

**INCIDENT TESTED: RESCUE, EVACUATION AND FIRE  
PROTECTION AT THE KORALM TUNNEL 2**

**A REVIEW OF THE FIRE EVENT IN 2015 AND THE PRACTICAL  
IMPLEMENTATION OF THE CONCEPT IN THE EVENT OF AN  
INCIDENT**

S. Fehleisen, ÖBB-Infrastruktur AG  
J. Frießnegg; ARGE KAT2, Austria

## **1. ABSTRACT**

As a new high-speed railway connection between Graz and Klagenfurt, the Koralm Railway represents a crucial component in the context of the Baltic-Adriatic Corridor. With a length of about 33 kilometres, the Koralm Tunnel--the centrepiece of this new line--will become one of the longest traffic tunnel constructions in the world.

In the tunnel construction phase, the construction lot “Koralm Tunnel 2” represents the longest of the three main construction lots. Apart from excavator driving and drill-and-blast driving, two tunnel boring machines are also being used on this 20 kilometre length. The length as well as the complexity already pose specific challenges for the construction phase in terms of safety, rescue and evacuation, and fire prevention.

With the starting of the construction in 2011, the implementation of the rescue, evacuation and fire protection concept specified in the tender was also initiated by the contractor in cooperation with the client and the emergency services.

In February 2015, the emergency management had to be put into real action on account of a fire in an standby generator on one of the two tunnel boring machines. The fire could be brought under control successfully and all persons were rescued and evacuated from the tunnel unharmed. The professional and calm handling of the incident showed how significant prior emergency drills and coordination are.

*Keywords: tunnel safety, evacuation and fire protection for underground construction, long tunnels, tunnel fire*

## **2. INTRODUCTION**

The construction of the Koralm Railway is carried out over several phases, with some sections being worked on simultaneously. Apart from the 33 kilometre long Koralm Tunnel--which is the centrepiece of the Koralm Railway--and other smaller stations and stops, two new intercity stations will be built near the two tunnel portals. Presently, the work is completed or under construction for 90 percent of the Koralm Railway projects. The Koralm Railway will be fully operational by 2023 as a continuous double-tracked, electrified high-speed railway line with maximum speed of up to 250 kilometres per hour (ÖBB, 2012a).

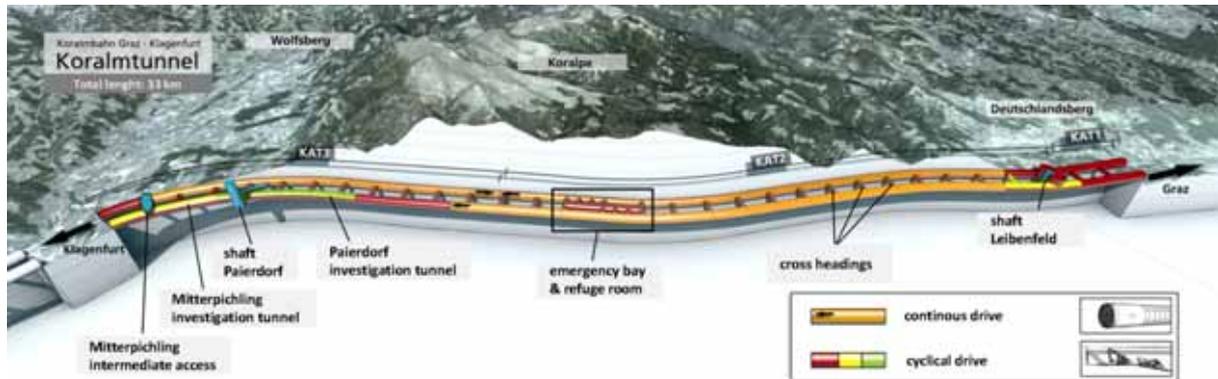
## **3. THE KORALM TUNNEL 2 CONSTRUCTION LOT (KAT2) AND ITS REQUIREMENTS IN TERMS OF RESCUE, EVACUATION AND FIRE PROTECTION**

The nearly 33 kilometre long Koralm Tunnel is designed as a twin-tube, single-track tunnel and passes under the Koralpe mountain massif with a maximum overburden of circa 1,200 metres.

