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Michael Bacher
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PREFACE

This conference proceedings brings together the contributions from the 13th International Conference on Tunnel Safety and Ventilation, which took place in Graz on April 21–22, 2026. The conference is an established meeting place for operators, users, technicians, researchers, and industry partners. The goal is to provide a structured forum for the exchange of information on the planning, construction, and equipment of road and rail tunnels, as well as for the continuous development of knowledge and practice. The contributions offer in-depth insights into key issues of tunnel safety and ventilation and make a concrete contribution to the sustainable and efficient development of the sector.

Special attention was given to cross-cutting topics that shape the state of the art and future directions. Sustainability and energy efficiency were examined from multiple angles, including low- and lean-tech approaches and concrete operational measures. Model-based predictive ventilation control demonstrates how energy demand can be reduced and emissions lowered.

Digitalization and automation were also in focus, addressing both the practical use of digital twins for road tunnels and secure, web-based supervisory control platforms. Advances in sensing and data fusion, as well as systematic condition assessment of tunnel equipment, form the foundation for proactive operations. The concept of smart tunnels in an Industry 5.0 context links dynamic risk analysis with enhanced resilience, while developments in risk analysis software support evidence-based decision-making.

In the field of ventilation, practice-oriented optimizations and fundamental findings were presented: optimization of main fans and associated drives, system upgrades in major road tunnels, acceptance criteria for longitudinal ventilation, and methods to enhance performance during the transient stages of fire events. Specific operational scenarios were addressed, such as control strategies for short, longitudinally ventilated tunnels under temporary bidirectional traffic, alongside phenomena like smoke recirculation at portals and pollutant dispersion at tunnel exits in urban street canyons. Foundational work on aerodynamics, such as the influence of cross-sectional geometry, air speeds near wall-mounted services, and train-induced aerodynamic loads, and on fire dynamics, including validation of flow resistance through full-scale fire tests and improved fidelity in simulations, strengthens both design and operational decision-making.

Safety under incident conditions was examined from multiple perspectives, including maintaining critical functions during widespread power outages and synthesizing lessons learned from numerous operating concepts in Swiss road tunnels. Cultural differences in road tunnel fire safety and the specific challenges of covered highways broaden the view on normative and context-dependent solutions. Empirical studies on human behavior in smoke, covering individual and group effects on movement, reaction, and evacuation, inform the design of escape

and rescue concepts. With new vehicle technologies advancing, several contributions considered risks and opportunities around automated driving in tunnels, thermal runaway in lithium-ion batteries, and the consequences of large electric vehicle fires, as well as heat transfer between ground and tunnel air and its implications for structural integrity and ventilation design. On the rail side, research conducted during the construction of large-scale projects, such as the Koralm Tunnel, provided valuable real-world insights.

The technical visit led to the new Wetmannstätten railway station and the ÖBB Asset Service Center (ASC). As decentralized hubs of ÖBB-Infrastruktur AG, the ASCs showcase maintenance, service, and fault rectification in practice; in incident response, they are often the first on site, ensuring the swift restoration of technical systems such as switches and signals. Insights into processes and technology underscore the importance of integrating planning, operation, and maintenance.

Our sincere thanks go to Austrian Federal Railways (ÖBB) for their support, to the exhibitors for presenting their products and engaging in intensive exchange, to all participants and last but not least the presenters for their dedicated contributions. We also thank everyone involved in ensuring the smooth running of the event. We hope that the contributions assembled here will provide impetus for future projects, research initiatives, and decisions, laying the foundation for reliable, evidence-based, and sustainable advancements.

Michael Bacher and Organizing Committee

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