealt with anonymously. They are based on contributions from the following countries:

- Chile
- Czech Republic,
- Denmark,
- France,
- Germany,
- Greece,
- Japan,
- Mexico,
- Norway,
- Singapore,

- South Korea,
- Slovenia,
- Spain,
- Sweden,
- The Netherlands
- Vietnam.

Note: Other very valuable information about real incidents can be collected from publicly available reports and/or publications, for instance well investigated and documented reports and/or publications related to major incidents such as: Mont-Blanc tunnel fire that happened on 24th of March 1999; Burnley tunnel (Melbourne city link) incident that happened on 23rd of March 2007 [55]; etc.

The purpose of the questionnaire was to allow the interviewers to gather general information about:

- The main tunnel characteristics where the incident took place (long/short tunnel; urban/intercity/rural environment; level of traffic; one way or bidirectional tunnel; etc.);
- The type of incident: breakdowns, collisions, fires, incidents with dangerous goods involved, etc.
- The type of vehicle(s) involved in the incident: car(s), HGV(s), Busses/coaches, vehicle carrying dangerous goods, etc.
- Main lessons drawn from the incident(s) from different points of views: road user's behaviour, tunnel operator, emergency services, infrastructures, etc.

In addition, pictures and/or videos have been collected for some incidents.

The table below illustrates the interesting variety of types of incidents collected and reported in *appendix 5.1*. In this table, the incidents collected are identified by the same number as reported in *appendix 5.1*:

TABLE 10 TYPOLOGY OF INCIDENTS INVESTIGATED					
Type of incident	Type of vehicle				
	Motorcycle	4 wheels light vehicle (car, etc.)	HGV	Bus / coach	DG vehicle
Breakdown		4, 15			
Collision with side wall	24	21, 25, 29	9, 30, 34		11, 12
Rear end collision		4, 5, 7, 14, 15, 31	2, 11, 33		11
Head-on collision		6	33		
Smoke		16		23	13
Fully developed Fire	24	1, 3, 6, 10, 14, 21, 25, 26, 27, 28	2, 17, 18, 19, 22, 30	8, 32	12
DG / fuel release			20		

The authors of this report would like to thank all the tunnel operators who gave to PIARC the opportunity to collect and use such very interesting and valuable information.

5.2. FINDINGS FROM REAL INCIDENTS INFORMATION – PRACTICAL EXAMPLES

Harvesting of information from real incidents provides a very useful data for prioritisation and characterisation of pragmatic risk management strategies. Indeed, post incident evaluation of a specific incident in a specific tunnel can be of great interest for improving any safety issue that has been highlighted by this incident. For instance:

- Modification of access routes or access protocols can be envisaged so as to reduce intervention delays when and where rescue services have experienced difficulties to approach a tunnel (due to congestion as reported in example 2, or any other reasons);
- Update of a specific Emergency Response Plan related to a specific tunnel can be decided so as to improve its applicability, and so as to improve accuracy of information exchanged between tunnel operator and rescue services (see for instance example 6 in *appendix 5.1*).

A few examples of findings which might be useful in a broader sense are reported here, based on the information reported in *appendix 5.1*. These findings are arranged according to the benefit they can provide with respect to the following aspects:

- Human behaviour;
- Tunnel Operation;
- Emergency Services;
- Tunnel provisions.

5.2.1. Human behaviour

Regarding human behaviour, the following findings and conclusions appear from incidents reported in *appendix 5.1*:

- When provided, evacuation instructions through broadcast, loud speakers and/or message signs are often followed by road users (see examples 16, 18);
- DG prohibition is not always respected by DGV drivers (see example 11);
- Training of professional drivers can lead to good driving behaviour and guidance to other drivers in a critical situation (see examples 8, 11);
- Bad driving behaviours (e.g. driving too fast and too close, undertaking unforeseeable manoeuvres) is a general problem, as it may cause collisions sometimes followed by fires (see examples 5, 14, 15, 24, 29, 30, 31, 33, 34);
- Objects on the roadway may cause collisions and/or fires (see example 26);
- Vehicles themselves may be the cause of a fire if they are used in bad shapes/conditions (see examples 27, 32);
- In case of a fire, many drivers pass by the vehicle on fire as long as they think it is possible to do so, despite of the potential danger (heat, lack of visibility due to the smokes, etc. - see examples 8, 9, 13, 17, 23). However, it happens that some drivers stop before reaching the fire, so that they can (but not always do) evacuate properly through emergency exits (see examples 8, 17).
- Some lack of respect to signalling systems (red crosses, flashing lights, VMS, etc.) has been experienced in quite some of the real incidents investigated (see for instance examples 1, 4, 5, 7, 10, 11, 23, 28). In addition, in some cases, forbidden movements (overtaking, driving backwards, making U-turns, etc.) have been noticed (see for instance examples 1, 13, 18, 23, 34):