Both traffic tubes are linked via cross passages every 500 metres and run at an axis-centre distance of 23-50 metres. The tunnel tubes will be excavated to have a diameter of ten metres.

As additional safety system, a refuge room with emergency station facing the traffic tubes is built approximately in the middle of the tunnel (ÖBB, 2012b). Two ventilation shafts will be provided for air circulation in both tubes in case of fire, during maintenance activities and in the event of breakdowns.

Measures for further investigation and research were undertaken in preparation of the main phase, which formed the basis for the detailed planning of the three main construction lots of the Koralm Tunnel: KAT1, KAT2 and KAT3 (Figure 1).



**Figure 1:** Construction lots division and tunnelling types (Source: ÖBB)

The construction work on the Koralm Tunnel began in 2008 with construction lot KAT1; the preliminary structural work has already been completed. Implementation of construction lot KAT2 followed in year 2011. In January 2014, the construction of the third tunnel construction lot KAT3 started from the western portal.

For the construction of the Koralm Tunnel, both cyclical (excavator and drill-and-blast driving) and continuous (mechanised) tunnelling techniques are being used. In total, three tunnel boring machines are being used, two in Styria and one in Kärnten in the construction lot KAT3.

### **3.1. Construction lot KAT2 at a glance**

In January 2011 began the implementation of the longest of the three tunnel construction lots in the Western Styrian region of Deutschlandsberg with 4,500 meters cyclical drive. Since early 2013, both tunnel boring machines of KAT2 have been running from Kärnten towards the boundary line of the third construction lot KAT3.

By year 2017, up to 17 kilometre length of tunnel has to be excavated by the machine. After that, 39 cross passages and the over 900 metre long refuge room will be built using cyclical tunnelling. This will be followed by the concreting phase and completion of the preliminary structure by 2019. At present, around 600 people are directly employed in the construction lot KAT2.

The long tunnelling lengths, the complexity as well as the long construction periods gave rise to safety-related parameters, which had to be appropriately taken into consideration in the planning phase itself (ÖBB, 2009):

- Entrance access via ventilation and construction shaft
- Two tunnelling activities operating in parallel with two tunnel boring machines
- Continuous segment lining
- Long tunnelling lengths, up to 17 kilometres from the construction shaft in the western direction

- Providing adequate quantities of air and ensuring tolerable temperatures at the work sites
- Occupational safety and fire protection
- Emergency exits for self-rescue: the distance between the heading face and the last cross passage that can be used as emergency exist can be up to six kilometres
- Evacuation routes for third-party rescue; only rail-bound from the point of mechanised tunnelling

These parameters, especially due to the long tunnelling lengths, made it necessary to include requirements and considerations in safety planning with regard to the layout of emergency exits, which was beyond the usual extent of planning until this point.

### **3.2. Rescue, evacuation and fire protection in the planning phase**

During the tender planning phase itself there was a fire in a small excavator that was tunnelling the Paierdorf exploratory tunnel (KAT3 zone) in 2008; luckily, the fire only caused damage to property.

The findings of the evaluation were incorporated into the rescue, evacuation and fire protection planning in the call for tenders for KAT2 (and KAT3). As a result, a detailed concept became available as guideline for specifying minimum standards, which with the award of the contract also became part of the construction contract (ÖBB, 2009). This concept was prepared jointly with the planning coordinator as well as an engineering consultancy for occupational safety and fire protection, which was called in additionally.

In a nutshell, the concept rests on three main pillars (ÖBB, 2009):

- Structural fire protection
- Technical fire protection, and
- Organisational fire protection

The aim was and remains to avoid incidents in advance through preventative measures and/or to reduce risks through measures that lower the probability of occurrence. Here, self-rescue with all its requirements and exigencies always remains in the foreground.

The individual points of the rescue, evacuation and fire protection concept are outlined in the following (ÖBB, 2009).

### **3.3. Implementation of measures during the construction phase**

#### *3.3.1 Preventative measures for structural fire protection*

Structural fire protection involves specifications with regard to e.g. the design and organisation of permanent assembly stations, workshops and storage areas below ground, as well as fire compartments below and above ground. In particular, the set of measures for emergency and escape exits deals with the minimum requirements for this part of the concept.

#### *3.3.2 Preventative measures for technical fire protection*

The measures refer to technical fire protection for the most part. These include devices like fire detection and alarm systems in sections with higher risk of fire, equipment for immediate fire-fighting and first response, special fire extinguishers, special fire extinguishing systems at exposed locations, as well as protective equipment, emergency vehicles and special fire-fighting equipment.

Following are examples of the technical measures:

- Safety centre KAT2

The safety centre was planned as a control and monitoring location, where all warning and communications systems converge. From here, the coordination happens for the ventilation and the emergency exits and the entire electronic personnel identification system below ground as well as the vehicle access above ground are monitored. Emergency services are alerted only by the safety centre. It has an emergency power back-up, is available round the clock and is connected to a control room from where all actions and measures are coordinated in an emergency situation.

- Communication systems

Upon mutual agreement between client, contractor and emergency services an analog radio system based on a 70-centimetre band was installed below ground. It not only connects to the emergency hotline of rescue services, the radio channels are also available as 'construction radio' to the workers on site and on the tunnel railway.

- Refuge chambers on the tunnel boring machines

In the concept, there was also a provision for refuge containers on both sides of the tunnelling machines. The specifications given in the tenders were appropriately adjusted to or expanded in accordance with the construction phases by the contractor consortium. Thus, the supply of breathing air in these refuge chambers was extended to 18 hours for 15 people.

- Rescue trains for the construction phase

In the planning phase itself, the refuge chambers on the tunnel boring machines were considered to be inadequate given the long tunnelling lengths. Therefore, four rescue trains permanently on standby were provided for the mechanised tunnelling phase. These rescue trains (Figure 2), as priority measure in terms of self-rescue, are intended as shelter or as means to exit the tunnel in emergency situations. A rescue train is always on standby to enter the tunnel for third-party rescue.



**Figure 2:** One of the four rescue trains at KAT2 (Source: ÖBB)

The four units are designed to carry 25 persons and with eight hours supply of breathing air. These four trains are driven by diesel engines. Measuring equipment, first-aid implements, means of lighting and communication, as well as fire-fighting and rescue equipment are all part of the train fittings.

An additional platform vehicle was designed for transporting the special fire-fighting equipment, which along with a high-pressure mist extinguisher system including power blowers also carries a generator, a portable fire pump with hose reel and a tank unit (4,000 litres).

### 3.3.3 *Organisational fire protection*

- Measures at the construction site

Organisational fire protection is a crucial component of the concept which should not be underestimated. It requires a significant amount of effort in terms of planning, implementation, coordination, sensitisation and communication. The guidelines and specifications for this have been considered in the tenders; the implementation, however, depends mainly on the dedication and commitment of the people on site. Therefore, apart from internal trainings in first aid and first response, additional restrictive regulations and rules of conduct have been prepared and implemented by the contractor consortium (ARGE KAT2, 2015).

Further specifications involve training of ‘pilots below ground’, who in an emergency situation enter the area along with the third-party rescue team. Fifteen employees of the construction company are presently trained as breathing apparatus wearers and accompany the emergency services personnel of the portal fire brigade in emergency situations. Emergency and contingency plans were prepared in parallel for each construction phase and for various scenarios, and allocated to the appropriate areas of responsibility within emergency management.

- Measures outside the construction site

Although self-rescue is the main focus of the concept, preliminary coordination and preventative emergency planning with third-party rescue teams is indispensable.

Apart from fire drills and site inspections, emergency management and its on-site implementation were evaluated in detail and appropriately updated at the beginning of the construction work.

In addition, trainings for incident commanders on site are an integral component of regular fire drills. The objective of these trainings is to optimise cooperation, identify weak points in the communication flow and interfaces, as well as to gain better knowledge and understanding of the processes and requirements of other institutions.