5.2.2. Tunnel operation

Regarding tunnel operation, the following findings and conclusions appear from incidents reported in *appendix 5.1* :

- Many communication problems can arise during an incident (between rescue services & operator, between operator & road users, between rescue services & road users, etc.), for a lot of possible different reasons: language problems (mainly with road users: see examples 7, 19), misapplication of/unsuited procedures (see examples 20, 21), malfunction/inadequacies of communication devices (see example 3), etc.
- Evacuation messages need to be subtly designed and delivered, otherwise, their strict application by road users can lead to unexpected behaviours (see examples 17, 18);
- On the one hand, not all operators are well trained and familiar with the systems available (see example 20). On the other hand, good results are obtained in handling an incident when staff is well trained (see examples 19, 32);
- Update of procedures is sometimes decided, based on conclusions from post incidents evaluation processes (see examples 16, 21, 32);
- The operator can be overburdened, if he has to handle too many tasks at the same time (see example 16), and/or if they are not well organized into a hierarchy.

5.2.3. Emergency services

Regarding intervention of emergency services, the following findings and conclusions appear from incidents reported in *appendix 5.1* :

- In unidirectional tunnels, when fire brigades try to approach the scene from upstream, they often have difficulties due to traffic jam (see examples 2, 18);
- Even in case of very quick response to tunnel incidents, the fire growth can even be quicker (see example 32);
- Communication problems reported in *paragraph 5.2.2* above can also be a concern for emergency services;
- As reported in *paragraph 5.2.2* above, update of procedures is sometimes decided, based on conclusions from post incidents evaluation processes (see examples 6, 28, 32);
- Sometimes, emergency services do not know/follow procedures (see examples 17, 20, 21). As a consequence, more intensive training can be decided after the incident (see examples 17, 20).

5.2.4. Tunnel provisions

Regarding tunnel infrastructure and equipment, the following findings and conclusions appear from incidents reported in *appendix 5.1* :

- Immediate tunnel closure after an incident seems to be a common procedure (see examples 9, 13, 28, 32). But not all tunnels are equipped with physical barriers (see examples 1, 2, 11, 28). When there are no barriers, the lack of respect to signalling system could cause further hazards, caused by vehicles passing the incident place during a longer period of time;
- Noise from ventilation system can disturb communication in the tunnel (see example 8);
- Different approaches how to operate a ventilation system were observed: when to start, who to start, ventilation strategy etc. (see for instance examples 1, 2, 3, 11, 12, 17, 32);

- Equipment usually functions well but some malfunctions can lead to less efficient handling of an incident (see examples 13, 17);
- Lack of compatibility between police and emergency services radio systems, or problems with communication devices are sometimes experienced (see examples 3, 20);
- DG releases in utility duct can lead to serious damages on installation (see example 12);
- Difficulties at reaching the emergency exits can be caused by unsuited infrastructure (see example 14);
- Long bidirectional tunnels with longitudinal ventilation and lack of emergency exits represent serious aggravating factors in case of a HGV fire (see example 22);
- When physical barriers are installed inside a tunnel (see example 23), they seem to be efficient to stop the traffic. However, some precaution need to be taken so as the barriers are used for sure to keep away others road users from the vehicle(s) involved in the incident, and not to regroup them all at the same place.

5.3. HOW THE DIFFERENT STAKEHOLDERS INVOLVED IN TUNNEL SAFETY CAN TAKE BENEFIT OF REAL INCIDENT INFORMATION

Different groups of people are involved in tunnel safety issues, such as:

- Road users,
- Administrative Authorities,
- Designers,
- Emergency services,
- Safety Officers,
- Tunnel Managers,
- Tunnel Operators.

The ways these stakeholders can benefit from real incident information are very diverse, and depend on: the information they can reach, the interest they have in this information, etc. In any case, the use of real incident information for the benefit of all people involved in tunnel safety in a systematic post-incident evaluation process should be part of the system of permanent feedback of experience.