## **4. THE UNDERGROUND FIRE EVENT IN 2015**

In February 2015, a fire in a standby generator below ground became the ‘worst case scenario’ for emergency preparedness.

At around 12:50 in the afternoon, the safety centre was informed by an employee below ground about a fire in the northern tunnel boring machine. The origin of the fire was a standby generator on the upper deck of the machine, which at the time was less than eleven kilometres away from the construction shaft KAT2 and was shut down for maintenance work.

The standby generator on fire--which had a power output of 130 kilovolt-ampere--was located 150 metres away from the heading face and was used for supplying power to lighting systems and auxiliary systems as well as for ventilation during the extension of high voltage power supply every 500 metres of excavation.

The standby generator, which at this point had been in operation only for 20 hours, had several safety and fire-fighting mechanisms (automatic shutdown and self-extinguishing devices) installed in it.

#### 4.1. The sequence of the fire event

The fire was detected by the persons present in the tunnel, who were standing less than 15 metres away from the standby generator. A rapid spreading of smoke was caused by the ventilator units.

Upon detecting the fire, the safety centre KAT2 was alerted by mobile phone. At this point, 25 persons were present in the area of the northern tunnel boring machine. A part of them could be brought to safety by means of the tunnel railway for personnel, a few reached the safe south tube on foot. Seven persons were unable to escape due to the smoke and had to withdraw into the refuge containers in the front part of the machine.

#### 4.2. Rescue and evacuation measures and emergency management

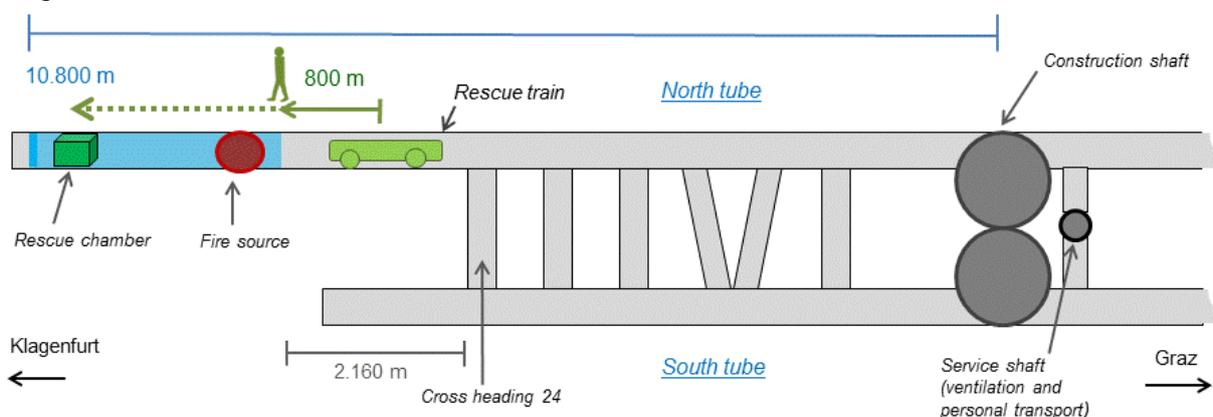
After the fire was discovered and the safety centre was informed, the emergency services was alerted by the safety centre and the internal alerting was carried out according to the alarm plan. Simultaneously, a team of incident commanders was formed. The operating officer-in-charge of the construction company coordinated with representatives of the client and the emergency services to take appropriate actions at the construction site.

The immediate actions taken were:

- Switching off the ventilation in the affected tube and starting up the ventilators as per the ventilation concept (supplying fresh air to the south tube)
- Evacuation of both tunnel tubes
- Ascertaining the number of persons present in the tunnel using the electronic personnel identification system
- Contacting the persons in charge below ground to clarify the situation
- Identifying the persons at the ventilator shaft above ground and comparing with the lists from the electronic personnel identification system

A crew of the construction company entered the safe south tube on a rescue train in order to clarify the situation and to clear the smoke in the north tube.

When no more smoke was perceived at the level of the last cross passage excavated towards the north tube, the incident commanders decided that a fire brigade crew with breathing gear and a construction site 'pilot below ground' should go towards the machine by a rescue train (Figure 3).