In the following, examples of information of interest that can be derived from real incidents are given, for the different stakeholders involved. Because they are based on examples, information of interest quoted in the following cannot always lead to general conclusion. Indeed, what happens in a specific context in a specific tunnel cannot necessarily happen the same way in other contexts or situations. That is also why real life experience often differs from assumptions in risk models which need to be generally applicable. However, it is always interesting to share practical experiences of incidents, because some of them can be of interest for people who could face the same types of incidents. As well, this information can be used for a continuous improvement of risk models and for providing more realistic or more specific input data for their application in general and for the quantitative assessment of risk mitigation measures in particular.

5.3.1. Tunnel managers, tunnel operators and/or safety officers

Based on the data collected, real incident information can be of specific benefit to tunnel managers, tunnel operators and/or safety officers for instance in the following situations:

- If communication problems occur (see examples 3, 7, 19, 20, 21) they should be analysed, and solutions should be proposed to solve them: if the problems experienced are due to defecting devices, improvement works could be needed; if they are due to misunderstanding between different services, the delivered messages must be cleared and the corresponding procedures should be updated; if they are due to misunderstanding of the safety messages delivered to the road users, maybe the message delivered could be reviewed;
- If experienced, the overburden of an operator in an incident (see example 16) should be investigated, and improvements should be proposed. In particular, the operator's tasks in a critical situation should be organised in a feasible and workable way (e.g. reduced to the absolute necessary or distributed between the tunnel operational staff).

Once improvements are implemented, they should be tested on the basis of exercises.

5.3.2. Tunnel designers

Based on the data collected, real incident information can be of specific benefit to tunnel designers for instance in the following situations:

- Whenever possible, the option of an implementation of physical barriers at portals shall be investigated (see examples 1, 2, 11, 28);
- Emergency exits shall be easy to reach and the signage easy to understand, otherwise they are not used. If the signage appears to be badly understood and followed by road users, improvements need to be made (see for instance examples 15, 28, 32);
- When experienced or suspected to be encountered, noise problems should be addressed (see example 8);
- Long bidirectional tunnels with longitudinal ventilation and lack of emergency exits should not be designed nor built (see example 22);
- Handling DG spill should be taken into account in tunnel design in order not to pollute the environment and to protect the tunnel interior from destruction due to DG (see example 12).

5.3.3. Administrative Authority / road user

Based on the data collected, real incident information can be of specific benefit to the Administrative Authority in the following way:

- Conclusions drawn based on the collected information can be useful to improve the design standards of tunnels and tunnel equipment as well as to give relevant advices on how to use it (ventilation systems, types of messages to deliver, etc.);
- Real incident information can be useful to conclude on the effectiveness of operational measures for the prevention, mitigation or the management of critical events in road tunnels;
- Conclusions drawn based on the collected information can be useful to organize national campaigns directed towards tunnel users, e.g. in national TV;
- Conclusions drawn based on the collected information could be useful to improve education programs of professional drivers, in order to improve behaviour in tunnels and provide guidance to other drivers in a critical situation.

5.3.4. Emergency services

Based on the data collected, incident information can be of specific benefit to the emergency services for instance in the following situations:

- In order to improve procedures to reach the place of an incident (see examples 2, 18);
- In order to evaluate and improve the clothing and equipment of emergency services (see example 32);
- In order to improve communications processes with tunnel operator & other services (see example 28).
- To support the planning of realistic tunnel exercises.

Once improvements implemented, they should be tested on the basis of exercises.

5.4. CONCLUSIONS AND WAY FORWARD

The statistical approach presented in *chapter 3* (for collisions) and in *chapter 4* (for fires) produces figures which can be used in risk analysis for instance. Such figures are theoretical. A more illustrative approach to the feedback from experience based on observations and findings of general interest can be very useful in addition to the statistical approach.

At the level of an individual tunnel, there are (hopefully) normally too few recordings for a sound statistical evaluation as well as for illustrative purposes.

Sharing information at national or international level allows gathering a greater variety of incidents giving way for a more representative view: whereas it is established practice to do it for statistical purposes, it is only rarely done for illustrative purposes, in most cases focussing on major incidents only (like Mont-Blanc tunnel fire, St-Gotthard tunnel fire, etc.). In this report this approach is expended to a randomly selected more representative set of different types of incidents.

In this chapter, it has been shown how useful such information collected at international level can be for a wide range of stakeholders involved in tunnel safety, for instance to improve operational procedures, installed equipment (radio, barriers, etc.) and the way they are used.

It is obvious that it would be interesting to go on with the collection of real incident information reported in *appendix 5.1*, so as to permanently continue in the future to enrich the set of findings that can be derived from the analysis of such incidents.