**Figure 3:** Diagrammatic representation of the course of action for rescuing the people (Source: ÖBB)

In clear visibility, the rescue train could pull in up to 800 metres before the northern tunnel boring machine. The last metres towards the tunnel boring machine had to be covered on foot by the crew with breathing gear because of the smoke in the tunnel tube.

On reaching the machine, the emergency services personnel made their way till the refuge chamber, where the seven persons found unharmed took their oxygen self-rescuers and were led to the rescue train by the crew.

In under two hours the rescued persons could be handed over to Red Cross above ground for a precautionary medical examination.

During the rescue operation below ground, further measures such as blockades and monitoring the access to the construction site equipment areas, creating reserves and withdrawal zones, as well as attending to media, etc. were coordinated by the incident commanders.

After the fire was out, the damages caused by it had to be ascertained: the area surrounding the standby generator had been severely damaged; however, the fire event remained limited to the area where the machine was installed.

The actual cause of the fire could not be established by the experts because of the heavy damage to the standby generator; a technical fault was suspected.



**Figure 4:** Standby generator after the fire (Source: ARGE KAT2)

## 5. SUMMARY

From the very beginning, a lot of importance was given in particular to the cooperation of the project partners on site with each other as well as with the external emergency service personnel. It was clear to all that to deal with a complicated incident--which cannot be excluded at a tunnelling site like KAT2, given the scale of the project--it is essential to have the knowledge about the relevant practices and processes.

To sum up the fire event, the following points may be noted: the rescue and evacuation concept had functioned successfully, the cooperation between the incident commanders and all persons involved was exceptionally professional. At the same time, the impact which such an incident may involve could also be reduced.

The approach to incorporate minimum standards for rescue, evacuation and fire protection into the tender planning phase aimed to set out a clear path for fulfilling the safety objectives

and to achieve the ability to act in an emergency situation. The details, however, could be defined only in the course of specific work preparation by the contractor company. It is important to define threats, risks and application limits as well as to specify clear responsibilities. This again calls for awareness and acknowledgement of the time and operational effort required for this purpose.

To arrive at reasonable solutions with acceptable effort and expenditure requires involvement and commitment on part of the client, contractor as well as the external rescue services and public authorities. The open exchange of experiences and perceptions has a positive impact on the cooperation and breaks down bias amongst all parties involved. The fact that a safety officer appointed by the contractor and a site coordinator for the client are always available on site from the very beginning has significantly contributed to high implementation quality.

The fire event and its professional and calm handling showed how significant prior emergency drills and coordination are. Quick and appropriately reliable communication and decision-making channels cannot be planned as part of a technical rescue and evacuation concept; instead, they are based on sincere cooperation and a culture of open discussion, which is preceded by one important thing: Commitment to the task and to the safety of all the people on site.

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### BIBLIOGRAPHY

ARGE KAT2 (2015): *Rettungs- und Brandschutzkonzept* [Concept for rescue, evacuation and fire protection] KAT2. Construction phase 2c. Deutschlandsberg.

ÖBB-Infrastruktur (2009): Koralm Tunnel construction lot KAT2. Tender documents - OHS plan, technical terms of contract Appendix 17. ÖBB-Infrastruktur AG. Vienna

ÖBB-Infrastruktur AG (2012a): *Durchbruch in die Zukunft. Der Koralmtunnel*. [Breaking through to the future - The Koralm Tunnel] 1st Edition, p. 9-11. ÖBB-Infrastruktur AG. Vienna

ÖBB-Infrastruktur AG (2012b): *Durchbruch in die Zukunft. Der Koralmtunnel*. [Breaking through to the future - The Koralm Tunnel] 1st Edition, p. 49-65. ÖBB-Infrastruktur AG. Vienna

### ABBREVIATIONS

KAT1, KAT2, KAT3	Main construction lots of the Koralm Tunnel
ÖBB	<i>Österreichische Bundesbahnen</i> [Austrian Federal Railways]
ARGE KAT2	Construction consortium Koralm Tunnel 2 (contractor)